

ACREAGE SUPPLY RESPONSE UNDER U.S. LAND DIVERSION PROGRAMS*

CHOI JUNG-SUP**

I. Introduction

U.S. domestic farm programs provide price and income support to farm producers. The primary policy instruments used for grain and cotton producers are (a) nonrecourse loans, (b) deficiency payments, (c) acreage controls, and (d) stock management. Since 1961, land diversion programs have been used to forestall commodity surpluses and to lower government expenditures.¹ Corn, sorghum, barley, wheat, oats, rice, upland cotton, and extra-long cotton are program crops. The purpose of this paper is to estimate acreage supply response functions under voluntary land diversion programs.

This paper draws upon the literature on the estimation of acreage response under land diversion programs (Houck and Ryan; Lidman and Bawden; Garst and Miller; Morzuch, Weaver and Helmberger; Lee and Helmberger; deGauter and Paddock). In order to identify economic variables that influence acreage supply response of both program and non-program crops under government programs, the allocatable fixed input model is applied. In what follows we present theoretical models in that an individual farmer's decision under

* This paper is modified based on the first part of the author's PH.D. thesis at the University of Wisconsin-Madison under the supervision of Professor Peter Helmberger. Comments by Professors Jean-Paul Chavas and Matt Holt and anonymous referee(s) with this Journal are greatly appreciated. Any remaining errors are solely the responsibility of the author.

** Research Associate at the KREI.

¹ Land diversion Programs include different versions of voluntary programs such as land diversion, set-aside, and acreage reduction programs.

a land diversion program is analyzed. The third section presents empirical estimation results using variables identified by the theoretical model. The last section summarizes the results.

II. Model

In order to facilitate the modeling of government program regimes, a simplified version of a land diversion program is considered: if an individual farmer chooses to participate in the program, a certain proportion of land must be set aside and the farmer must abide by the acreage allotment for the program crop to be eligible for program benefits. Program benefits are twofold — a nonrecourse loan through government purchases and a deficiency payment. The program variables under government control include the target price, loan rate, land diversion proportion, and program yield.

Modeling is based on a two-crop farm sector in which one crop is subject to a land diversion program described above and the other is not. The allocatable fixed input model is applied to identify the variables and the economic relationships among the variables in the presence of a voluntary land diversion program (Schumway, Pope, and Nash; Moschini). The allocatable fixed input model accounts for joint dual representations of the technology of multi-product firms when efficient production is defined by individual production functions for each separate output. An individual farmer's problem is considered first. Individual economic relationships are aggregated later under the assumption that all farmers are identical in terms of resources. A *non-participating farmer* who optimizes without participating in the program is assumed to maximize the expected profit.²

² Throughout this section, it is assumed that the production uncertainty shows up in linear form in the yield function, i.e., $y_i = f_i(x_i, a_i) + \epsilon \cdot b(x_i, a_i)$, where y = yield and $E(\epsilon) = 0$, $V(\epsilon) = 1$ (refer to Just and Pope, 1979). This assumption is necessary when we write expected production functions as constraints of the expected cost function.

$$E\pi^n(P_c, P_s, W, \bar{a}) \\ = \text{Max}_{q_c^n, q_s^n} \{E[\text{Max}(P_L, P_c) \cdot q_c^n + p_s \cdot q_s^n - c(W, q_c^n, q_s^n, \bar{a})]\},$$

where P = output price (P_L = loan rate for corn), W = input price, q = quantity produced per acre, a = acreage, and subscript c and s denote corn and soybeans, respectively. Superscript n denotes variables associated with non-participating farmers. Acreage is considered as a fixed input. We may rewrite the problem taking the expectation operator into account, assuming $\text{cov}(p, y) = 0$:³

$$\pi^n(P_c^e, P_s^e, W, \bar{a}) \\ = \text{Max}_{q_c^{ne}, q_s^{ne}} \{P_c^e \cdot q_c^{ne} + P_s^e \cdot q_s^{ne} - c(W, q_c^{ne}, q_s^{ne}, \bar{a})\},$$

