ESTIMATING THE EFFECT OF GOVERNMENT PROGRAMS ON THE SUPPLY OF WHEAT IN THE UNITED STATES

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Abstract

Acreage functions for wheat, incorporating variables that reflect the value of voluntary acreage diversion programs to producers, are estimated for 1962-76. The elasticities of response to such programs are generally low in comparison to those for market price, indicating that the reduction of production through voluntary diversion is relatively expensive.

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A major problem encountered by analysts of agricultural commodity supply in the United States is the determination of the influence of market price and government programs on acreage and output (Tomek and Robinson). In the case of wheat, the number of policy instruments used since 1950, and the frequent marginal changes in the form and use of these instruments has introduced considerable complexity into the estimation of supply response (Hadwiger). These problems, which are frequently compounded by the short time series involved, have elicited a number of different approaches to the estimation of the wheat supply relationship. These can be classified as follows:

(1) Flexible program definition. A single supply function is hypothesized and a number of program variables are specified for the entire period of analysis. These "generic" variables are given new definitions as programs change, and are used to reflect the impact of different programs in different years. The work of Lidman and Bawden is an example of this type of approach.

(2) Spliced data periods. As above, a single supply curve is hypothesized for the entire period of analysis. Variables used to represent different programs enter and leave the relationship as programs vary over time. Garst and Miller employ this technique.

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(3) Effective program variable. Houck and Subotnik recommend the construction of a proxy variable to reflect the impact of acreage restrictions and associated compliance incentives on producer acreage decisions. This proxy, the effective price support, folds all program instruments into a single time series which is assumed to capture the equilibrium adjustment of producers to program constraints. It is assumed that the supply relationship identified would operate in the absence of restrictions. (4) Separated data periods. Morzuch, Weaver and Helmberger argue that it is not appropriate to assume a priori that elasticities are constant across quota and non-quota years, and that an aggregate approach cannot provide sufficient accuracy in variable definition. Their investigation of wheat supply is performed at the state level with separate supply relationships hypothesized for quota (1950 and 1954-64) and non-quota (1965-73) years.

The disaggregated analysis of Morzuch et al. represents an important departure from previous studies in that it recognizes that while most government programs include a single announced support or payment rate, the actual monetary value of compliance is not uniform across all geographic production regions or sizes of farm. Since payments are tied to the farm program yield (which is determined at the county level) and are restricted to some proportion of the yield on diverted acres, the value of payments offered will vary with the farm's base allotment and the corresponding farm (county) yield. Under voluntary programs, where participation is optional, producers are offered a known revenue earning alternative for part of their land (diversion payments), which must be evaluated relative to expected returns from production.

Given that there are differences among firms in wheat yields, and that payments are tied to yield and allotment, the argument for a disaggregated

analysis of producer response to government programs is compelling. However, the problems of the specification of government program benefits in the face of changing program provisions, and the representation of market price expectations must be dealt with. The purpose of this paper is to present a method of separating market price effects from the influence of government program benefits and, at the same time, take into account both the changes in program provisions and the benefit differentials that result from differences in yields.

Effective Program Payments

The analysis focuses on 1962-76, the period of voluntary government wheat programs. Its objective is to derive estimates of the elasticity of wheat acreage response to both market prices and to government program instruments, and to compare their relative magnitudes.

The six instruments employed to induce acreage diversion during the period and their associated payment and acreage eligibility rates are given in table 1. While the loan rate operated throughout, export quotas were used only in 1964 and 1965. The last three years (1974-1976) were distinguished by the lack of any active program beyond the loan program and represented a period of expansion of wheat acreage in the absence of government acreage restrictions.

The six programs were combined into four as follows:

V1 = loan rate (GP1) program;

V6 = voluntary diversion (GP6) program;

V7 = price support (GP2) and mandatory diversion (GP5) programs; and

V8 = domestic (GP3) and export certification (GP4) programs.

