1980

Wheat Acreage Supply Response under Changing Farm Programs

BJ Morzuch

RD WEAVER

PG HELMBERGER

Wheat Acreage Supply Response under Changing Farm Programs

B. J. Morzuch, R. D. Weaver, and P. G. Helmberger

Planted wheat acreage supply elasticities are estimated for each of several leading wheat-producing states. Estimates of elasticities for the aggregate of these states are 0.77, 0.45, and 0.52 for spring wheat, winter wheat, and all wheat, respectively, but there is considerable heterogeneity among states. Acreage allotments and marketing quotas appear to have destroyed the role of prices in allocating acreage between wheat and other crops during the years 1950 and 1954–64. Estimates were obtained using multiple regression analysis of time-series data for the period 1948–74. This period was subdivided in order to take account of changing farm programs.

Key words: farm programs, regression analysis, supply elasticities, wheat acreage.

In their survey of agricultural price analysis, Tomek and Robinson call attention to the difficulties encountered in supply analysis and to the inadequacy of the elasticity estimates currently available. Supply estimation is particularly difficult for major commodities subject to farm programs. These programs change every three to five years and tend to complicate supply estimation because relevant variables and structural parameters may change over time. While supply equations must be conceptualized under alternative policy regimes, conserving degrees of freedom often necessitates approximations that are difficult to justify on strictly a priori grounds.

The need for good estimates of supply elasticities is great, however, and researchers continue to experiment with alternative approaches. Developing outlook information, predicting the consequences of proposed changes in farm policy, analyzing the welfare implications of commodity storage, and quantification of spatial equilibrium models are examples of research areas that require estimates of supply elasticities.

The purpose of this paper is to present the main results of an analysis of wheat acreage supply response. Unlike other studies of wheat supply, this study uses futures prices as a proxy for expected prices for wheat and competing crops. A different acreage response equation is conceptualized for each of three periods since World War II in light of changing farm programs for wheat. Supply equations are estimated for each of several major wheat states rather than for the nation as a whole. A considerable effort was made to measure all variables with as much precision as possible.

Our estimates of structural parameters support the following conclusions. First, during the years when acreage allotments and marketing quotas were not in effect, the response of wheat acreage to the price of wheat relative to prices of competing crops was larger than previous supply estimates would suggest. Second, there is a considerable heterogeneity in supply response among major wheat-producing states. Third, farm policy during the "quota years" appears likely to have destroyed the role of price in allocating acreage between wheat and competing crops. Finally, the voluntary nature and substitution and other provisions of programs beginning in the mid-sixties restored an allocative role to wheat price not unlike that under "free market" conditions. It appears that policy changes introduced in the sixties were quite successful in

---

Bernard J. Morzuch is an assistant professor in the Department of Food and Resource Economics, University of Massachusetts; Robert D. Weaver is an assistant professor in the Department of Agricultural Economics and Rural Sociology, Pennsylvania State University; and Peter G. Helmberger is a professor in the Department of Agricultural Economics, University of Wisconsin, Madison.

Research supported by the College of Agricultural and Life Sciences and the Institute for Environmental Studies, University of Wisconsin, Madison, and by the Charles F. Kettering Foundation.

The authors wish to thank Thomas A. Miller for his helpful comments on earlier drafts.

making greater use of the market mechanism in resource allocation.

Our analysis draws upon previous work in several important respects, but, at the same time, questions some existing research procedures and results. Gardner has proposed using futures prices as proxies for expected prices; our findings lend further support for this thesis. To take account of farm programs Lidman and Bawden inserted several program variables in a regression equation, giving little attention to the modeling of producer decision making in the face of changing programs over time. Garst and Miller improved upon the Lidman and Bawden work, in effect allowing new variables to appear (disappear) and parameters to change as programs varied. Their decision to include land diversion and set-asides as independent variables is of some concern, however, in that decisions to plant and divert are made simultaneously. Some of their independent variables may be endogenous, thus raising the question of simultaneous equations bias. We return to this issue later. Garst and Miller and Houck et al. insert price as an independent variable, but price is not expressed relative to the prices of competing crops. Their procedure receives little support from economic theory. Unlike the previous works of Garst and Miller, Lidman and Bawden, and Houck et al., we do not assume that wheat acreage supply elasticities are the same for quota and nonquota years. As a final preliminary, the decision to disaggregate supply analysis to the state level stands in contrast to previous work and allows greater accuracy in the definition of variables. For instance, Lidman and Bawden divided lagged U.S. wheat price by a lagged U.S. index of feed grain and hay prices received by farmers. This index is dominated by U.S. corn prices which, while quite appropriate for wheat producers in the Corn Belt, would seem to be much less so for wheat producers in the plains states.