where superscript e denotes expected values. Optimal production quantities are given as functions of expected output prices, input prices, and acreage availability:

$$q_c^n = q_c^{n*}(P_c^e, P_s^e, W, \bar{a})$$

$$q_s^n = q_s^{n*}(P_c^e, P_s^e, W, \bar{a}).$$

By substituting these equations into optimal allocation equations derived from the solutions of cost maximization problem, we get acreage functions:

$$a_c^n = a_c^{n*}(P_c^e, P_s^e, W, \bar{a})$$

$$a_s^n = a_s^{n*}(P_c^e, P_s^e, W, \bar{a}).$$

In contrast, for a *participating farmer's* optimization problem, we start with the expected joint cost function to explicitly take the acreage constraints imposed by the corn diversion program

³ Expected corn price under diversion programs, P_c^e is higher than the mean of corn price without programs, $E(P)$, because the loan rate truncates the distribution of expected corn price from below. Refer to Chavas and Holt (1990) for the derivation of P_c^e .

into consideration:

$$\begin{aligned}
 E_c^j(W, q_c^j, q_s^j, \bar{a}, \beta, a_{cb}) = & \text{Min } W \cdot x_c^j \cdot a_c^j + W \cdot x_s^j \cdot a_s^j \\
 & x_c^j, x_s^j \\
 & a_c^j, a_s^j \\
 \text{s.t. } E(q_c^j) \leq & E\{f_c(x_c^j, a_c^j) \cdot a_c^j\} \\
 E(q_s^j) \leq & E\{f_s(x_s^j, a_s^j) \cdot a_s^j\} \\
 a_c^j \leq & \beta \cdot a_{cb} \\
 \bar{a} - a_c^j - a_s^j \geq & (1 - \beta) \cdot a_{cb}
 \end{aligned}$$

where β is the proportion of corn base acreage, a_{cb} , permitted to be planted, x is a vector of input per acre, f is yield per acre, and the superscript j denotes variables associated with the participating farmer. The first two constraints are associated with production technologies. Note the yield response functions follow the linear specification of Just and Pope. Additional constraints derive from the acreage allotment and the minimum diversion requirement of the land diversion program. The fourth constraint derives from the restriction that acreage diverted from planting should be no less than the announced diversion proportion times the individual base acreage.

We construct an expected joint profit function for a *participating farmer* based on the joint cost function derived above:

$$\begin{aligned}
 E\pi^j(P_c, P_s, P_L, P_T, W, \bar{a}, \beta, a_{cb}, \bar{Y}) \\
 = \text{Max } E[\text{Max}(P_L, P_c) \cdot q_c^j + P_s \cdot q_s^j - c(W, q_c^j, q_s^j, \bar{a}, \beta, a_{cb}) \\
 q_c^j, q_s^j + \{P_T - \text{Max}(P_L, P_c)\} \cdot \bar{Y} \cdot a_c^j],
 \end{aligned}$$

where P_T is target price for corn, P_L is loan rate for corn, and \bar{Y} is corn program yield.

We may rewrite the problem with expected profit expressed as a function of expected prices and output:

$$\begin{aligned}
 \pi^j(P_c^e, P_s^e, P_L, P_T, W, \bar{a}, \beta, a_{cb}, \bar{Y}) \\
 = \text{Max}[\text{Max}(P_L, P_c^e) \cdot q_c^{je} + P_s \cdot q_s^{je} - c(W, q_c^{je}, q_s^{je}, \bar{a}, \beta, a_{cb}) \\
 q_c^{je}, q_s^{je} + \{P_T - \text{Max}(P_L, P_c^e)\} \cdot \bar{Y} \cdot a_c^j].
 \end{aligned}$$

Using the same method applied in the case of nonparticipants, the following acreage functions are derived :

$$a_{c,i}^j = a_{c,i}^j (P_c^e, P_s^e, P_T, P_L, W, \bar{a}, \beta, a_{c,b}, \bar{Y})$$

$$a_{s,i}^j = a_{s,i}^j (P_c^e, P_s^e, P_T, P_L, W, \bar{a}, \beta, a_{c,b}, \bar{Y}).$$