Observations for these variables were derived by taking the product of the payment rate and the eligibility rate for each of the six programs (GP1-GP6) and then aggregating appropriately. Note that the loan rate (V1) is

Table 1. Payment Rates and Proportion of Acreage Eligible for Payment for Government Wheat Programs[a/]

Year	Program Component											
	Loan Rate (GP1)		Price Support (GP2)		Domestic Certificate (GP3)		Export Certificate (GP4)		Mandatory Diversion (GP5)		Voluntary Diversion (GP6)	
	$/bu.	Eligible	$/bu.	Eligible	$/bu.	Eligible	$/bu.	Eligible	$/bu.	Eligible	$/bu.	Eligible
1962	2.00	Total Prod.	0		0		0		2.00	.45	2.00	.60
1963	1.82		.18	1.0	0		0		1.82	.50	1.82	.50
1964	1.30		0		.70	.45	.25	.45	1.30	.20	1.30	.20
1965	1.25		0		.75	.45	1.32	.35	0		1.25	.50
1966	1.25		0		.30	.45	0		0		1.25	.40
1967	1.25		0		1.36	.35	0		0		0	
1968	1.25		0		1.38	.40	0		0		0	
1969	1.25		0		1.52	.43	0		0		1.25	.50
1970	1.25		0		1.57[b/]	.48	0		0		1.25	.50
1971	1.25		0		2.93[b/]	.75	0		0		0	0
1972	1.25		0		3.02[b/]	.83	0		0		.94	1
1973	1.25		0		3.39	.86	0		0		.83	1
1974	1.37		0		0		0		0		0	
1975	1.37		0		0		0		0		0	
1976	2.25		0		0		0		0		0	

Source: U.S. Department of Agriculture, Agricultural Statistics. Stat. Rep. Service, Washington, D.C.: 1977 and other issues.

a/ Eligible refers to proportion of allotment on which payment is made.

b/ Payment rate set at difference between season average market price and target price. Since market price information is not available prior to production decisions, the target price proxys for expected program payment rate.

applicable to total production and thus resembles market prices or price expectations while the variables (V6-V8) are announced program payment rates adjusted for the proportion of base acreage upon which payment is made.

The rates derived represent the announced per bushel payment for program compliance under voluntary programs. While these are uniform across all producers, the actual benefits received depend on the farm program yield, i.e., the program payment rate times the eligibility rate times the appropriate yield. The value of the program therefore can be represented by multiplying V1 and V6-V8 by the farm program yield. However, since yields vary by geographic location and by the type of wheat produced (winter, durum, other springs), the value of program payments is specified by region and by wheat type. The resulting measure of the value of participation in government programs, subsequently referred to as the effective program payments, is used to estimate regional acreage response elasticities to government programs.

Regional Wheat Acreage Model

The general form of the acreage relationship specified is:

$$R_{ij} = f(PO_j, PO_k, PF_{00}, W_i, V6R_{ij}, V7R_{ij}, V8R_{ij})$$

where R_{ij} = acres of wheat planted in region i of wheat type j,

PO_j = season average price ($/bushel) of wheat type j,

PO_k = season average price ($/bushel) of substitute crop k; k=1 (winter wheat), 2 (durum wheat), 3(other spring wheat), 4 (soybeans), 5 (corn), 6 (oats), 7 (barley),

PF_{00} = season average price ($/ton) of fertilizer (10-10-10) with no regional differential assumed,

W_i = range index for region i (WSO = September index, WJO = June index),

V6R, V7R, V8R = value of government programs ($/bushel) as defined above,

i = 1, 2, ... 5 regions,

j = 1, 2, 3 wheat types (1 (winter), 2 (durum), 3 (spring)),

and all prices are lagged one period.

Government program benefits are given by the V6R-V8R variables while market price effects on acreage planted are represented by lagged wheat and substitute crop prices. Lagged market prices are used to match available information with the timing of the planting decision. The loan rate is not included since it is assumed to contain information similar to that of market prices and is therefore redundant (and statistically collinear).