Conceptualizing Acreage Response Functions under Alternative Policies

In major wheat-producing areas, farmers have flexible production capacity that can be used to produce various crops other than wheat, including feed grains, rye, soybeans, flax, etc. We assume that producers allocate acreage among competing crops to maximize expected profit.[1] Under free market conditions, acreage planted to wheat may be viewed as a function of expected crop prices, exogenous input prices, variables measuring climatic expectations and endowments, the nature and extent of fixed-scale factors, and the current state of technology. Such a relationship is merely one among several reduced-form relationships, others being those for output, inputs other than acreage, and endogenous input prices (Weaver 1978). In addition, theory of the firm suggests that the function in question is homogenous of degree zero in prices; and increase in all prices will have no impact on planting decisions. This suggests that farmers are concerned with relative expected crop prices in allocating acreage among competing crops and would not respond to a proportional change in all expected prices. Although this point would seem clear even on an intuitive basis, typical acreage response functions estimated in the past have not been restricted to be linearly homogenous in prices.

A simple wheat acreage response function may be hypothesized under these conditions as follows:

$$(1) \quad WAP = \alpha_0 + \alpha_1 \, ERP + \alpha_2 \, TREND + \epsilon,$$

where WAP represents acreage planted to wheat; ERP represents the expected relative price, i.e., the expected price of wheat divided by an index of expected prices for competing crops; $TREND$ is self-explanatory; and ϵ is a stochastic term. $TREND$ is inserted to capture the effects of omitted variables that may have exerted systematic effects over time. For example, if technological change has tended to increase wheat yields less rapidly than the yields for competing crops, then for a given ERP, acreage planted to wheat would likely decline. In this study, equation (1) is hypothesized for each of the several major wheat-producing states with the variables defined accordingly. Because equation (1) makes no provision for farm programs, it is hypothesized for those years during which no programs were in effect. These "free market" years consisted of 1948, '49, '51, '52, '53, and 1974. We argue, however, that with suitable modifications, equation (1) may also be appropriate for the years 1965–73.

[1] Similar results undoubtedly would follow from a model of risk-averse choice. However, where risk measures are independent of expectations, exclusions of these variables will not bias our results.

The wheat programs for 1965–70 were voluntary (see Cochrane and Ryan). Wheat producers were awarded direct payments if they abided by their allotments and idled specified minimum percentages of their acreage allotments. Land diversion was not used in 1967 and 1968, but for the other years (1965, '66, '69, and 1970) land beyond the minimum diversions could be idled for additional payments. Wheat producers also were required to maintain normal acreages in conservation uses. Price supports through the nonrecourse loan system still were available to participants, but at greatly reduced levels relative to earlier years. The strategy of the new programs was aimed at allowing wheat output to be marketed through normal commercial channels. Of considerable relevance to the present study were the so-called substitution provisions included in both the wheat and feed grain programs. The feed grain program was similar in essential respects to that for wheat. Farmers who participated in both the wheat and feed grain programs could substitute acreage of feed grains for wheat, or wheat acreage for feed grains, within the total acreage permitted under both programs. A similar provision was open to the producer who had an oat-rye acreage base and was willing to divert some of that base to conservation uses. Wheat could be planted on the oat-rye base acreage. Finally, an overplanting provision allowed the producer to overplant up to 50% of the farm's permitted wheat acreage. The excess production had to be stored under bond, but could be marketed in future years under certain specified conditions. The substitution and storage provisions together with the voluntary nature of the program allowed considerable room for farmers to allocate acreage among competing crops on the basis of expected prices.

Relative to the 1965–70 programs those for 1971, '72, and '73 constituted an even smaller encumbrance on the allocative role of crop prices. Under the wheat and feed grain setaside programs for the latter three years, acreage diversion (set-aside) was required under most options in return for eligibility for direct payments. All remaining land, with the exception of a conserving base, could be allocated among crops in any way the farmer chose. The option of voluntary diversion of cropland beyond minimum diversions for additional payments was also available to feed grain producers in 1972 and to wheat producers in 1972 and 1973.