This model does not explicitly account for the individual farmer's acreage decision conditional on participation. Instead, it is postulated that in market equilibrium the expected profit is the same for participants and nonparticipants. Two implicit functions that show per acre expected profits for nonparticipating and participating farmers are formulated and set equal. This assumes a market equilibrium such that expected prices will equate expected profits for participants and nonparticipants. This allows for, at least, some program participation.⁴

The final equations to be estimated are

$$A_{it} = a_i + bP_{it-1} + cP_{jt-1} + dS_{it-1} + eE_{it} + fG_{it} + gA_{it-1} + \epsilon_{it},$$

where A = acreage; P = price; S = lagged total supply; E = exchange rate; G = government program variable(s); ϵ = disturbance term; i, j = corn, soybean, and wheat ($i \neq j$); and a, b, c, d, e, f and g are coefficients to be estimated.

Note that lower case letters are switched to upper case letters to reflect the aggregation. Lagged total supply, S , is the sum of lagged production and total carry-in stocks. It is included as an indicator of future supply conditions and (exogenous) private and government stocks carried into the current period. Crop-specific exchange rates are included as foreign demand shifters. Lagged crop prices are included in the acreage equations as proxies for expected prices. A large body of previous work supports the inclusion of lagged prices in crop acreage response functions (Houck and Ryan 1972; Brorsen, Chavas, and Grant 1987; Chavas, Pope, and Kao, 1983 etc.).

⁴ This is based on the concept of the *indifference price* (Lee and Helmberger).

Acreage functions are estimated using three different approaches in terms of modeling government programs. In the first approach (it will be referred as Model 1 hereafter), *government program variables* such as the land diversion requirement, loan rate, and target price are included as independent variables in the regression equation.

The second approach (hereafter Model 2) includes a *binary dummy variable* to distinguish between free market and government program regimes. This method, while used by Garst and Miller and Burt and Worthington, among others, largely abstracts from the changing provisions of land diversion programs. It facilitates the estimation of acreage supply functions at the cost of ignoring detailed impacts of different policy variables.

In the third approach (hereafter Model 3), *diverted acres* are used directly as a measure of the extent of government intervention. This has the advantage of simplicity and convenience in comparison with Model 1 (*government program variable* approach) in light of changing program provisions.

U.S. Corn, soybean, and wheat markets are chosen for empirical analysis because they are the most important field crops in U.S. agriculture, ordinarily accounting for about 59 percent of total cropland planted and 67 percent of farm cash receipts from field crop. Corn and wheat are important in terms of government program outlays. For example, during 1986~88, about 5.5 billion and 2.8 billion dollars were paid annually under corn and wheat programs, respectively.

Data used in the estimation are collected from various USDA publications including commodity-specific *Situation and Outlook Yearbooks*, *Agricultural Outlook*, and *Background for 1990 Farm Legislation*. The data period runs from crop year 1961 through 1988.

III. Estimation Results

Table 1 presents OLS estimates of the coefficients for corn acreage supply response equations using the three approaches set forth above.

TABLE 1 Estimated Corn Acreage Response Models Using OLS

Model 1: Government Program Variable Model

$$\begin{aligned}
 AC = & 74.628 - 0.817LPC - 0.209LPS - 0.059LSF + 0.716TREND \\
 & (2.502) \quad (0.894) \quad (0.024)^{***} \quad (0.258)^{***} \\
 & + 7.749RPC - 0.346BC \\
 & (2.967)^{***} \quad (0.052)^{***}
 \end{aligned}$$

$\bar{R}^2 = 0.878 \quad D.W. = 1.76$

Model 2: Dummy Variable Model

$$\begin{aligned}
 AC = & 88.198 - 4.388LPC + 1.234LPS - 0.114LSF + 0.954TREND \\
 & (4.582) \quad (1.586) \quad (0.044)^{***} \quad (0.247)^{***} \\
 & + 7.625DC \\
 & (3.619)^{**}
 \end{aligned}$$

$\bar{R}^2 = 0.587 \quad D.W. = 1.64$

Model 3: Diverted Acreage Model

$$\begin{aligned}
 AC = & 93.835 - 1.787LPC + 1.020LPS - 0.049LTF + 0.018LYC \\
 & (1.374) \quad (0.617) \quad (0.015)^{**} \quad (0.032) \\
 & - 0.743IAC \\
 & (0.050)^{**}
 \end{aligned}$$

$\bar{R}^2 = 0.944 \quad D.W. = 1.55$

Note: Standard errors appear in parentheses.

