REGIONAL ACREAGE RESPONSE FOR U.S. CORN AND WHEAT: THE EFFECTS OF GOVERNMENT PROGRAMS

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Abstract

This paper presents findings from an analytical scheme that offers a promising alternative to traditional procedures of modeling acreage response. The scheme addresses the two-step decision process in which program and nonprogram planting decisions are modeled separately, conditional on the decision to participate. This provides a more realistic and intuitive portrayal of producers' decision making process. The model is applied at the regional level to assess the impact of farm programs on acreage response for corn in the Cornbelt and Lake States, and for wheat in the Northern Plains. The impacts of policy variable changes on participation and planted acreage are also analyzed.

Key words: acreage response, government programs, program participation

Structural changes in agriculture have often reflected the impact of farm programs that influence acreage of both controlled and uncontrolled commodities as well as the location of production. As a result, integration of farm programs in supply response models has received considerable attention in recent years. The most important tools that the government has employed to steer the direction of agricultural production have been nonrecourse loans, direct payments, deficiency payments, acreage allotments, and land retirement programs. The success of land retirement programs requires that producers be compensated for foregone production in order to elicit participation. A farmer considering the participation decision must weigh program benefits resulting from nonrecourse loans and deficiency payments against program costs resulting from set-aside requirements. Given the operational complexity of commodity programs, the participation decision requires careful individual analysis.

Much literature exists that has examined the impact of farm programs on the supply of agricultural products (Houck and Subotnik; Houck and Ryan; Lidman and Bawden; Garst and Miller; Gallagher; Morzuch et al.; Bailey and Womack; de Gorter and Paddock; Lee and Helmberger; McIntosh and Shideed). In the development of policy variables, the basic methodology adopted by most studies is the one developed by Houck and Subotnik, who collapsed the price support rate with the program acreage restriction requirements into one composite explanatory variable called "effective support price." Even though Gallagher retains the basic Houck-Subotnik formulation, he notes that this specification does not allow for producers' responses to market prices. By assuming weak and strong market conditions, Gallagher developed a composite expected producer incentive price variable that incorporated both lagged farm price and current support price. The reasoning behind this formulation is that when market conditions are weak, the expected producer price collapses to the support level. It is higher than the support price when market conditions are strong. The weakness of Gallagher's formulation is that the expected producer incentive price will always remain above support price, except when target and lagged farm prices are equal. This discrepancy is very important to recognize, especially in recent years when market prices have consistently remained below support level. In addition, this method results in nonlinear relationships among observable variables, creating estimation problems.

Other approaches dealing with farm programs in supply response analysis include one by Morzuch et al., who disaggregated the time series into years with similar programs and then performed separate regressions. Lee and Helmberger also divided the period 1948-1980 into a 'farm program regime' and a 'free market regime' and performed separate regressions. The problem with this procedure is that it is expensive in terms of degrees of freedom. Rausser and Just also point out that given that some policy instruments are used for a very short period of time, the information gained through historical observations of their impact may be limited.

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Recent developments in supply response analysis suggest that much of the work in previous studies has failed to develop a consistent analytical framework that distinguishes the factors affecting producers' decisions to participate from the factors affecting their planting decisions. Participants' and nonparticipants' planting decisions have been modeled in a single equation. In the presence of farm programs, this approach is less preferred because it fails to recognize the two-step decision making process by producers and imposes questionable restrictions on the effects of policy variable changes on aggregate plantings (de Gorter and Paddock). For instance, the effective support price approach by Houck and Subotnik assumes that an increase in support price will almost always increase aggregate planted acreage. de Gorter and Paddock contended that this analysis ignores the potential offsetting effects of program participants' and nonparticipants' planted acreage. Higher support prices could actually reduce aggregate plantings as increased program participation results in more acreage being idled in land diversion programs. A more effective method of modeling supply analysis in the presence of government programs is to estimate producers' program participation responses first and then relate this to program planted acreage. Nonprogram acreage response is estimated separately, and this should be inversely related to program participants' responses.

de Gorter and Paddock conceived a scheme that accounts for both program participation and planting decisions. The key element in this approach is to distinguish the discrete choice of whether or not to comply with government programs and to show that this is interrelated with the continuous choice of how many acres to plant. Subotnik argued that the estimation of the discrete and continuous decision model proposed by de Gorter and Paddock requires single farm observations and cannot be estimated successfully given the aggregate annual data published by the U.S. Department of Agriculture. He instead suggested a methodology in which the decision to participate in the program, as measured by the amount of acreage enrolled in the program, is estimated independently from the planting decisions within and outside the program. Thus, program and nonprogram planting decisions are estimated separately, conditional on the decision to participate.

The objective of this paper is to provide empirical estimates from the analytical procedure proposed by Subotnik. This procedure was applied at the regional level to assess the impact of farm programs on acreage response for corn in the Cornbelt and Lake States and wheat in the Northern Plains. Three policy scenarios were analyzed for 1989 to assess the model's aptness for policy analysis. The policy changes evaluated are a 10 percent decrease in target price; introduction of a 10 percent paid land diversion at \$1.10 per bushel; and introduction of a 25 percent voluntary land diversion at \$2.00 per bushel. The effects of changes in farmers' price expectations were also investigated. The two diversion options were chosen because such provisions did not exist in 1989. The evaluation of a reduction in target price and of an increase in expected market price was motivated by the fact that the program provisions of the 1990 Farm Bill provide a greater latitude for free market production than did the provisions of the 1985 Farm Bill.