The above discussion indicates that wheat producers had considerable leeway in allocating land among competing crops over the period 1965–73. Farm programs served mainly to provide farmers with another cropland alternative, viz., the diversion of land for direct payments and other benefits. A wheat acreage response function may be hypothesized under these conditions as follows:

$$(2) \quad WAP = \gamma_0 + \gamma_1\, ERP + \gamma_2\, TREND + \gamma_3\, RUDC + \gamma_4\, MAXD + e,$$

where *ERP* and *TREND* are as explained above, *RUDC* equals an estimated diversion payment per bushel divided by the index of expected prices for all other crops, and *MAXD* equals the upper limit on the extent of permissible land diversion. The homogeneity condition for returns to land diverted is maintained as in the case for returns to land planted to wheat. It is hypothesized that γ_3 is negative in that the higher the relative diversion payment rate, the more land would be diverted and the less land would be planted to wheat. It is hypothesized that γ_4 is negative in that to the extent *MAXD* was actually binding, raising its value would have the effect of increasing land diversion (Weaver 1978a).

In order to conserve degrees of freedom we assume that $\alpha_0 = \gamma_0$, $\alpha_1 = \gamma_1$, and $\alpha_2 = \gamma_2$. This allows using data for the "free market" years along with data for the years 1965–73 for estimating the parameters of equation (2). The two variables *RUDC* and *MAXD* are set equal to zero for the "free market" years, a procedure that disallows acreage diversion during those years. Importantly, we are assuming that the acreage supply equation has the same slope for "free market" years as it did during the "land diversion" years. We also assume that the coefficients for *RUDC* and *MAXD* are the same for 1965–70 as for 1971–73. These are restrictive hypotheses which, given a sufficiently large sample, could be subjected to empirical testing. It should be stressed, however, that our hypothesis regarding slopes is much less restrictive than that maintained by previous supply analysts who have assumed constant supply slopes between quota and nonquota years. To this matter we now turn.

Beginning in 1954 and continuing through 1963, the wheat program involved price supports, acreage allotments, and marketing quotas. Producers who did not exceed their wheat acreage allotments could place their production under nonrecourse loans which included price support. They were, therefore, guaranteed a minimum price for wheat. Farmers who exceeded allotments and failed to store their excess production were subject to a penalty tax on the excess marketed. For each acre planted (harvested, after 1955) in excess of the allotment, the producer was required by law to pay a tax equal to the product of his weighted average yield over the previous three years and a per bushel tax. In addition, for some years the future allotment was reduced for the farmer who did not comply with his current allotment. After 1957, noncommercial wheat farmers could harvest thirty acres without penalty so long as the output was fed on the farm. Farmers who planted not more than fifteen acres of wheat were exempt from marketing quota penalties, a provision that was attractive to many farmers in the Corn Belt who were not mainly wheat producers.

Given a package of specific program parameters (allotments, penalties, and price supports) various responses by producers could be rationalized. Agricultural Stabilization and Conservation Service data show that in major wheat-producing states there was widespread compliance with allotments. If penalties were sufficiently onerous and all allotments were actually binding, then acreage allotment alone would determine planted (or harvested) wheat acreage, subject to the exception of land diversion programs to be discussed in a moment, and there would be no basis for including *ERP* as a relevant variable. In other words, the conventional concept of an upward-sloping supply simply would not apply. Hadwiger (p. 197) argues, however, that "during the Benson administration, program rules came to be structured somewhat more in favor of the noncompliers or violators, to the point where the advantage for many producers seemed definitely to be in noncompliance with the program." He further notes that in 1960, the last year of the Benson reign, "43.1 million acres of wheat were in compliance on a total allotment of 50.6 million acres" (p. 194). The 15-acre exemption, the "wheat-for-feed" exemption, and other provisions indicate that the relative price of wheat might be a relevant variable in determining wheat acreage. On balance we are inclined to include *ERP* as an independent variable, but with the expectation that its coefficient is likely to be a good deal less than for the nonquota years and might in fact equal zero.

The wheat program for 1950 involved acreage allotments. Farmers who exceeded allotments paid no penalties but lost price supports. Penalties also were dropped in 1964, although allotments and loss of allotment history were maintained. Importantly, there were no substitution provisions in either 1950 or 1964. For this reason, these two years were included in the "quota years."

