1987

An Analysis of Corn and Soybean Supply Response to Changing Government Programs

by

Karl D. Skold
Patrick Westhoff*

Paper presented at the Selected Papers session of the annual meeting of the American Agricultural Economics Association at Michigan State University, August 2-5, 1987.

Corn

*The authors are research assistant and pre-doctorate research associate with the Center for Agricultural and Rural Development, Department of Economics, Iowa State University, Ames, Iowa.

Abstract

An econometric model of corn and soybean supply response model is provided that endogenously determines program participation. The impacts of a decrease in the target price, an increase in the set-aside rate, and the introduction of a paid diversion are analyzed for the 1985 crop.

The estimation of the supply response to changing government commodity programs has been problematic due to the frequent adjustments made in the composition of the commodity programs, as well as changes in their underlying payment structures and acreage reduction options. The most common approach used to incorporate the influence of commodity programs is the inclusion of effective support payment and diversion payment variables as explanatory variables in the planted acres equations, as exemplified by Houck and Ryan (1972). However, as de Gorter and Paddock (1985) note, these composite variables ignore the voluntary nature of the commodity programs, and impose questionable restrictions on the effects of changing policy parameters.

For example, with the use of effective price support variables, an increase in price support payments will always increase total production. As de Gorter and Paddock correctly contend, this ignores the potentially offsetting effects of participant planted acres, and non-participant planted acres. Higher support prices may actually reduce production as increased participation in government programs results in more acres being idled in land diversion programs. Thus, it is possible that an increase in support prices may result in an increase in participant planted acres which is smaller than the decrease in non-participant planted acres. The effective policy proxy variables do not account for changes in participation in the commodity program, and thus ignore changes in program and non-program planted acres. To remove these policy variable response restrictions, de Gorter and Paddock advance a corn supply response model that explicitly accounts for the discrete program participation choice, as well as the continuous planting decision.

This paper extends the model of de Gorter and Paddock. This paper presents a corn and soybean acreage response model that incorporates the corn

program participation decision in the determination of planted acres for corn and soybeans. This provides a means of analyzing the effects of policy parameter changes on the participation rate, corn acreage planted by participants and non-participants, corn yields, corn production, and soybean planted acres. The next section outlines the model's structure, after which estimation results are provided and discussed. Then, the effects of three separate policy parameter changes are analyzed for the 1985 crop. The policy changes are a 10 percent decrease in the target price, an increase of the set-aside rate from 10 percent to 20 percent, and the inclusion of a 10 percent paid diversion, paid at the rate of $1.50 per bushel.

Corn and Soybean Supply Model Structure

The model consists of five behavioral equations, and three identities. The model endogenously determines the corn program participation rate, total planted corn acres, participant planted corn acres, non-participant corn planted acres, corn yield, corn acres harvested, total corn production, and soybean acres planted. In Table 1, definitions of the endogenous variables, and the exogenous variables are provided. Below is provided the general form of the model; each equation will be discussed in turn.

(1.1) COPART = F(COPRTNR, CONPNR, SOYNPNR)

(1.2) COAPLU9 = F(CONPNR/SOYNPNR, (COPART/100) * COABST * (CODIVR + CODIVA))

(1.3) COAPLPT = (COPART/100) * COABST * (1 - CODIVR - CODIVA)

(1.4) COAPLNP = COAPLU9 - COAPLPT

(1.5) COYD = F(TREND, (COPART/100) * COABST * (CODIVR + CODIVA))

(1.6) COAHAU9 = F(COAPLU9, TREND)

(1.7) COSPR = COAHAU9 * COYD

(1.8) SOYSA = F(SOYNPNR, CONPNR, (COPART/100) * COABST, TREND)