CONCEPTUAL FRAMEWORK

Consider the case of corn production where a producer may elect to plant corn within or outside the program. Under the program the producer idles land and abides by a corn acreage limitation (base acreage) in return for a deficiency payment and diversion payment when available. The deficiency payment rate per bushel equals target price, known in advance, minus expected average market price. Deficiency payments are made on program yields rather than actual market yields. The program yields are established by Agricultural Stabilization and Conservation Service (ASCS) county committees. The diversion payment equals a payment rate per bushel, also known in advance, times established program yield, times a specified proportion of base acreage diverted under paid land diversion. An additional voluntary diversion option exists in some years for which a farmer is compensated to elicit participation. A minimum set-aside and/or acreage reduction program (ARP) also exists in some years for which no remuneration is paid. The set-aside or ARP, when in effect, equals a percentage of the base acreage, the latter reflecting historical acreage allocation.

The starting point is a single profit maximizing farmer faced with the joint decisions of whether or not to participate in the program and the level of production. A farmer considering the participation decision evaluates the expected profit functions inside and outside the program, and chooses to produce under conditions with the highest profit value. The participating farmer is assumed to maximize expected profit π_p in equation (1) subject to constraints in equations (2) and (3). In equation (2), acres planted in the program (A_p) plus those idled under voluntary diversion (A_v) must not exceed the maximum amount of acreage (permitted acreage) that can be planted ($A_b(1-\theta_1-\theta_2)$) after the minimum requirements for program benefits are met. Equation (3) asserts that acreage diverted under voluntary diversion may not exceed the maximum allowed under the provision.

(1) $\pi_p = P_p Y_m A_p + P_v Y_p A_v - C(A_p, P_i)$,

(2) $A_b(1 - \theta_1 - \theta_2 \geq A_p + A_v$, and

(3) $\theta_3 A_b \geq A_v$,

where P_p is the program production inducing price, P_v is the voluntary diversion payment, P_i is a vector of input prices, Y_m is expected market yield (exogenous trend yield), Y_p is program yield, A_b is base acreage, θ_1, θ_2 and θ_3 are minimum required set-aside or ARP, diversion and voluntary diversion rates, respectively, and $C(A_p,P_i)$ is a variable cost function. The program production inducing price is the sum of expected average market price (the higher of the loan rate and lagged average market price) and deficiency payment rate (or direct payments per bushel for years prior to 1974) when available. Because the deficiency payment was based on program yield rather than market yield, it was redefined in terms of market yield by weighting the payment rate per bushel by the ratio of program yield to market yield.

There are no competing crops for a participant because program provisions do not allow planting of other crops on the same base.[1] However, within limits, voluntary diversion may be regarded as an activity competing with the program crop for available land. As it becomes more lucrative to be paid for idling more acreage, less is planted to the program crop. Given equations (1) to (3), the Lagrangean for profit maximization is given by equation (4) as follows:

$$(4)\ L(A_p,A_v,\lambda,\psi) = P_p Y_m A_p + P_v Y_p A_v - C(A_p,P_i) + \lambda(A_b(1-\theta_1-\theta_2) - A_v - A_p) + \psi(\theta_3 A_b - A_v).$$

The Kuhn-Tucker conditions are necessary and sufficient for optimal solutions.

$$(5)\ \frac{\partial L}{\partial A_p} = P_p Y_m - MC(A_p,P_i) - \lambda \leq 0,$$

$$(6)\ \frac{\partial L}{\partial A_v} = P_v Y_p - \lambda - \psi \leq 0,$$

$$(7)\ \frac{\partial L}{\partial \lambda} = A_b(1 - \theta_1 - \theta_2) - A_v - A_p \geq 0,$$

$$(8)\ \frac{\partial L}{\partial \psi} = \theta_3 A_b - A_v \geq 0.$$

where $MC(A_p,P_i)$ is a marginal cost function for corn and λ and ψ are Lagrangean multipliers. The Kuhn-Tucker conditions suggest that there can only be four possible solutions for planted and diverted acreage. These are obtained under four assumptions regarding the two constraints: (i) both constraints are binding; (ii) only the voluntary diversion constraint is binding; (iii) only the acreage constraint (minimum requirements for program benefits) is binding; and (iv) neither constraint is binding. Assuming yield is constant and independent of planted acreage, the optimal solutions are, respectively, given in equations (9) to (12):

(9a) $A_p = (1-\theta_1-\theta_2-\theta_3)A_b$,

(9b) $A_v = \theta_3 A_b$,

(10a) $A_p = f(P_p,P_i)$,

(10b) $A_v = \theta_3 A_b$,

(11a) $A_p = g((P_p-P_v),P_i)$,

(11b) $A_v = A_b(1-\theta_1-\theta_2) - g((P_p-P_v),P_i)$,

(12a) $A_p = A_b$, and

(12b) $A_v = 0$.

Under the first assumption, equations (5) to (8) become the ordinary first-order conditions which means that $A_v = \theta_3 A_b$, implying that the maximum amount of acreage permissible under voluntary diversion is idled. Acreage planted in the program is $(1-\theta_1-\theta_2-\theta_3)A_b$.