Data are derived from the U.S.D.A. (see Neenan) and the model applied to five regional aggregates (Gomme). They are as follows:

Region I: Wyoming, Nebraska, Colorado, Kansas, New Mexico, Texas and Oklahoma;

Region II: Montana, North Dakota, South Dakota and Minnesota;

Region III: Washington, Oregon, Idaho, California, Nevada, Utah, and Arizona;

Region IV: Michigan, Wisconsin, Iowa, Missouri, Illinois, Indiana, Ohio, Pennsylvania, Maryland, Delaware, New York, New Jersey, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut and Maine;

Region V: Arkansas, Louisiana, Mississippi, Kentucky, Tennessee, Alabama, Georgia, Florida, West Virginia, Virginia, North Carolina and South Carolina.

All equations were estimated for the period 1962-1976 by ordinary least squares. The short time series restricts the available degrees of freedom and prevents the use of generalized least squares to correct for the contemporary correlation that may exist across the error terms of the equations.

Market Price and Program Benefit Elasticities

Estimated winter wheat relationships are presented in table 2 and those for durum and other spring wheat in table 3. Regional functions are not

Table 2. Estimated Winter Wheat Acreage Relationships

Acreage Relationship	Parameter Estimates												
	Intercept	PO1	PO5	PO6	PO7	PFOO	WSOi	V6Rij	V7Rij	V8Rij	$\bar{R}^2$	DW	F
R11	29,116 (3.72)	2,138 (.96)			8,338 (2.23)	-3.72 (1.87)	71 (.82)	-61 (.72)	-170 (1.54)	2.74 (.09)	.65	2.19	4.66
R21	3,977 (4.04)	158 (.41)		3,756 (2.76)		-53 (1.92)	-15 (1.51)	.39 (.03)	-17 (.84)	-1.79 (.33)	.66	2.20	4.86
R31	4,905 (2.41)	66 (.01)	246 (.20)			20 (.55)	-17 (.70)	-2.11 (.16)	-32 (1.71)	2.62 (.51)	.69	1.92	5.41
R41	11,807 (4.79)	1,303 (1.23)	-1,070 (.49)			-15 (.25)	-53 (1.87)	-29 (1.22)	-.04 (.01)	-17 (1.78)	.62	2.23	4.24
R51	996 (.81)	254 (.64)	-887 (1.11)			23 (1.02)	13 (.85)	-27 (2.55)	-24 (1.45)	.55 (.12)	.65	2.46	4.73

Notes: All relationships estimated by least squares for the period 1962-1976.
Acres planted measured in thousands of acres.
All crop prices are lagged (one season), season average price.
$\bar{R}^2$ is the adjusted (for degrees of freedom) R^2 measure of fit and DW is the Durbin-Watson statistic.
The "i" index in V6Rij and V8Rij indicates that government program variables are specific to each region (i=1,2,3,4,5).
Numbers in parenthesis are (the absolute values of) the ratio of the estimated coefficient to its standard error.

Table 3. Estimated Spring and Durum Wheat Acreage Relationships

Acreage Relationship	Parameter Estimates												
	Intercept	P02	P03	P05	P06	P07	PF00	WJ0i	V6Rij	V7Rij	V8Rij	$\bar{R}^2$	DW	F
R13	41 (1.16)		8.64 (.63)			25 (.93)	-1.92 (1.19)	1.14 (1.65)	-.53 (1.01)	.10 (.14)	-.32 (1.69)	.18	3.13	1.43
R23	12,290 (2.52)		270 (.22)			314 (.14)	74 (.59)	-98 (1.61)	-71 (1.36)	32 (.46)	47 (2.47)	.78	2.31	7.99
R33	1,410 (.89)		444 (1.75)			231 (.52)	-20 (.88)	-9.51 (.55)	1.29 (.21)	-2.33 (.32)	.81 (.32)	.42	2.29	2.43
R43	38 (2,87)		1.18 (.39)	-.98 (.16)			.06 (.31)	-.24 (1.79)	-.16 (1.49)	-.03 (.36)	-.87 (2.66)	.71	2.11	5.89
R22	4,156 (1.69)	2.67 (.80)			-2.77 (.13)		15 (.34)	-30 (.97)	-8.60 (.48)	-22 (.39)	2.91 (.39)	.71	2.17	5.88