In addition to direct acreage controls, land diversion opportunities were offered to producers during many of the quota years. These programs required that the allotment be reduced by the number of acres diverted. Land diversion introduced an alternative use of the allotted wheat acreage, which was constrained by a maximum allowable diversion (*MAXD*) and encouraged by a per bushel incentive equal to a percentage (*PERRU*) times the loan rate.

The acreage supply response hypothesized for the quota years is

$$(3) \quad WAP = \beta_0 + \beta_1\, ERP + \beta_2\, WAL + \beta_3\, PERRU + \beta_4\, MAXD + \mu,$$

where *WAL* equals the wheat acreage allotment, μ is a stochastic term, and remaining variables are as defined previously. Dividing the per bushel payment for land diversion by the loan rate is equivalent to using *PERRU* and again invokes the homogeneity condition in that only those producers who complied with allotments were eligible to participate in land diversion programs. Because the sample period spans only fifteen years and the number of observations is limited, trend was excluded from (3). It is hypothesized that β_1 and β_2 are positive and β_3 and β_4 are negative.

Data

Acreages. The spring wheat states in this study are North Dakota, South Dakota, and Montana. For any one year during the sample period, these three states accounted for a minimum of 76% of U.S. spring wheat production. The winter wheat states are Colorado, Illinois, Indiana, Kansas, Montana, Nebraska, Ohio, Oklahoma, Texas, and Washington. For any one year, these ten states accounted for a minimum of 78% of U.S. winter wheat production. For the spring wheat equations, acreage consists of acres planted to both durum wheat and other spring wheat. The acreage data are taken from various issues of *Crop Production-Revised Estimates* and of *Field Crops-Revised Estimates by States*, both series published by the U.S. Department of Agriculture (USDA).[2]

Prices. The expected prices for durum wheat and for other spring wheat are measured by the closing futures prices for the two kinds of wheat at Minneapolis on 15 April for the contract delivery month of September. The expected prices for certain other commodities were measured in an analogous fashion. Closing futures prices and contract delivery months were matched with planting dates and harvest dates, respectively, using data from *Usual Planting and Harvesting Dates*, USDA. For all winter wheat states, the closing futures prices on 30 September for delivery in July were used. Chicago quotations were used for soft winter wheat, oats, soybeans, and corn for grain. Kansas City and Minneapolis quotations were used for hard winter wheat and rye, respectively. Winnipeg quotations were used for barley and flax. The futures prices were taken from various issues of the *Wall Street Journal* for the period 1948–74.

Futures prices are unavailable for a number of crops grown in the twelve states. These include hay, sugarbeets, corn for silage and forage, sorghum for grain, forage and silage, potatoes, edible beans, edible peas, mung beans, rice, peanuts, popcorn, cotton, clover, broomcorn, buckwheat, and cowpeas. One-period lagged prices for these crops were chosen as a proxy for the unobtainable futures prices in the construction of an appropriate other crops price index corresponding to either winter wheat or spring wheat. Price information for most crops was taken from various issues of the USDA's *Agricultural Statistics* and *Crop Values*. Prices for crops such as hay, corn for silage and forage, and sorghum for silage and forage were estimated with the assistance of the Statistical Reporting Service, USDA.

A spring wheat price index, its corresponding other crop price index, a winter wheat price index, and its corresponding other crop price index, were derived using Divisia weights. This approach differs from the Paashe or Lespeyres approach in that the weights used by the latter two consist of a given base period weight, whereas the Divisia approach uses weights that change from year to year. The attractiveness of the Divisia scheme lies in its use of changing weights that in turn reflect the changing importance of commodities in terms of both their prices and quantities produced (Tornquist). The quantities used in the formation of these indices were the production figures associated with each crop. The sources of data on production are the same as for wheat acreages.

Government programs. The sum of the domestic marketing certificate and export marketing certificate values for wheat was used as the estimated diversion payment per bushel for 1965. The domestic marketing certificate value and the marketing certificate payment rate were used, respectively, for the periods 1966–70 and 1971–73. These data are taken from *Wheat-1978 Program*, USDA. Data on wheat acreage allotments, diverted acres, percentages of allotments used in figuring maxima for diverted acreages, and the percentages of loan rates used in figuring diversion payments during the quota years are taken from various issues of *Wheat Situation*, published by the USDA, and from Cochrane and Ryan.

Empirical Results

Where contemporaneous correlation exists among the error terms in a set of equations, generalized least squares (GLS) estimation of all equations taken together yields more efficient estimates than does ordinary least squares (OLS) estimation of each equation separately (Kmenta, pp. 517–29). Because of number of observations available and the number of parameters to be estimated there were insufficient degrees of freedom for GLS to be used.