The assumption that only voluntary diversion is constraining implies that $\lambda = 0$, $\theta_3 A_b = A_v$, $(A_b(1-\theta_1-\theta_2) - A_v) > A_p$ and $P_p Y_m \leq MC(A_p,P_i)$. All the acreage allowed under voluntary diversion is idled. However, as long as marginal revenue is strictly less than the marginal costs, $A_p = 0$. Under the 1985 Farm Bill, the farmer has the option of enrolling in the 0/92 reduced planting option to protect his base. The 0/92 provision benefits crop producers in years when the risk of negative market returns from crop production is perceived to be substantial (Thompson, Knight and Boren). As marginal revenue increases and exceeds marginal costs, $A_p > 0$. Figure 1 illustrates the point more clearly. For ease of exposition only, it is assumed there are no costs associated with diversion. The relevant segment of operation on the kinked budget line, $\theta_3 A_b B A_b(1-\theta_1-\theta_2)$, given the voluntary diversion constraint, is $\theta_3 A_b B$. At any point along this segment, $\theta_3 A_b$ acres are diverted and the

[1] Under the 1990 Farm Bill, competing crops are permitted under the triple base option (on normal and optional flex acreage). Also in the early 1970s some competition between crops was permitted providing the farmer idled an amount of land corresponding to the plantings and set-aside rate of each chosen crop.

planting decision is based on the principle that 'marginal cost equals marginal revenue'. Some slack of acres may remain. At point B, θ_3A_b and $(1-\theta_1-\theta_2-\theta_3)A_b$ acres are diverted and planted, respectively. This also is the optimal point when both constraints are binding. At this point, an increase in either P_v or P_p will have no effect on participants' acreage allocation decisions because there are no more acres to draw upon. However, the increase in these incentives may attract additional farmers into the program.

Assuming that only the acreage constraint (minimum required diversion and set-aside or ARP) is binding, then $\psi = 0$, $A_v = (A_b(1-\theta_1-\theta_2) - A_p) < \theta_3A_b$ and $(P_p - P_v) = MC(A_p,P_i) > 0$. The optimal solution is determined by equating the difference between the program production inducing price and voluntary diversion payments per bushel to marginal costs. Voluntary diversion acreage has no unique solution and is obtained as a residual because the voluntary diversion option is not binding. Changes in P_p and P_v will have the same but opposite sign effects on A_p. As voluntary diversion payments increase, program planted acreage declines by the same amount that diverted acreage is increased. In terms of Figure 1, the optimal level of operation will lie along the budget line $A_b(1-\theta_1-\theta_2)BA_b(1-\theta_1-\theta_2)$. When there is no more diverted acreage to draw upon, we have a corner solution. Program planted acreage will be equal to the maximum that can be planted (permitted acreage) after minimum requirements for program benefits are met, $(1-\theta_1-\theta_2)A_b$, on the horizontal axis.

The assumption that neither constraint is binding results in a solution similar to equation (10a), but acreage diverted is obtained as a residual. However, as incentives become more lucrative, the farmer's will to expand production will be limited by the available base acreage. When the entire base is exhausted, an increase in price will have no effect on the farmer's planting decision as long as he remains a program participant. Program planted acreage will be equal to base acreage, and no acreage will be diverted.

The derivation of response functions in equations (9) to (12) may also be understood intuitively with the help of Figure 2 which indicates the level of program planted acreage at every level of program production inducing price. At any price $P_p < P_0$, the maximum amount of acreage permitted under the voluntary diversion option is diverted, but no production takes place because the price is less than marginal cost. As alluded to earlier, the farmer may enroll in the 0/92 reduced planting provision to protect his base. In the price interval $P_0 \le P_p \le P_1$, the farmer diverts θ_3A_b in response to the voluntary diversion constraint. The planting decision is based on the principle of marginal cost (MC) equals marginal revenue (MR). At any price, $P_1 \le P_p \le P_2$, the farmer continues to idle θ_3A_b and plants $(1-\theta_1-\theta_2-\theta_3)A_b$. P_p and P_v have no effect on a participant's acreage decisions because both constraints are now binding.

As price exceeds P_2 and approaches P_3, only the acreage constraint is binding. The level of production is determined according to MC=MR. The marginal revenue in this price segment is the difference between program price and voluntary diversion payment. In the price range $P_3 \le P_p \le P_4$, price, once again, is rendered impotent as acreage becomes a constraint. All the permitted acreage $((1-\theta_1-\theta_2)A_b)$ is planted, and none is placed under voluntary diversion.

The case of neither constraint binding exists in the price range $P_4 \le P_p \le P_5$, although the farmer must still abide by his available base allocation. As long as not all the base is exhausted, planted acreage is determined according to the MC=MR principle. As price exceeds P_5, the entire base is planted and no acres are diverted under any diversion option. Once again, price ceases to have any impact on the farmer's acreage allocation decisions as long as he remains a program participant. The curve connecting points P_0VWXYZ may be thought of as a locus of points tracing the supply function for program planted acreage.

Modeling of nonprogram acreage response is straight-forward given that nonparticipants are not constrained by program requirements. The farmer has a lot of flexibility regarding the use of his available land. This implies that a rational producer will continue to expand production until the marginal cost of a particular crop is equal to its marginal revenue.

Defining π^*_p and π^*_m as the expected indirect profit functions associated with program participation and lack of it, respectively, then a farmer will join the program if $\pi^*_p \ge \pi^*_m$ and will remain outside the program if $\pi^*_p < \pi^*_m$. The factors affecting the two profit functions will also affect the decision to participate. The effects of the arguments in the participation decision function will depend upon their effects on participants' and nonparticipants' profit functions. This analysis assumes the farmer is risk-neutral, or alternatively, that the two technologies embody the same degree of risk. Consideration of risk attitudes and other factors like the need to build a crop base on farms with little or no base could change the participation decision.