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

AC = Acreage planted to corn, million acres.

LPC = Lagged price of corn deflated by the index of prices paid by farmers, dollars per bushel.

LPS = Lagged price of soybeans deflated by the index of prices paid by farmers, dollars per bushel.

LSF = The sum of lagged production and lagged ending stocks of feed grains, million metric tons.

TREND = A time trend which represents technological change, 1961 = 1, etc.

RPC = Loan rate for corn deflated by the index of prices paid by farmers,

dollars per bushel.

- BC = Diversion requirement for corn program participating farmers: the sum of the minimum diversion under the Acreage Reduction Program and the additional diversion requirement under the Paid Land Diversion program, percent.
- LTF = Lagged ending stocks of feedgrains, million bushels.
- DC = Dummy variable: 1 for 1974~77 & 1980~81, 0 otherwise.
- LYC = Previous three year moving average yields of corn as a measure for technological change, bushels per acre.
- IAC = Acreage diverted under corn program, million acres.

Estimated results of Model 1 (the government program model) for corn acreage appear in the first equation of Table 1. Coefficients for lagged prices of corn and soybeans show little statistical significance. The lagged total supply of feed grains, LSF, has a significant, negative effect on corn acreage with an elasticity of -0.193 . The coefficient for loan rate of corn is positive and significant at the 1 percent level. The elasticity calculated at the mean is 0.191 . A 10 percent increase of loan rate would raise corn acreage by 1.9 percent. The coefficient on the land diversion requirement, BC, is significant at the 1 percent level. The calculated elasticity is -0.124 : a 10 percent increase in diversion requirement would be expected to decrease corn acreage by 1.2 percent.

Model 2 (the dummy variable model) for corn shows limited statistical significance (see Table 1). It has a lower adjusted R^2 than other models. Coefficients for the lagged prices of corn and soybeans also show little statistical significance in this model. The coefficient for lagged supply of feed grains is significant at the 1 percent level with a calculated elasticity of -0.371 . The coefficient for time trend is significant and has a positive sign. The coefficient for the dummy variable, DC, is significant at the 5 percent level. It shows a positive sign, as we may expect.

The last equation in Table 1 presents the estimated parameters of Model 3 (the diverted acreage model). Judging from the adjusted R^2 , the model tracks history closely during

the sample period. The coefficient for lagged total stock of feed grains is statistically significant and shows a negative sign, meaning higher lagged stocks of feedgrains implies lower corn acreage. This result is as expected because LTF is included as a shifter of the expected price function. Coefficients for lagged prices of corn and soybeans, as in previous models, show little statistical significance. The coefficient for diverted acreage is significant at the 1 percent level. The estimated coefficient, -0.743 , for acres diverted reflects the magnitude of slippage under the corn program⁵. In other words, one additional acre of diverted land reduces corn acreage planted by 0.74 acres.

Generally, the quality of the estimation results for corn acreage vary with the type of model. Models 1 and 3 perform better than Model 2. Lagged corn and soybean prices never show significance in determining U.S. corn acreage, while the variables designed to reflect government intervention show high *t*-ratios; perhaps reflecting the magnitude and impact of government intervention on a continuous base. The program variables in each equation show consistent results with respect to expected signs and statistical significance. According to Models 2 and 3, corn diversion programs reduce corn acreage, but there is not a one-to-one relationship between acreage diverted and acreage planted. Again, this effect can be attributed to commodity program slippage.