The corn program participation decision is based on a comparison of the expected net returns per acre of participation and non-participation, and with the expected net returns per acre from soybean production. Thus, the corn program participation rate (1.1) is a function of expected participant net returns, expected non-participant corn net returns, and expected soybean net returns. Increases in participant net returns are expected to have a positive effect on program participation, while increases in non-participant corn and soybean net returns are expected to have a negative effect on program participation. The model assumes that soybeans are the only alternative crop. Equations 1.9 to 1.11, detail the derivation of participant net returns, non-participant net returns, and soybean net returns respectively.

$$\begin{aligned}(1.9)\quad COPRTNR = \max\{COPFML,\ COLOAN + DPS\} * (1 - CODIVR - CODIVA) * COYDT \\ + (COPTGT - COPFML) * (1 - CODIVR - CODIVA) * COYDPRG \\ + CODIVA * COEDP * COYDPRG - COVC * (1 - CODIVR - DCODIVA)\end{aligned}$$

$$(1.10)\quad CONPNR = (COPFML * COYDT - COVC)$$

$$(1.11)\quad SOYNPNR = (SOYPFML * SOYYOT - SOYVC)$$

Producers are assumed to have naive price expectations, and base their yield projections on an exogeneous trend yield. In the participation net returns calculation (1.9), the expected price is the maximum of the expected market price and the loan rate plus the direct price support payment. The direct price support payment was paid on total production in the 1962 through 1965 crops. This maximum is multiplied by the proportion of base acres in production, (1 - CODIVR - CODIVA). CODIVR is the proportion of base acres idled in any unpaid set-aside, and CODIVA is the proportion of base acres idled under any paid diversion provisions. This product is multiplied by the exogeneous trend yield, COYDT. The next component of the participant

net return derivation is the expected deficiency payment, which is the target price, COPTGT, less the expected market price, COPFML. The deficiency payment is multiplied by the proportion of base acres in production, and then multiplied by the program yield, COYDPRG. The target price was set equal to the expected market price when no deficiency payments were made, or when only advance deficiency payments were paid (1969-1973), and when market prices were above the target price (1974-1977 and 1980-1981). The next component is the paid diversion, which equals the proportion of base acres idled under the the paid diversion, CODIVA, times the effective diversion payment, COEDP, times the program yield. The effective diversion payment was calculated as a weighted average of diversion payment rates when more than one diversion option was available. The weights represent the fraction of total paid diverted acres removed under each diverison provision. The variable cost per acre, COVC, is multiplied by the proportion of base acres planted in compliance with program provisions. No cost is assumed for idled acres, since in many years participants could graze livestock for limited time periods. The expected net returns for non-participants planting corn (1.10) and soybeans (1.11) on a per acre basis are simply the expected market prices times the trend yield less a per acre variable cost for the respective crops. In the model, the net returns are deflated by the wholesale price index, USPW.

Total corn planted acres (1.2) is a determined by the ratio of non-participant net returns to soybean net returns. This explanatory variable is expected to have a positive influence on total planted acreage, since increasing returns of non-participant corn would induce increased corn planting, and increases in soybean net returns would decrease corn plantings. Also, the corn acres set-aside and diverted, (COPART/100) * COABST * (CODIVR + CODIVA), is expected to have a negative effect on total corn planted acres. Corn acres set-aside and diverted is a product of the participation rate, as a

fraction, times total base acres, times the proportion of base acres set-aside and diverted. Participant planted acres (1.3) are derived from an identity, and equals the participation rate times total base acres, times the proportion of base acres in production. Non-participant planted acres (1.4) are total corn planted acres less participant planted acres.

Corn yield (1.5), used to determine total corn production, is a function of a trend to capture advances in technology, and the number of corn acres set-aside and diverted, (COPART/100) * COABST * (CODIVR + CODIVA). The latter explanatory variable is included to capture the effect of intensified production practices on non-diverted land, and thus is expected to have a positive effect on the corn yield. Total corn harvested acres (1.6) are simply a function of total planted acres, and a time trend. The trend captures the increased harvesting of total planted acres over the sample period, and thus a positive sign is hypothesized for the trend's coefficient. Total corn production (1.7) is total planted acres multiplied by the endogeneous yield. Soybean acres planted (1.8) are hypothesized to be positively influenced by soybean net returns, and negatively affected by nonparticipant corn net returns. Also, the number of acres removed by corn program participants, (COPART/100) * COABST, is hypothesized to have a negative effect on soybean planted acres because of an assumed implicit total land constraint. A time trend is also included as an explanatory variable to capture the increase in soybean planted acres over the sample period.