EMPIRICAL SPECIFICATION

Empirical specification of the estimating equations descends directly from the discussion presented in the preceding section. Acreage enrolled in the program (A_q) was used as a proxy for the participation decision, and was estimated as a function of program production inducing price, own market price, prices of competing crops, diversion payments, and base acreage. The competing crops were soybeans and wheat for corn in the Cornbelt and Lake States, and corn and sorghum for wheat in the Northern Plains. The planting decision within the program was dependent on the program production-inducing price, payments for voluntary diversion, and the planting constraints discussed in the preceding section. Nonprogram acreage response (A_m) was estimated as a function of own market price and prices of competing crops. Both participants' and nonparticipants' planting decisions were estimated conditional on the decision to participate (A_q). The information for deciding whether or not to participate is embedded in A_q. Thus, conditions that induce some farmers to participate influence others not to participate.

To account for the different policy regimes depicted in Figure 2, a method had to be devised with the help of dummy variables (S1, S2, S3, and S4) without excessive loss of degrees of freedom. The introduction of dummy variables facilitated the estimation of acreage response functions in equations (9) to (12) as a single equation. The outcome is much the same as that in a switching regression model.[2] The model was specified as follows:

(13) $A_q = S1*(\alpha_0 + \alpha_1 P_p + \alpha_2 P_m + \alpha_3 P_s + \alpha_4 P_d) + \alpha_5(S2*A_b) + \varepsilon_1,$

(14) $A_p = S3*[\beta_1(P_p - P_v) + \beta_2 A_q + \beta_3 R_t] + \beta_4[S4*(1-R_t)A_q] + \beta_5(S2*A_b) + \varepsilon_2,$ and

(15) $A_m = \gamma_0 + \gamma_1 P_m + \gamma_2 P_s + \gamma_3 A_q + \varepsilon_3,$

$0 < \beta_2, \beta_4 \leq 1, \ [\alpha_5, \beta_5] = 1, \ -1 \leq \gamma_3 < 0,$

where S1 is zero if neither constraint is binding and one otherwise, S2 is the opposite of S1, S3 is zero if neither or only the acreage constraint is binding and one otherwise, S4 is one if both constraints are binding and zero otherwise, α_i, β_i and γ_i are the parameters to be estimated, $R_t = (\theta_1+\theta_2+\theta_3)$ is the sum of minimum required set-aside (or ARP), diversion and voluntary diversion rates, and ε_i is the error term. All the other variables are as previously defined. No intercept was allowed for in equations (13) and (14) for years in which neither constraint was binding. The reason was that during those years, total acreage enrolled in the program was assumed to be equal to base acreage which was also equal to acreage planted in the program.

DATA AND EMPIRICAL RESULTS

The model was estimated using annual data for 24 years, 1966 to 1989. The data were obtained from fact sheets and publications by the USDA. Program variables and other related variables on a state-by-state basis were obtained from various statistical summary publications for wheat and feed grains.

The market prices used in the analysis were the regional market-year average prices received. The regional averages were developed by using share of regional production to weight state average prices. The diversion payment variable (P_d) was defined as a nonlinear function of payments on minimum required diversion and voluntary diversion payments (Chembezi; Chembezi and Womack; Subotnik). Producers were assumed to have naive price expectations. Under these conditions, expected market price for participants was the higher of the lagged farm price and the loan rate. For nonparticipants, it was merely lagged farm price. Even though the assumption of naive expectations may be a little unrealistic, previous research did not reach a consensus as to the most plausible form of price expectations to use. Even the performance of alternative forms of price expectations in previous studies provided conflicting evidence (Shideed and White; Chavas et al.; Gardner; Turnovsky). All price variables were deflated to 1980 dollars using the producer price index.

The equations in the model are recursive in nature. The application of the ordinary least squares estimator provides estimates that are unbiased and efficient. The basic assumption underpinning the method of least squares, however, is one of spherical error terms. It involves the double assumption that the error variance is constant at each observation point and that the error covariances at all possible pairs of observation points are zero (Johnston). The assumption of constant or homogeneous variance is likely to have been violated in this analysis, especially for years when both constraints (equations (2) and (3)) are said to be binding. In these years, the error term

[2] Under the assumption that both constraints are binding, the relevant response functions are as follows: $A_q = f(P_p, P_m, P_s, P_d)$ and $A_p = (1-R_t)A_q$. When either one of the constraints is binding (but not both), $A_p = g(P_p, P_v, R_t, A_q)$. A_q remains the same as in the first case. With neither constraint binding, $A_q = A_p = A_b$. Thus, program planted acreage equals the entire base when no mandatory or additional voluntary diversion requirements are in effect (1974-1977, 1980-1981). The nonprogram acreage equation remains the same in all cases.