Table 2 presents the Maximum Likelihood estimation results for soybean acreage response functions. Original OLS estimation of the soybean acreage response functions showed high Durbin *h* statistics; -1.851 , -2.443 , and -1.450 for Models 1, 2, and 3, respectively. In order to correct the negative first-order autocorrelation with lagged dependent variables, Maximum Likelihood method with grid search is applied to the estimation. The estimated standard errors are calculated using Dhrymes' Theorem 7.1 (White et al., p.81). All models explain soybean acreage reasonably well, showing R^2 s of over 0.98.

⁵ Slippage is defined as the difference between policy intention and policy outcome of land diversion policy (Tweeten, p. 350). It indicates the effectiveness of the land diversion policy in reducing U.S. crop acreage.

TABLE 2 Estimated Soybean Acreage Response Models Using ML**Model 1: Government Program Variable Model**

$$AS = -4.726 + 4.568LPS - 8.539LPC + 0.932LAS + 2.208RPC \\ (0.404)^{***} \quad (0.859)^{***} \quad (0.033)^{***} \quad (0.771)^{***} \\ + 0.009BC \\ (0.023)$$

$$\bar{R}^2 = 0.983 \quad RHO = -0.012 \\ \text{Log of Likelihood Function} = -53.441$$

Model 2: Dummy Variable Model

$$AS = -1.600 + 4.660LPS - 7.618LPC + 0.915LAS - 2.609DC \\ (0.410)^{***} \quad (0.990)^{***} \quad (0.023)^{***} \quad (0.956)^{***}$$

$$\bar{R}^2 = 0.983 \quad RHO = -0.012 \\ \text{Log of Likelihood Function} = -53.113$$

Model 3: Diverted Acreage Model

$$AS = 5.992 + 4.368LPS - 8.860LPC + 0.849LAS - 0.040IAC \\ (0.504)^{***} \quad (1.059)^{***} \quad (0.032)^{***} \quad (0.050)$$

$$\bar{R}^2 = 0.984 \quad RHO = -0.012 \\ \text{Log of Likelihood Function} = -56.537$$

Note: AS = Acreage planted to soybeans, million acres.

LAS = Lagged acreage planted to soybeans, million acres.

The remaining variables are explained in Table 1.

The first model in Table 2 explains soybean acreage using corn program variables, including the diversion requirement BC and the deflated loan rate RPC. In the Corn Belt states, corn and soybeans are grown together and compete for agricultural resources. The coefficient for corn diversion requirement, BC, is not statistically significant in explaining soybean acreage for the sample period.⁶ The coefficient on corn loan rate, RPC, is

positive and significant. It is difficult to anticipate the sign of the coefficient for RPC since a higher loan rate for corn may result in lower corn acreage due to higher program participation rate, but higher loan rates may also induce nonparticipants to increase corn acreage. Moreover, the relationship between corn and soybean acreages in the presence of land diversion programs are difficult to determine. Market variables—such as the lagged price of soybeans and corn—show high *t*-ratios. Both coefficients have expected signs. The short-run own price elasticity of soybeans calculated at the sample mean is 0.466, while the short-run cross price elasticity is -0.367 . The short-run own price elasticity is close to the estimates of Gardner (0.45~0.61) and of Chavas and Holt (0.44). The coefficients of lagged acreage planted to soybeans, in this model and in the second and third models, are significant and the coefficients are in the stable range, supported by distributed lag or cobweb models. The long-run own price elasticity of soybeans is 6.90.

The second model in Table 2 explains soybean acreage using a binary dummy variable based on the corn diversion program. Lagged prices of both corn and soybeans are significant and have expected signs. The short-run own price elasticity of soybean acreage is 0.476, and the cross price elasticity is -0.327 . The calculated long-run own price elasticity of soybeans is 5.59. The dummy variable coefficient is significant at the 1 percent level, and has a negative sign. Hence soybean acreage decreases during free market years. According to this model, corn diversion programs switched annually about 2.6 million acres of corn plantings to soybeans during the sample period. It does not, however, seem to be economically significant amount since this acreage is less than 5 percent of acreage planted annually to soybeans in the 1980's

Model 3 for soybeans is the last equation in Table 2. Except for policy variables, it contains the same set of variables included in Models 1 and 2. Coefficients for lagged prices of

⁶ This may reflect the fact that U.S. soybean acreage has substantially increased in the Southern Plains, Southeast, and Delta states (Schaub et al, pp. 3–5), where less competition with corn is evident.