Equations (2) and (3) were estimated by OLS for spring wheat in three states and winter wheat in ten states for the period 1948–74. Estimates for equation (2) are given in table 1. These estimates indicate that acreage planted to wheat was quite responsive to the relative price of wheat in nonquota years. The estimated coefficients for *ERP* are positive in all cases. The *t*-ratios range from 0.42 to 6.62 and exceed 1.8, the critical value at the 5% level of significance using a one-tailed test, in eight of the thirteen cases. Where the Durbin-Watson (D-W) statistics are low (e.g., Montana and Colorado), *t*-ratios are probably high.

Price elasticities vary considerably across states. Elasticities range from 0.61 to 0.95 for

[2] Interested readers may write to the senior author for data used in the analysis.

Table 1. Wheat Acreage Response Functions, Major Wheat Producing States, 1948–49, 1951–53, and 1965–74

State	Regression Coefficients (with t-Ratios)[a]					R^2	$D-W$	Own-Price Elasticity
	CONST	*ERP*	*TREND*	*RUDC*	*MAXD*			
North Dakota	3.250	5.900	−.326	−.018	−.082	.87	2.09	.71
	(1.76)	(3.98)	(−1.94)	(−.72)	(−.21)			
South Dakota	1.273	2.127	−.125	−.073	−.046	.98	1.55	.99
	(3.14)	(6.62)	(−1.25)	(−13.75)	(−.49)			
Montana[b]	3.577	.673	−.244	−.085	−.102	.80	.54	.27
	(1.67)	(.42)	(−.78)	(−3.06)	(−.35)			
Colorado	2.863	.581	−.032	−.031	−.071	.74	1.02	.22
	(4.70)	(1.22)	(−.13)	(−3.04)	(−.33)			
Illinois	.721	.938	.053	−.003	−.138	.52	1.69	.61
	(.76)	(1.20)	(.16)	(−.23)	(−.66)			
Indiana	.285	1.107	−.033	−.007	−.152	.75	1.76	.93
	(.40)	(1.88)	(−.10)	(−.80)	(−.93)			
Kansas	9.360	4.522	−.242	−.116	.161	.81	1.76	.41
	(4.60)	(2.71)	(−1.04)	(−3.24)	(.21)			
Montana[c]	1.200	.259	−.007	−.057	−.387	.71	1.16	.13
	(1.12)	(.32)	(−.04)	(4.24)	(−1.81)			
Nebraska	3.191	1.207	−.168	−.060	.002	.90	2.00	.37
	(4.54)	(2.00)	(−.86)	(−5.98)	(.01)			
Ohio	.573	1.408	−.111	−.025	−.116	.82	1.93	.95
	(.63)	(1.92)	(−.30)	(−2.21)	(−.54)			
Oklahoma	3.112	2.380	−.284	.018	.140	.69	2.56	.46
	(3.23)	(3.52)	(−1.12)	(.93)	(.33)			
Texas	3.414	2.105	−.268	−.028	−.192	.58	1.61	.46
	(2.64)	(1.87)	(−.56)	(−.97)	(−.29)			
Washington	1.421	.637	−.273	.025	.054	.47	1.35	.29
	(2.81)	(1.75)	(−1.03)	(2.81)	(.31)			

[a] The dependent variable is acreage planted to spring wheat (North and South Dakota, Montana) or to winter wheat (remaining states including Montana); *CONST* is the constant term; *ERP* is the ratio of the expected price of wheat to the index of expected prices for other crops; *TREND* has gaps for missing years; *RUDC* is the ratio of the diversion payment per bushel to the index of expected prices for crops other than wheat; and *MAXD* is maximum allowable acreage diversion. See text for details.
[b] Spring wheat.
[c] Winter wheat.

the three Corn Belt states and from 0.22 to 0.46 for the remaining winter wheat states. This is not too surprising in that one might expect an inverse relationship between extent of specialization and elasticity of acreage response. Acreage elasticities were relatively high for North and South Dakota. It may be noted that the spring wheat states tend to be less specialized than major winter wheat states.