Table 1. Acreage Response Equations for Corn and Wheat, 1966-1989[a]

Corn Model - Cornbelt and Lake States

1.1 $$A_q = 707.093\,(S1*P_p) - 751.097\,(S1*P_c) - 264.991\,(S1*P_s) + 307.536\,(S1*P_d) + 1.000\,(S2*A_b) + 46.812\,S1$$
(1.930) (-2.290) (-2.770) (4.000) (18.670) (7.000)

Adj. $R^2 = 0.973$ D-W = 1.965 RMSE = 5.305

1.2 $$A_p = 149.901\,(S3*(P_p - P_v)) + 0.806\,(S3*A_q) - 15.751\,(S3*R_t) + 0.998\,(S4*(1 - R_t)A_q) + 1.000\,(S2*A_b)$$
(5.930) (37.850) (-8.650) (70.310) (87.850)

Adj. $R^2 = 0.987$ D-W = 1.843 RMSE = 1.218

1.3 $$A_m = 56.778 + 136.665\,P_c - 60.335\,P_s - 105.976\,P_w - 0.948\,A_q$$
(19.980) (1.880) (-1.910) (-1.780) (-19.640)

Adj. $R^2 = 0.939$ D-W = 1.974 RMSE =2.501

Wheat Model - Northern Plains

1.4 $$A_q = 292.240\,(S1*P_p) - 273.192\,(S1*P_w) - 234.801\,(S1*P_c) + 16.745\,(S1*P_d) + 1.000\,(S2*A_b) + 36.411\,S1$$
(3.020) (-2.930) (-2.440) (2.540) (30.790) (10.560)

Adj. $R^2 = 0.981$ D-W = 1.721 RMSE =2.878

1.5 $$A_p = 203.329\,(S3*(P_p - P_v)) + 0.634\,(S3*A_q) - 18.113\,(S3*R_t) + 1.000\,(S2*A_b) + 0.995\,S4*(1 - R_t)A_q)$$
(3.590) (13.000) (-2.430) (33.080) (24.390)

Adj. $R^2 = 0.963$ D-W = 1.875 RMSE =2.726

1.6 $$A_m = 22.657 + 142.183\,P_w - 157.502\,P_c - 161.371\,P_g - 0.411\,A_q + 8.623\,S5$$
(3.840) (1.830) (-1.907) (-1.920) (-3.210) (5.790)

Adj. $R^2 = 0.869$ D-W = 1.683 RMSE =2.693

VARIABLE DEFINITIONS

A_b = Base Acreage
A_m =Nonprogram acreage
A_p = Program planted acreage.
A_q = Total acreage enrolled in the program.
P_c = Corn expected market price.
P_d = All diversion payments
P_g = Sorghum expected market price.
P_p = Program production-inducing price.
P_s = Soybeans expected market price.
P_v = Voluntary diversion payments.
P_w = Wheat expected market price.
R_t = Sum of ARP, diversion and voluntary diversion rates.
S1 = Dummy variable, 0 if 1974-77or 1980-81; 1 if otherwise.
S2 = Dummy variable, 1 if 1974-77 or 1980-81; 0 if otherwise.
S3 = Dummy variable, 0 if neither or only acreage constraint is binding; 1 if otherwise.
S4 = Dummy variable, 1 if both constraints are binding; 0 otherwise.
S5 = Dummy variable, 1 if 1982-85; 0 if otherwise.

[a]Numbers in parentheses are asymptotic values of t-stastics. All parameter estimates are stastically significant at the 10 percent level or better.

is zero because acreage planted in the program is simply total base minus idled acreage. To account for the possibility of such a violation, the generalized least squares (GLS) estimator was applied in the estimation of the model. The GLS estimator provides estimates which are asymptotically more efficient than ordinary least squares by using the information contained in the covariance matrix to improve the estimates. The parameter estimates are presented in Table 1. The values in parentheses are the asymptotic t-statistics. Root-mean square error (RMSE), Durbin-Watson, and adjusted R-square statistics are also provided for each equation. The estimates indicate that the model has good explanatory power. The parameter estimates are all significant at the 10 percent level or better. The Durbin-Watson statistics reveal no sign of first order serial correlation.

As expected, farm programs showed strong influence on plantings within and outside the program. For nonparticipants, there must be a one-to-one correspondence between program and nonprogram acreage. An acre enrolled in the program must reflect a one-acre decrease in nonprogram acreage. The parameter estimates with respect to program acreage were -0.946 for corn and -0.411 for wheat. The estimate for corn was in the neighborhood of the ideal estimate of -1.0. However, the estimate for wheat showed a substantial amount of slippage present because an acre enrolled in the program reduced nonprogram plantings by only about 0.411 acres. One of the reasons the substitution may not be acre-for-acre is that nonparticipants may choose to plant other crops or to idle land that cannot be used to grow the program crop profitably at the market price. Besides, idled land is sometimes marginal land which would not be planted even if there were no incentives for diversion.

Because program planted acreage is a substantial part of total acreage enrolled in the program (A_q), the significance of A_q in the program planted acreage equations was less surprising. The parameter estimates with respect to A_q in equations 1.2 and 1.5 were 0.806 and 0.634, respectively. These estimates suggest that for every acre enrolled in the program, only about 81 percent for corn and 63 percent for wheat was planted because about 19 percent and 37 percent, respectively, of the same unit acre was idled to meet the various land retirement programs. These rates compare well with those actually observed over the historical period. Equations 1.2 and 1.5 in Table 1 also support the assertion that in those years in which both constraints were binding, program planted acreage may be approximated merely by base acreage less set-aside and/or diversion requirements ($(1-R_t)A_q$). The estimates with respect to $(1-R_t)A_q$, a proxy for maximum permitted plantings, were 0.998 for corn and 0.995 for wheat. In equations 1.1, 1.2, 1.4, and 1.5 of Table 1, the estimates with respect to base acreage were all equal to unity, as expected, supporting the contention that for years in which acreage reduction programs were nonexistent, program planted acreage was equal to total acreage enrolled in the program which was also equal to base acreage.