TABLE 3 Estimated Wheat Acreage Response Models Using OLS**Model 1: Government Program Variable Model**

$$\begin{aligned}
 AW = & 24.170 + 0.314LPW + 1.721LYW - 0.020LSF - 0.294EW \\
 & \quad (1.366) \quad (0.497)^{***} \quad (0.025)^{***} \quad (0.125)^{***} \\
 & + 0.333LAW + 1.529RPW - 0.411BW \\
 & \quad (0.142)^{**} \quad (1.921) \quad (0.129)^{***}
 \end{aligned}$$

$\bar{R}^2 = 0.879$ Durbin h = 1.506

Model 2: Dummy Variable Model

$$\begin{aligned}
 AW = & 10.734 + 2.154LPW + 0.909LYW - 0.200EW + 0.571LAW \\
 & \quad (1.149) \quad (0.273) \quad (0.125)^{***} \quad (0.112)^{***} \\
 & + 5.140DW \\
 & \quad (2.405)^{**}
 \end{aligned}$$

$\bar{R}^2 = 0.861$ Durbin h = 1.237

Model 3: Diverted Acreage Model

$$\begin{aligned}
 AW = & -4.217 + 1.353LPW + 0.084EW + 1.305LYW - 0.590LAW \\
 & \quad (1.088) \quad (0.124) \quad (0.281)^{***} \quad (0.100)^{***}
 \end{aligned}$$

$\bar{R}^2 = 0.888$ Durbin h = 0.746

AW = Acreage planted to wheat, million acres.

LPW= Lagged price of wheat deflated by the index of prices paid by farmers, dollars per bushel.

LYW= Previous three year moving average yields of wheat, bushels per acre.

EW = Exchange rate weighted for U.S. wheat markets.

LAW= Lagged acres planted to wheat, million acres.

RPW= Loan rate for wheat deflated by the index of prices paid by farmers, dollars per bushel.

BW = The minimum diversion requirement under the Acreage Reduction Program for farmers participating wheat program.

DW = Dummy variable; 1 for 1961, 1967~68, 1974~77 & 1980~81, 0 otherwise.

IAW = Acreage diverted under wheat program, million acres.

soybeans and corn and for lagged acreage planted to soybeans are highly significant. According to this model, the short-run own price elasticity of soybeans is 0.446 and the cross price elasticity is -0.381 (The long-run own price elasticity is 2.94).

The coefficient for diverted acres under the corn program is insignificant. This means land diverted under the corn program has a statistically insignificant impact on determining soybean planted acreage. Recall that while the dummy variable coefficient in Model 2 was statistically significant, its magnitude was rather small. Since acreage diverted under the corn program is a more restrictive concept than the dummy variable in explaining corn diversion program, it may not be highly correlated with soybean acreage.

In sum, market variables and lagged soybean acreage explain most of the variation in U.S. soybean acreage; corn program variables show ambiguous and inconsistent results. Corn diversion programs may tend to increase acres planted to soybeans, but not significantly

Table 3 presents estimated equations for U.S. wheat acreage. The first regression is for Model 1. The coefficient for lagged own price is not statistically significant.⁷ Recall that similar results were reported for the corn acreage equation with government program variables in Table 1. Consequently, price effects may be masked by the strong influence of government price support programs (Chavas, Pope and Kao, p.32). According to the Durbin h statistics, no model shows significant first-order autocorrelation at the 5 percent level.