Notes: All relationships estimated by least squares for the period 1962-1976.
Acres planted measured in thousands of acres.
All crop prices are lagged (one season), season average price.
$\bar{R}^2$ is the adjusted (for degrees of freedom) R^2 measure of fit and DW is the Durbin-Watson statistic.
The "i" index in V6Rij, V7Rij and V8Rij indicates that government program variables are specific to each region (i=1,2,3,4).
Numbers in parentheses are (the absolute value of) the ratio of the estimated coefficient to its standard error.

specified for some wheat types because of the negligible acreages involved. The estimated relationships display a satisfactory statistical fit with the exception of spring wheat in Regions I and III. However, these two regions account for less than 2 percent of all wheat grown and therefore have little effect on the overall conclusions drawn below. While the ratios of the coefficients to their standard errors tend to be low, the model was deemed acceptable on the basis of the consistency of the signs of the estimated parameters with a priori expectations. The short time series combined with the number of effects to be estimated may account for the relative inefficiency of the estimates.

The estimated elasticities of acreage planted with respect to the own-price of wheat, other crops, fertilizer and government program benefits are presented in table 4. The remainder of the discussion will be directed toward the price and benefit response elasticities.

When voluntary wheat programs are in effect, producers are faced with allocating available acreage to wheat or to diversion based on the relative value of program participation (as measured by program benefits) and expectations of the market value of wheat. Higher market prices (expectations), under conditions of an upward sloping marginal cost curve, would encourage wheat plantings and a positive elasticity of acreage response would be expected. Conversely, the effect of positive program benefits is to increase the value of land diverted and increase the value of the entire base acreage. Thus government program benefits are generally assumed to reduce acreage, other factors constant.

The nine estimated acreage response relationships all exhibit positive (lagged) market price elasticities. The government program benefit elasticities are for the most part negative, although the values vary be region, wheat crop and program. The market price effect, in terms of the estimated

Table 4. Elasticities of Acreage Planted with Respect to Wheat, Other Crop and Fertilizer Prices and Government Program Benefits

Acreage Relationship	Elasticity of Acres Planted with Respect to									
	Wheat Price			Other Crop Prices			Fertilizer Price	Government Program Benefits		
	P01	P02	P03	P05	P06	P07	PF00	V6Rij	V7Rij	V8Rij
R11	.179					.491	-.816	-.024	-.020	.002
R21	.112				1.093		-.981	.001	-.016	-.011
R31	.030			.082			.241	-.007	-.032	.016
R41	.426			-.256			-.129	-.064	0	-.066
R51	.267			-.678			.634	-.156	-.042	.006
R13		.349				.692	-2.01	-.096	.006	-.101
R23		.063				.051	.446	-.071	.010	.087
R33		1.380				.500	-1.611	.029	-.019	.030
R43		.159		-.095			.209	-.142	-.011	-1.121
R22			.253		-.088		.304	-.032	-.026	.019

Notes: Elasticities estimated at the mean of data, 1962-1976.
V6Rij = Voluntary diversion program benefits for region i and crop j.
V7Rij = Support and mandatory diversion program benefits for region i and crop j.
V8Rij = Domestic and export certificate program benefits for region i and crop j.

elasticities, is considerably larger than any of the program benefit effects which demonstrates how costly voluntary diversion programs are to the government. For example, to induce a 10 percent reduction in planted acreage of winter wheat in Region I a fourfold increase in the voluntary program payment rate (V6) would be required, other factors constant.

By weighting the individual elasticities by the corresponding proportion of total production, aggregate own-price elasticities of wheat acreage can be derived and compared to estimates from other models. The estimates of winter, all spring and all wheat own-price elasticities, .20, .18, and .20, respectively, are considerably lower than those reported by Morzuch et al. (.45, .77 and .52, respectively). Allowing for separate program effects results in lower estimates of the own-price elasticities of acreage. The results suggest that acreage response in general is low and that the market price effects are much larger than the program effects. Furthermore, the program effects are not uniform across all regions so that the use of a single benefit rate, in the presence of regional productivity differences, increases the cost of diverting a given amount of acreage or meeting a given target for reduced production. Offering regionally differentiated benefits may greatly reduce the cost of supply control but also may be politically infeasible.

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