Elasticity Estimates

The estimates presented here are total elasticities reflecting the direct price effects and also indirect or expansion effects from increased participation. Equations (16) and (17) show how elasticity estimates for program and nonprogram acreage with respect to program and expected market prices, respectively, were derived; and provide an indication of how the rest of the estimates were calculated. The total effect on program (nonprogram) acreage of a change in program production-inducing (expected market) price for corn is split into two effects. A direct or substitution effect represented by the first term in the square bracket, and an expansion effect shown by the second term. In other words, a change in the program (market) price for corn induces a change in output price ratios which entails technical substitution among the outputs. Secondly, it causes changes in the decision to participate along a new expansion path associated with output prices, which yield the subsequent changes in the level of plantings.

$$(16)\quad \xi_{A_p \cdot P_p} = \left[\frac{\partial A_p}{\partial P_p} + \frac{\partial A_p}{\partial A_q}\frac{\partial A_q}{\partial P_p}\right]\frac{P_p}{A_p},$$

$$(17)\quad \xi_{A_m \cdot P_c} = \left[\frac{\partial A_m}{\partial P_c} + \frac{\partial A_m}{\partial A_q}\frac{\partial A_q}{\partial P_c}\right]\frac{P_c}{A_m},$$

where $\xi_{Ap.Pp}$ and $\xi_{Am.Pc}$ are program and nonprogram planted acreage elasticities with respect to program price and market price, respectively. All the estimates are presented in Table 2. Nonprogram acreage elasticities were generally larger than those of program planted acreage, reflecting the restrictions program provisions impose on planting decisions within the program. This is also explained in terms of substitution between program and nonprogram acreage given a change in market or program price. Thus, for every acre enrolled in the program, less than an acre was planted. The elasticity of nonprogram acreage for corn with respect to price of soybeans was positive because the expansion effects due to increased program participation dominated the direct price effects. This result seems counter-intuitive at first. However, it must be realized that as the price of soybeans increased, the relative profits of being in and out of the program were both reduced. The relative profits affected the most will affect the numerical outcome. These results suggest that program profits are affected the most, causing the profits obtained outside the program to be relatively higher. In his national model for corn, Subotnik observed a similar relationship between nonprogram acreage for corn and soybean price.

The program production-inducing price elasticity of program planted acreage was larger than that of total program acreage for both crops. This is due to the fact that the former reflects the effects of two factors, each of which had a positive influence. First, there were the direct effects of the production-inducing price. Second, there were the indirect effects of increased program participation. Both of these factors affect program planted acreage positively. The elasticity of total program acreage, on the other hand, reflected only the positive effects of the program production-inducing price.

The elasticity of total planted acreage with respect to program production- inducing price was negative for corn and positive for wheat, suggesting that policy instruments have been effective for corn but ineffective for wheat in reducing plantings. These

Table 2. Estimates of Acreage Elasticities for Corn and Wheat[a]

Model\Acreage Type	Program Price	Corn Price	Wheat Price	Bean Price	Sorghum Price	Diversion Payments Minimum	Diversion Payments Maximum
CORN MODEL:							
Total Program Acres	0.683	-0.646	-	-0.570	-	0.018	0.182
Program Planted Acres	0.741	-0.630	-	-0.556	-	0.063	-0.060
Nonprogram Acres	-1.311	1.414	-0.226	0.076	-	-0.114	-0.334
Total Planted Acres	-0.049	0.156	-0.087	-0.070	-	-0.005	-0.092
WHEAT MODEL:							
Total Program Acres	0.414	-0.220	-0.319	-	-	0.056	0.131
Program Planted Acres	0.461	-0.155	-0.234	-	-	0.041	-0.104
Nonprogram Acres	-1.383	-0.263	1.520	-	-0.639	-0.188	-0.202
Total Planted Acres	0.101	-0.176	0.108	-	-0.125	-0.004	-0.123

[a]All values are evaluated at the mean. The average shares for acreage planted within and outside the program over the estimation period are, respectively, 0.615 and 0.385 for Corn and 0.085 and 0.195 for Wheat.

results confirm de Gorter and Paddock's contention that the effects of program variables like target price on total production may be ambiguous (i.e., cannot be signed *a priori*) because of the offsetting effects between program and nonprogram plantings. For instance, if the positive effects of target price on program planted acreage outweigh its negative effects on nonprogram planted acreage, the net result is a positive effect on total plantings. The sign and magnitude of the net effect depend on the size of the elasticities, relative shares of program and nonprogram planted acreage, and on the size of the acreage reduction program.

The elasticity of total planted acreage with respect to voluntary diversion payments for both crops was negative, as expected, suggesting that these payments have been effective in reducing corn and wheat plantings over the years. Voluntary diversion payments affect both program and nonprogram planted acreage negatively, implying that these payments have a depressing effect on plantings.

Even though the method employed in calculating these elasticity estimates is different from that of most studies, some comparison with previous studies could still be made with some caution. The corn market price elasticity of total planted acreage (0.156) compares favorably with 0.419 to 0.188 by Chembezi and Womack, 0.112 and 0.185 by Gallagher, 0.130 by Houck and Ryan, 0.137 by Shideed, et al., and 0.109 to 0.199 by Shideed and White. The value is, however, smaller than 0.330 and 0.434 by Subotnik, 0.240 by de Gorter and Paddock, and 0.249 by Lee and Helmberger. The elasticity with respect to program production-inducing price for corn is -0.049, and compares with Subotnik's estimate of -0.036 and -0.052 to -0.086 by Chembezi and Womack. Wheat market estimates are also consistent with some of the previous studies. For example, values of 0.124, 0.390, and 0.111 by Bailey and Womack, Hoffman, and Young, respectively, compare with 0.108 in this study, although Hoffman's estimate (0.390) is much larger. The estimate with respect to program production-inducing price of 0.101 is difficult to evaluate but is consistent with the value of 0.073 by Chembezi and Womack. It is cautioned, however, that some of the estimates from previous studies are national rather than regional averages.