The coefficient for the lagged three year moving average of wheat yield, a proxy for technological progress, is statistically significant and has a positive sign. The coefficients for lagged total supply of feed grains and lagged price of wheat are insignificant. The negative sign for the weighted exchange rate coefficient for the U.S. wheat market is as anticipated, — meaning a stronger dollar decreases U.S. exports and so acreage. The exchange rate coefficient is also significant at the 5

⁷ Lidman and Bawden reported that the coefficient of wheat price was not significant in determining acreage planted to wheat during 1954~70.

percent level, and the calculated elasticity is -0.398 . The lagged wheat acreage coefficient is positive and significant at the 5 percent level. According to this model more wheat acreage in the previous year is followed by increased wheat acreage planted, *ceteris paribus*. The estimated coefficient for the land diversion requirement is -0.411 , which is statistically significant. The wheat acreage elasticity with respect to the diversion requirement, calculated at the mean, is -0.086 . This means that a 10 percent increase in the wheat diversion requirement reduces wheat acreage by 0.86 percent, 0.3 percentage points lower than for corn. Another program variable, the real loan rate for wheat RPW, is not statistically significant.

Estimation results for Model 2 are presented as the second equation in Table 3. With the exception of the exchange rate, all estimated coefficients have expected signs and are significant at the 10 percent level or higher. The estimated short-run own price elasticity of wheat for Model 2 is 0.097, while the long-run acreage supply elasticity being 0.23. This wheat acreage supply elasticity is much lower than the elasticities reported previously by Morzuch, Weaver, and Helmberger (0.52) and Houck, Abel, et al. (0.39). The elasticity is close to the elasticities reported by Garst and Miller. Their elasticities were 0.04, 0.19, and 0.17 for spring, winter, and all wheat, respectively. Lagged acreage has a positive effect on current wheat acreage. The coefficient for the dummy variable DW, which is set to 1 for free market years and 0 for wheat program years, is significant at the 5 percent level. It has a positive sign which is consistent with the results of the first and the third models, meaning less acreage is planted during the wheat diversion program years.

The last model in Table 3 is Model 3. As with Model 1, the coefficient for lagged wheat price is not significant. The weighted exchange rate coefficient is also insignificant. The coefficients for lagged wheat yields and lagged acreage planted are, however, highly significant. The estimated coefficient for diverted acreage is significant at the 1 percent level. The coefficient for diverted acres is -0.507 , meaning that every acre diverted under U.S. wheat program subtracts only 0.5 acres from actual production. The remaining 0.5 acres may be

TABLE 4 Mean Absolute Percent Error of Acreage for Corn, Soybeans, and Wheat, 1980~81

Crop	Mean Absolute Percent Error*		
	Model 1	Model 2	Model 3
Corn	1.617	6.398	0.982
Soybeans	4.021	2.689	3.963
Wheat	11.166	11.036	8.801

* Model 1 = Government program variable model.

Model 2 = Binary dummy variable model.

Model 3 = Diverted acreage model.

attributed to slippage in the wheat program (In the case of corn, the corresponding coefficient estimate is 0.74).

In sum, the estimated wheat acreage functions show reasonably high R^2 s, 0.861 to 0.888 depending on the model. For all models the coefficient for the lagged moving average of wheat yield is highly significant, showing elasticities between 0.42 to 0.79. In contrast with soybeans, government program variables such as the diversion requirement BW, dummy variable DW, and diverted acres IAW, show high t-ratios and consistent signs among the models. Coefficients for lagged acres planted to wheat, LAW, are in the stable range throughout, supporting the Nerlovian distributed lag scheme. Market variables such as the lagged price of wheat, LPW, show relatively low t-ratios, however.

The empirical validity of the models is assessed using out-of-sample forecasting. The three equations are reestimated with 19 observations running from 1961 to 1979. The resulting estimates are then used to make *ex post* predictions for 1980 and 1981. The years 1980 and 1981 are chosen since we want to verify the performance of the model when no diversion programs were in effect. Acreage of each crop is forecasted using observed values for the exogenous variables. Predicted acreage for 1980 is then substituted for lagged acreage in 1981. The results of the forecasting exercise are reported in Table 4.