Aggregate supply elasticities were estimated as weighted averages using mean acreages for individual states as weights. Montana was excluded. (In much of our statistical work, the estimates for Montana were neither consistent with expectations nor with the results for other states.) The aggregate acreage supply elasticities for spring wheat, winter wheat, and all wheat combined are 0.77, 0.45, and 0.52, respectively. Previous acreage supply elasticities by Garst and Miller (p. 34) for spring, winter, and all wheat are 0.04, 0.19, and 0.17, respectively. The elasticity reported by Houck et al. (p. 37) equalled 0.39. Over the period 1954–70, Lidman and Bawden (p. 331) found that lagged wheat price was not significant in explaining acres planted to wheat. In most of their formulations the estimated coefficient for price was, in fact, negative.

Although the estimated coefficients for *RUDC* and *MAXD* tend to be negative, as expected, the t-ratios are low. Yet we know that substantial acreages were diverted under major programs during the period 1965–73, and it would seem strange indeed if these idled acres did not reduce at least to some extent acreage planted to wheat. The low t-ratios may be the result of the high levels of correlation observed between *RUDC* and *MAXD*. Moreover, it may well be that the land diversion programs in question were too complex to be represented adequately by the inclusion of

Table 2. Wheat Acreage Response Functions, Major Wheat Producing States, 1948–49, 1951–53, and 1965–74

State	Regression Coefficients (with *t*-Ratios)[a]				R^2	*D–W*	Own-Price Elasticity
	CONST	*ERP*	*TREND*	*DIV*			
North Dakota	2.549	6.375	−.017	−.225	.82	1.63	.77
	(1.37)	(4.02)	(−.31)	(−1.36)			
South Dakota	.284	2.954	−.131	−.106	.95	.82	1.40
	(.25)	(3.17)	(−6.18)	(−.59)			
Montana[b]	−.581	3.740	−.109	.128	.64	.71	1.50
	(−.25)	(2.09)	(−1.66)	(.32)			
Colorado	2.770	.690	−.060	−.175	.77	1.08	.26
	(6.25)	(1.93)	(−3.21)	(−1.14)			
Illinois	1.098	.636	−.001	−.140	.59	1.81	.41
	(1.47)	(1.03)	(−.09)	(−1.55)			
Indiana	1.158	.406	−.010	−.332	.88	1.88	.34
	(2.50)	(1.07)	(−1.06)	(−4.30)			
Kansas	10.721	3.528	−.231	−.265	.81	2.16	.32
	(6.95)	(2.75)	(−3.29)	(−1.63)			
Montana[c]	1.219	.244	.107	−.277	.49	.81	.13
	(1.35)	(.35)	(3.12)	(−1.50)			
Nebraska	3.639	.884	−.109	−.166	.91	2.61	.27
	(6.51)	(1.84)	(−5.96)	(−2.66)			
Ohio	1.770	.466	−.043	−.584	.90	2.28	.31
	(2.59)	(.85)	(−3.12)	(−3.71)			
Oklahoma	3.885	1.827	.024	−.172	.65	2.31	.36
	(4.72)	(3.04)	(.61)	(−.75)			
Texas	3.847	1.818	−.078	−.151	.54	1.59	.40
	(3.63)	(2.02)	(−1.57)	(1.11)			
Washington	1.901	.296	.035	−.089	.30	1.22	.14
	(4.81)	(1.01)	(1.94)	(−.27)			

[a] All variables are defined as in table 1 except *DIV* equals acreage diverted under both the wheat and feed grain programs. See text for details.
[b] Spring wheat.
[c] Winter wheat.

but two variables. For example, the two program variables do not take account of minimum diversion, payment rates for additional diversion, allotments, and several other program details that were likely of some importance in determining planted wheat acreage. While further work on this problem may be useful, the number of observations is limited in light of the number of parameters that might require estimation in models more complicated than those considered here.

As part of our exploration, equation (1) was modified by the inclusion of diverted acres (*DIV*) as an independent variable. The variable *DIV* equals the land diverted under both the feed grain and wheat programs and was zero for the free market years and nonzero for the years 1965–73. As noted previously, including *DIV* as an independent variable risks simultaneous equations bias in that diverted and planted acreages are probably endogenous in any reasonable model of producer decision making.

Alternatively, the estimates of equation (1) modified by including *DIV* may be unbiased if it is assumed that the expected value of the dependent variable is conditional on all independent variables including *DIV*.[3] On this interpretation, applicable to the estimates discussed below much as it is to the previous results of Garst and Miller, the estimated equation can be used only in prediction if knowledge of an estimate of the extent of land diversion is available prior to planting times. Clearly this approach, aside from problems of application, is less powerful than one which involves estimation of the reduced forms of a structural model.