Policy Variable Simulations

The impacts of three policy changes on planted acreage for corn and wheat were analyzed to determine the performance and appropriateness of the model for policy analysis (Table 3). Scenario A shows that a 10 percent decrease in 1989 target price reduced total corn and wheat plantings by about 0.31 and 2.16 percent, respectively. The increase in nonprogram acreage failed to compensate for the decrease in program planted acreage. Program acreage, and hence program planted acreage, decreased for both crops as production within the program became less lucrative and therefore less able to induce increased participation. These impact changes compare favorably with elasticity estimates with respect to program price (evaluated at 1989 values) which showed that a 10 percent increase in program price increases corn and wheat plantings by 0.29 percent and 2.42 percent, respectively.

Table 3. Impacts of Policy Changes on Corn and Wheat Acreage[a]

	Corn Model			Wheat Model		
Scenario\Acreage	Baseline	Simulation	Impact	Baseline	Simulation	Impact
SCENARIO A:	(million acres)		(percent)	(million acres)		(percent)
Total Program Acres	38.316	36.233	-5.437	36.470	35.153	-3.611
Program Planted Acres	31.987	29.866	-6.631	27.254	25.719	-5.632
Nonprogram Acres	15.926	17.901	12.403	7.560	8.343	10.357
Total Planted Acres	47.913	47.767	-0.305	34.814	34.062	-2.160
SCENARIO B:						
Total Program Acres	39.316	41.866	9.317	36.470	37.459	2.712
Program Planted Acres	31.987	33.289	4.070	27.254	26.619	-2.363
Nonprogram Acres	15.926	12.542	-21.247	7.560	6.842	-9.497
Total Planted Acres	47.913	45.831	-4.345	34.814	33.452	-3.912
SCENARIO C:						
Total Program Acres	38.316	45.311	18.256	36.470	39.061	7.104
Program Planted Acres	31.987	30.989	-3.214	27.254	26.487	-2.814
Nonprogram Acres	15.926	13.243	-16.847	7.560	6.580	-12.963
Total Planted Acres	47.913	44.202	-7.745	34.814	33.067	-5.018
SCENARIO D:						
Total Program Acres	38.316	36.790	-3.984	36.470	34.408	-2.013
Program Planted Acres	31.987	30.974	-3.167	27.254	26.712	-1.989
Nonprogram Acres	15.926	17.632	10.712	7.560	8.189	8.320
Total Planted Acres	47.913	48.606	1.756	34.814	34.901	0.250

[a]Baseline refers to the model's prediction before it is shocked.
SCENARIO A: Impacts of a 10 percent decrease in 1989 target price.
SCENARIO B: Impacts of introducing a 10 percent paid land diversion at $1.10 per bushel.
SCENARIO C: Impacts of introducing a 25 percent voluntary diversion at $2.00 per bushel.
SCENARIO D: Impact of a 10 percent increase in expected market price.

Note that while the impact of a decrease in target price in 1989 for corn was a reduction in total plantings (Table 3), the elasticity of total planted acreage with respect to program production-inducing price (evaluated at the mean) in Table 2 suggests that an increase in program production-inducing price reduces total plantings also. At first, these results seem contradictory. However, the results simply suggest that while the target price option has been effective, on average, in reducing plantings over the years, the option was not effective in 1989. Because most of the production in the 1980s took place in the program in which target price (deficiency payment) was the supply-inducing price, it is expected that a decrease in deficiency payments should lead to a reduction in program plantings due to a decrease in program participation. Even though this phenomenon, simultaneously, leads to an increase in nonprogram production, the results suggest that the increase in nonprogram plantings was not sufficient to offset the reduction in program plantings, hence the reduction in total plantings for corn. The central issue in this analysis is that when offsetting effects of program and nonprogram planted acreage are taken into account, the direction of change in aggregate plantings associated with a change in a policy variable such as target price is indeterminate (de Gorter and Paddock). The introduction of a 10 percent paid land diversion in 1989 at $1.10 per bushel resulted in a decrease in total plantings for both crops (Scenario B). Corn showed an increase in both program participation and program plantings. This increase, however, was not enough to undo the decrease in nonprogram acreage, causing total planted acreage for corn to decline by about 4.35 percent. Wheat showed an increase in participation but a decrease in both nonprogram and program planted acreage as more land was diverted, leading to a 3.92 percent decline in wheat plantings.

The last policy scenario was the introduction of a 25 percent additional voluntary diversion in 1989 at $2.00 per bushel. Both corn and wheat models (Scenario C) showed a decline in total planted acreage. Program participation went up substantially by about 9.32 percent for corn and 7.10 percent for wheat. Because more acreage was placed under voluntary diversion, program planted acreage shrank. Plantings outside the program also decreased as program provisions became more lucrative, leading to a decrease in total production of about 7.75 percent for corn and 5.02 percent for wheat.

The impact of a change in producers' price expectations was also examined. The results (Scenario D) were consistent with intuition and prior expectations. An increase in expected market price rendered program activities less attractive, causing both program participation and program plantings to decline while nonprogram and total production increased as the decrease in program plantings was overwhelmed by the increase in nonprogram planted acreage.