Estimation Results

The sample period for estimation was 1961 to 1985, and the model was estimated with ordinary least squares. The data used in estimation and to derive the expected net returns were obtained from USDA's Feed Situation,

Table 1.0. Variable Definitions

COPART	= Corn program participant rate, percent of total base acres in compliance with program provisions
COPRTNR	= Expected corn net returns for program participants, dollars per acre
CONPNR	= Expected corn net return for nonparticipants, dollars per acre
SOYNPNR	= Expected soybean net return, dollars per acre
COAPLU9	= Total corn planted acres, millions of acres
COAPLPT	= Participant corn planted acres, millions of acres
COAPLNP	= Nonparticipant corn planted acres, millions of acres
COABST	= Total corn base acres, millions of acres
CODIVR	= Proportion of total participant base acres set-aside
CODIVA	= Proportion of total participant base acres diverted
COYD	= Corn yield, bushels per acre
TREND	= Time trend
COAHAU9	= Total corn acres harvested, millions of acres
COSPR	= Total corn production, millions of bushels
SOYSA	= Total soybean planted acres, millions of acres
COLOAN	= Corn price support loan rate, dollars per bushel
COPFML	= Expected corn price, previous crop year's season average price, dollars per bushel
DPS	= Direct price support payment, dollars per bushel
COYDT	= Corn trend yield, bushels per acre
COPTGT	= Corn target price, dollars per bushel
COYDPRG	= Corn program yield, bushels per acre
COEDP	= Effective diversion payment, dollars per bushel
COVC	= Corn variable cost, dollars per acre
SOYYDT	= Soybean trend yield, bushels per acre
SOYVC	= Soybean variable cost, dollars per acre
USPW	= 1 divided by the U.S. wholesale price index (1980 = 100)
DM17173	= Dummy variable, 1 if year 1971-1973, 0 otherwise
DM1**	= Dummy variable, 1 if year **, 0 otherwise, ** = 74, 75, 76, 77, 80, 81, 82

Agricultural Statistics, News, and ASCS Commodity Fact Sheet. The variable cost data and the wholesale price index was obtained from the data bank of the Center for Agricultural and Rural Development. Below, the estimation results are presented. Student's t-statistics are presented below the estimated coefficients in parentheses, and elasticities are provided in brackets below the t-statistic values. Durbin-Watson and R^2 statistics are also provided for each equation. Following the estimated model, a discussion of relevant coefficients and variables will be provided.

Corn Participation Rate

(2.1) COPART = 62.65 + 0.44 * COPRTNR * USPW - 0.13 * CONPNR * USPW
(5.93) (3.20) (1.23)
[1.22] [-0.33]

- 0.39 * SOYNPNR * USPW + 29.39 * DM17173 - 61.78 * DM174
(4.31) (7.40) (-5.90)
[-1.03]

- 66.68 * DM175 - 74.16 * DM176 - 32.31 * DM177
(-4.97) (-8.16) (3.65)

- 54.84 * DM180 - 57.54 * DM181 - 32.39 * DM182
(-8.83) (-8.68) (-5.16)

R^2 = 0.98 D.W. = 2.16

Total Planted Corn Acres

(2.2) COAPLU9 = 79.51 + 3.04 * (CONPNR/SOYNPNR) - 0.67 * (COPART/100)
(29.26) (1.30) (10.41)
[0.39] [-0.11]

* COABST * (CODIVR + CODIVA) - 8.15 * DM183
(-2.74)