Estimates of equation (1) modified by the inclusion of *DIV* are given in table 2. Again, the results for *ERP* are impressive judged by the usual economic statistical criteria. The associated aggregate acreage supply elasticities, again excluding Montana, are 0.90, 0.32, and 0.46 for spring wheat, winter wheat, and all

[3] For a presentation of the relevant theorems and a brief critique, see Malinvaud (pp. 614–17).

Table 3. Wheat Acreage Response Functions, Major Wheat Producing States, 1950 and 1954–64

State	Regression Coefficients (with *t*-Ratios)[a]					R^2	$D-W$
	CONST	*ERP*	*WAL*	*PERRU*	*MAXD*		
North Dakota	−.211	−.188	1.009	−.797	.115	.85	1.40
	(−.12)	(−.17)	(4.70)	(−.42)	(.36)		
South Dakota	−1.963	.210	1.337	.076	−.100	.78	2.51
	(−1.37)	(.22)	(3.58)	(.06)	(−.17)		
Montana[b]	−2.555	−1.310	1.616	1.297	−.115	.45	1.61
	(−.77)	(−.46)	(2.00)	(.45)	(−.13)		
Colorado	−1.933	−2.620	3.098	4.379	−2.165	.73	1.12
	(−1.17)	(−3.50)	(3.75)	(2.71)	(−2.97)		
Illinois	1.550	−.226	.270	.990	−.663	.69	2.55
	(5.061)	(−1.11)	(1.18)	(2.97)	(−2.25)		
Indiana	.752	−.067	.516	.857	−.780	.57	2.09
	(2.49)	(−.29)	(2.73)	(2.373)	(−1.95)		
Kansas	4.103	−2.678	.962	7.429	−1.088	.56	1.65
	(.82)	(−1.14)	(2.34)	(1.34)	(−1.64)		
Montana[c]	5.543	−1.581	−.341	−2.543	.775	.55	1.79
	(4.60)	(−1.53)	(−1.01)	(−2.19)	(2.13)		
Nebraska	1.145	−.837	1.014	1.221	−.418	.82	4.33
	(1.37)	(−1.74)	(5.28)	(1.47)	(−1.29)		
Onio	.296	−.338	1.023	1.069	−.759	.82	3.58
	(.932)	(−1.41)	(5.41)	(2.74)	(−2.43)		
Oklahoma	1.421	−1.642	1.185	2.700	−.784	.66	1.90
	(1.01)	(−2.29)	(3.28)	(1.68)	(−1.89)		
Texas	2.905	−2.241	.947	2.809	−1.017	.85	1.22
	(2.88)	(−2.11)	(5.19)	(2.22)	(−2.64)		
Washington	1.508	−1.468	1.144	.659	−.336	.90	2.13
	(4.95)	(−6.40)	(6.96)	(1.96)	(−1.59)		

[a] The dependent variables, *ERP*, and *MAXD* are the same as in table 1. *CONST* is the constant term; *WAL* is the wheat acreage allotment; and *PERRU* is the percentage of the loan rate used in figuring diversion payments. See text for details.
[b] Spring wheat.
[c] Winter wheat.

wheat, respectively. The estimated coefficients for *DIV* are negative in all cases except for spring wheat in Montana. The *t*-ratios tend to be small, but the pattern of results across states seems encouraging and the magnitudes of the estimates appear reasonable. Thus, for example, for every 100 acres diverted under the wheat and feed grain programs, the acreage planted to wheat fell by twenty-two acres in North Dakota and twenty-six acres in Kansas. The estimated coefficients are strikingly similar for Nebraska, Oklahoma, Texas, and Colorado.

Turning to the quota years, the estimates for equation (3) are given in table 3. The importance of wheat allotments in determining planted wheat acreage during the quota years is remarkable. Excluding winter wheat in Montana, the estimated coefficients for wheat allotments (*WAL*) are positive for the remaining twelve cases. For eight of these twelve cases the *t*-ratios for *WAL* exceed 3.0. For several states the estimated coefficient is close to unity, indicating that a one acre increase in allotments was associated with a one acre increase in planted acreage.