To facilitate comparative analysis, the Mean Absolute

Percent Errors (MAPEs) are calculated for all models. The MAPEs show little variation among models in terms of predictive power. Most models display reasonable out-of-sample predictive capability, showing MAPEs of about 10 percent or less. Based on the MAPE criterion, corn and soybean models generally perform better than wheat models.⁸ For corn, Models 1 and 3 show small MAPE's than Model 3. With regard to soybeans and wheat, all models show little variation in MAPE.

In general, Models 1 and 3 for corn appear useful in explaining acreages during the sample period. For soybeans all models show reasonably good results. Model 1 forecasts wheat acreage more successfully than the other models.

IV. Summary and Implications

The estimation results reveal that the lagged price of corn is statistically insignificant in determining U.S. corn acreage during the sample period. Acreage diverted under the corn program is highly significant in explaining corn acreage. The slippage rate associated with the corn diversion programs is 26 percent.

For soybeans, market variables such as lagged prices of soybeans and corn are highly significant in explaining planted acreage. This may reflect the absence of government programs that restrict soybean acreage. Lagged prices of corn and soybeans and lagged planted acreage explain most of the variation in soybean acreage during the sample period; the variables that reflect corn program provisions show inconsistent results.

For wheat, the lagged price of wheat is insignificant in all models except for Model 2, where it is significant at the 10 percent level only. As with corn, this result apparently reflects

⁸ The MAPEs from out-of-sample forecast are not perfectly correlated with the model performances measured by the adjusted R^2 s. The adjusted R^2 s of estimated functions based on 19 observations are; corn 0.94, 0.76, 0.94; soybeans 0.99, 0.99, 0.99; wheat 0.81, 0.81, 0.85, for models 1, 2 and 3, respectively.

continuous government intervention in the wheat market. Wheat slippage amounts to about 50 percent.

According to the results of this paper, market variables such as lagged prices do not influence wheat acreage response. Instead, variables that are designed to capture the impacts of government intervention in the markets—e. g., loan rates, land diversion requirements for participating farmers, the binary dummy variable, and diverted acreage—appear to explain variation in U.S. corn and wheat acreage response. On the other hand, the estimates for the soybean acreage equations show opposite results; i. e., high significance for coefficients on lagged prices and less significance for coefficients associated with government program variables.

The inclusion of data for the 1980's complicates the estimation of acreage response functions for program crops.⁹ It is also difficult to model the changing provisions of land diversion programs. Burt and Worthington report similar problems with the estimation of U.S. wheat acreage function (p.105, p.110).

In order to investigate the impact of farm programs on the level of farm output, a model that predicts what planted acreages would be in the absence of farm programs. It appears likely that in the absence of programs expected prices would be instrumental in determining acreage. What is required, therefore, are models that show how acreages planted respond to changes in prices or expected prices, particularly for relatively low prices. For many years, farm prices likely would have been much lower without farm programs than with farm programs. This would certainly seem to be the case in the 1980's. As we have seen, however, the above analyses, based on conventional approaches to the estimations of acreage response,

⁹ An experimental regression of Model 1 for corn estimated without 1982~88 data gave a significant, positive sign for the coefficient of lagged corn price. A number of previous researches using pre-1980's data report positive short-run own price elasticities for corn acreage response. For example, Lee and Helmerger, 0.12~0.25(1948~80); Chavas, Pope, and Kao, 0.44(1957~77); Shonkwiler and Maddala, 0.39(1952~81:corn supply response); and Tegene, Huffman, and Miranowski, 0.24(1948~80).

do an inadequate job of predicting how acreages respond to lagged prices.

The analysis set forth in this paper together with the results from previous research suggest that new approaches are needed to estimate acreage response in the presence of farm programs. For example, Holt and Johnson report a positive short-run own price elasticity of corn supply (not acreage supply) equaling 0.46(1950~85) using an endogenous switching model with rational expectations (1989). Chavas and Holt explore the estimation of risk-responsive acreage equations giving particular attention to the truncation effects of government price supports on the distribution of crop prices (1990), reporting a positive short-run own price elasticity of corn acreage supply equaling 0.16 (1954~85).

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