R^2 = 0.91 D.W. = 1.27

Participant Planted Corn Acres

(2.3) COAPLPT = (COPART/100) * COABST * (1 - CODIVR - CODIVA)

Nonparticipant Planted Corn Acres

(2.4) COAPLNP = COAPLU9 - COAPLPT

Corn Yield

(2.5) COYD = -4956.42 + 2.56 * TREND + 0.38 * (COPART/100) * COABST
(-12.03)(12.28) (2.41)
[0.05]

* (CODIVR + CODIVA) - 14.69 * DM170 - 15.78 * DM174
(-2.95) (-3.16)

- 12.01 * DM180 - 38.01 * DM183
(-2.47) (-6.49)

R^2 = 0.94 D.W. = 1.95

Total Harvest Corn Acreage

(2.6) COAHAU9 = -169.92 + 0.88 * COAPLU9 + 0.09 * TREND
(-1.99)(22.18) (1.92)
[1.02]

R^2 = 0.98 D.W. = 1.26

Total Corn Production

(2.7) COSPR = COAHAU9 * COYD

Soybean Acres Planted

(2.8) SOYSA = 3741.66 + 0.102 * SOYNPNR * USPW - 0.067 * CONPNR * USPW
(15.27) (2.57) (2.45)
[0.24] [-0.15]

+ 1.92 * TREND - 0.05 * (COPART/100) * COABST
(15.47) (1.17)
[-0.04]

R^2 = 0.94 D.W. = 1.24

The coefficients in the participation rate equation (2.1) have the hypothesized signs and are significant at the 99 percent confidence level, except for the coefficient on CONPNR. The results suggest that the

participation choice is more heavily based on a comparison of participant net returns and soybean net returns with non-participant net return having less weight in the decision process. Dummy varibles were included for years in which the corn program had no effect, 1974 to 1977, 1980, and 1981. Also, dummy variables were included for the 1971 to 1973 and 1982 crops. The dummy variable for the 1971 to 1973 crops was included to account for the cross compliance provisions imposed, and the dummy variable for the 1982 crop was included because it was an outlier.

The estimates of the total planted acres equation (2.2) imply a very inelastic response to changes in non-participant corn or soybeans net returns once the participation decision has been determined. The coefficient on the expected net return ratio has the anticipated sign, but is not significant at conventional levels. The acres diverted and set-aside has a negative and highly significant effect on total planted corn acres as hypothesized. The coefficient is significantly different from negative one at the 99 percent significant level. This would suggest a relatively high amount of slippage present, since an acre diverted or set-aside removes two-thirds of an acre of total corn plantings. The dummy variable for the 1983 crop is included because of the Payment-in-Kind program.

In the corn yield equation (2.5) all variables have the hypothesized signs and are significant at conventional levels. Acres diverted and set-aside have a positive influence on yields due to the adoption of more intensive production practices on nondiverted acres. The dummy variables for the 1970, 1974, 1980, and 1983 crops are included to account for low yields due to unfavorable weather conditions and pervasive disease outbreaks.

The explanatory variables in the total area harvested equation (2.6) have the correct signs and are both significant at the 90 percent significance

level. The variables in the soybean acreage equation (2.8) have anticipated signs and all but one are significant at the 95 percent significant level. The exception is the area planted and idled by program participants, which is insignificant at conventional levels, but is retained to capture the effects of changes in program participation, and thus the removal of acres available for soybeans.

Policy Variable Simulations

Three separate policy parameter changes affecting the 1985 crop were made in order to analyze the effect on the endogeneous variables. The three policy changes were as follows: (1) a 10 percent decrease in the target price, from $3.03 per bushel to $2.73 per bushel; (2) an increase in the set-aside rate from 10 percent to 20 percent; (3) an introduction of a 10 percent paid diversion, paid at the rate of $1.50 per bushel on diverted acres, assuming all participants comply. The effects on selected endogeneous variables as compared with baseline solutions are presented below. Table 2 presents the effect of the target price decrease. Tables 3 and 4 present the results of the set-aside increase, and the introduction of a paid diversion, respectively.