IMPLICATIONS AND CONCLUDING REMARKS

This study has presented findings from a scheme which offers significant results and valuable insights on producers' acreage response behavior. The scheme is an improvement over traditional approaches that model program and nonprogram planting decisions in a single equation. The traditional approaches are less preferred to a procedure in which program and nonprogram planted acres are modeled conditional on the decision to participate. The approach used in this study provides a more realistic and intuitive portrayal of producers' decision making processes. The policy scenarios analyzed cast some light on the aptness of the scheme for policy analysis.

The results support the following conclusions. First, policy variables play a major role in corn and wheat production decisions, reflecting the strong influence of government programs in the last three decades. The program production inducing price adequately reflects the economic incentives for producers to join farm programs. Other policy options are also important in both program participation and acreage allocation decisions. The parameter estimates with respect to diversion payments were negative for the program planted acreage equations and positive for total program acreage equations, suggesting that diversion payments may be effective in lowering plantings and eliciting program participation. This conclusion is also supported by the policy evaluation results of the two diversion options in Table 3. Our findings suggest that government programs have generally been successful in reducing corn and wheat plantings over the years. This conclusion is suported by the fact that a 10 percent increase in target price (deficiency payment rate) and diversion payments (payments on minimum diversion and voluntary diversion payments) reduced crop plantings by about 1.50 percent for corn and 0.26 percent for wheat.

Second, the question of offsetting effects of program and nonprogram acreage has been explored. Evaluated at the mean, the econometric results (Table 2) indicate that deficiency payments (or target price), as reflected by the program production-inducing price, have been effective for corn but ineffective for wheat in reducing aggregate plantings. The results of impact evaluations in Table 3 (Scenario A) suggest that target price in 1989 for both crops was ineffective since a decrease (increase) in target price reduced (increased) total production. These results are less surprising bearing in mind that over three-fourths of corn and wheat production in recent years has taken place within the program. On average, 62 percent of corn plantings in the Cornbelt and Lake States and 80 percent of wheat in the Northern Plains was in the program over the sample period (Table 2). In 1989 the share for corn rose to about 78 percent while that of wheat dropped slightly to about 76 percent. Given these figures and also the fact that target price is the supply-inducing price in the program, it makes sense to see positive effects of target price on program plantings overwhelm its negative effects on nonprogram plantings, resulting in an increase in total plantings. The implication of this is that target price would seem to have become more a means of supporting farm incomes than of controlling supply. An effective way of achieving both these goals concurrently, as has been the case over the years, would be through the implementation of target price policy along with paid land diversion options. As alluded to earlier, our results demonstrate that a proportionate increase in all policy prices results in a decrease in plantings for both corn and wheat.

Third, estimation of program and nonprogram planted acreage separately, conditional on the decision to participate, seems a useful construct in modeling program participation and planting decisions in the presence of farm programs. This also helps to identify response differentials between program and nonprogram planted acreage to changes in market or policy variables. The estimates in Table 2 suggest that nonprogram acreage is more responsive to changes in price signals than is program planted acreage, reflecting the restrictions and/or lack of flexibility programs impose on participants' planting decisions.

Fourth, this study has attempted to deal with farm programs in supply response for corn and wheat. The analysis is equally applicable to other program crops. So far, the analysis has concentrated on previous programs up to and including the 1985 Farm Bill. However, as we enter the 1990s, the real question centers around the effect of the 1990 Farm Bill on the overall specification of this model. Clearly, the 1990 Farm Bill exhibits some departure from previous legislations. For instance, the new legislation advocates a lower government support and freezes minimum target price on program crops at 1990 levels for five years. Even though the ARP of the 1985 Farm Bill still exists, there are no paid land diversion options (minimum required and voluntary diversion options). Instead, normal and optional flexible acreage options are included. On this acreage, the farmer has freedom to make his own production decisions without losing his crop acreage base. The farmer, however, loses deficiency payments on flexible acreage. Will these elements have any effect on the specification? Given lack of data for the post 1990 era, it is very difficult to answer this question empirically. However, it seems clear that the technical aspects just outlined will not present major analytical problems to warrant a major overhaul of the specification. Normal and optional flex acreage provisions will be handled in exactly the same way minimum and additional voluntary diversion options have been handled in previous programs. In short, while some adjustments will be required to accommodate the provisions of the 1990 Farm Bill, these are likely to be minor and will be modeled in the same way the previous provisions over the historical period have been handled.

Finally, the analytical procedure in this paper should be useful in evaluating supply response behavior for time periods governed by multiple farm programs. This should be more pertinent if the objective, in addition to merely estimating elasticities, includes a proper evaluation of the impacts of policy variables on program participation and acreage allocation, as should be the case. Some suggestions for future improvements, however, are in order. First, the question of risk-aversion has been mentioned but not addressed exhaustively. Even though evidence of the importance of risk (price and yield) in production decisions is overwhelming (Just; Ryan; Seale and Shonkwiler; Traill), its significance in the presence of government intervention is still in question. Thompson et al. found risk attitudes to be important in the presence of the 50/92 and/or 0/92 reduced planting options. Gallagher and Bailey and Womack found price risk to have little influence on supply response in the presence of farm programs. Seale and Shonkwiler doubted the usefulness of risk consideration in supply response for regulated crops. Despite such divided evidence, the question of risk aversion in the program participation decision is crucial. A risk-averse farmer may still decide to join the program even if it would be less profitable to do so. Finally, it is suggested that the analysis be extended to the remaining corn and wheat producing regions.

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