A second conclusion is that acreage planted to wheat did not respond positively to the relative price of wheat. The coefficients for *ERP* are negative in every case except one. The *t*-ratios are low in the majority of cases. Simple correlation coefficients between *ERP* and each of the program variables were very low with only a few exceptions. Adding trend to the equation does not alter the pattern of unexpected signs for *ERP*. These findings may reflect the downward movement of the national average support price for wheat (loan rate) from $2.24 per bushel in 1954 to $1.30 in 1964. The negative sign for *ERP* may reflect an empirical regularity growing out of the evolution of farm policy. In any event, the hypothesis, implicit in previous work, that the acreage supply function during the quota years has the same slope as during the nonquota years would appear to have received a near-fatal blow.

Finally, although the estimated coefficients for *MAXD* have the expected signs in most cases, the same cannot be said for *PERRU*. While we are unable to explain these results it is possible that the high correlation between *PERRU* and *MAXD* prohibited measuring the separate effects of each with much precision. On balance, however, the findings do not lend much support to the view that diversion programs reduced significantly the acreage planted to wheat during the quota years. This conclusion was also supported by further statistical work in which *MAXD* and *PERRU* were deleted from (3) and a land diversion variable was added in their place. In the revised formulation, the estimated coefficients for land diversion were negative in seven cases and positive in six. Once again, the estimated coefficients for *ERP* were mostly negative.

Implications for Future Work

Three suggestions for future supply analysis may be offered on the basis of findings discussed above. First, futures prices appear to merit consideration as an alternative to using distributed lags in modeling price expectations for economic research. Second, spatial heterogeneity and the opportunity for measuring variables with greater precision might well make disaggregation at least to the state level well worth the extra costs of data collection and analysis. Third, because farm programs change over time and may have profound impacts on the nature of supply response, it is important to structure analysis to allow for changes in relevant variables and in parameters, including elasticities, over sample periods.

[*Received January 1979; revision accepted September 1979.*]

References

Cochrane, W. W., and Mary E. Ryan. *American Farm Policy, 1948–1973*. Minneapolis: University of Minnesota Press, 1976.

Dow Jones & Co. *Wall Street Journal*, various issues 1948–74.

Gardner, B. L. "Futures Prices in Supply Analysis." *Amer. J. Agr. Econ.* 58(1976):81–84.

Garst, G. D., and T. A. Miller. "Impact of the Set-Aside Program on U.S. Wheat Acreages." *Agr. Econ. Res.* 27(1975):30–37.

Hadwiger, D. F. *Federal Wheat Commodity Programs*. Ames: Iowa State University Press, 1970.

Houck, J. P., M. E. Abel, M. E. Ryan, P. W. Gallagher, R. G. Hoffman, and J. B. Penn. *Analyzing the Impact of Government Programs on Crop Acreage*. USDA ERS Tech. Bull. 1548, Aug. 1976.

Kmenta, J. *Elements of Econometrics*. New York: Macmillan Co., 1971.

Lidman, R., and D. L. Bawden. "The Impact of Government Programs on Wheat Acreage." *Land Econ.* 50(1974):327–35.

Malinvaud, E. *Statistical Methods of Econometrics*. New York: American Elsevier Publishing Co., 1970.

Tomek, W. G., and K. L. Robinson. "Agricultural Price Analysis and Outlook." *A Survey of Agricultural Economics Literature*, vol. 1, ed. L. Martin, pp. 329–409. Minneapolis: University of Minnesota Press, 1977.

Tornquist, L. "The Bank of Finland's Consumption Price Index." *Bank of Finland Monthly Bull.*, no. 10 (1936), pp. 1–8.

U.S. Department of Agriculture. *Agricultural Statistics*. SRS, 1948–1976 issues.

———. *Crop Production—Revised Estimates: 1944–1949*. BAE Statist. Bull. No. 108.

———. *Crop Values*. SRS CRB 1961–76 issues.

———. *Field Crops—Revised Estimates by States*. SRS Statist. Bull. nos. 185, 290, 384, 498, and 582.

———. *Usual Planting and Harvesting Dates*. SRS Agr. Handbook no. 283, Mar. 1972.

———. *Wheat—1978 Program*. ASCS Commodity Fact Sheet, undated.

———. *Wheat Situation*. ERS nos. WS-149, WS-158, WS-174, WS-180, WS-201, WS-205, WS-210, WS-218, and WS-226.

Weaver, R. D. *Supply and Input Choice Response by Multiple Product Firms: New Approaches*. Agr. Econ. and Rural Soc. No. 137, Pennsylvania State University, Oct. 1978.