The decrease in the target price by 10 percent in 1985 causes a dramatic drop, 21 percent, in the participation rate. Nonetheless, the decline in participant planted acreage is almost perfectly offset by an increase in non-participant planted acres. The yield decreases as less land is idled, and total production demonstrates a small increase. Soybean planted acreage increases slightly, as most of the acreage leaving the corn program is shifted to non-participant corn production.

Table 2. Decrease the Target Price by 10 Percent in 1985

Variable	Baseline	Simulation	Percentage Change
Participation Rate	70.90%	58.80%	-21.0%
Total Corn Planted Acres	79.02	79.66	+0.8%
Corn Yield	118.00	117.65	-0.3%
Corn Production	8197.00	8238.00	+0.5%
Soybean Acres	70.40	70.80	+0.6%

Table 3. Increase the Set-Aside Requirement from 10 to 20 Percent in 1985

Variable	Baseline	Simulation	Percentage Change
Participation Rate	70.90%	64.00%	-11.0%
Total Corn Planted Acres	79.02	75.80	-4.0%
Corn Yield	118.00	119.84	+1.5%
Corn Production	8197.00	7980.37	-2.7%
Soybean Acres	70.40	70.60	+0.3%

Table 4. Introduce a 10 percent Paid Diversion in 1985

Variable	Baseline	Simulation	Percentage Change
Participation Rate	70.90%	70.23%	-0.9%
Total Corn Planted Acres	79.02	75.08	-5.2%
Corn Yield	118.00	120.20	+1.8%
Corn Production	8197.00	7932.50	-3.3%
Soybean Acres	70.40	70.36	-0.05%

The increase in the set-aside requirement from 10 to 20 percent decreases the participation rate by 11 percent. Total planted acres decline by 4 percent, as the increase in non-participant planted acres does not offset the decline in participant planted acres due to the increased set-aside requirement, and the drop in participation. The corn yield increases slightly as more intensive production practices are applied. However, the yield increase does not displace the decrease in total planted acres, and thus total production declines by 2.7 percent. Soybean acres increase slightly.

The introduction of a 10 percent paid diversion, paid at the rate of $1.50 per bushel on diverted acres, decreases the participation rate marginally. Total planted acres decline by 5.2 percent as additional acres are diverted. The corn yield increases by 1.8 percent as more acres are idled, and total production declines because the yield increase fails to offset the effect of the decline in total planted acres. Soybean acreage declines slightly as more acres are devoted to participant planted and idled acres.

Summary

The corn and soybean supply response model presented provides a means of capturing the effect of changes in policy parameters on participant and non-participant corn acreage planted. The model is an improvement over traditional approaches because it accounts for the possible offsetting effects between participant and nonparticipant corn planted acres, and the increase in yields when more acres are idled. However, the model is not complete as corn and soybean prices remain exogeneous. Also, the naive price expectations assumption is far from adequate, as more advanced models of price expectations have been advanced. Nevertheless, the model provides a start at incorporating the discrete participation choice with the continuous planting decision in a complete model framework.

References

de Gorter, Harry and Brian W. Paddock. "The Impact of U.S. Price Support and Acreage Reduction on Crop Output." International Trade Policy Division, Agriculture Canada, November 18, 1985, mimeo.

Houck, James P. and Mary E. Ryan. "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs." American Journal of Agricultural Economics 54(72):184-91.

U.S. Department of Agriculture. Agricultural Statistics. Washington, D.C., 1963-1985.

_____. ASCS Commodity Fact Sheet: Feed Grains. Agricultural and Stabilization and Conservation Service. Washington, D.C., 1978, 1979, 1982-1984.

_____. Feed Situation. Economic Research Service, Washington, D.C., various issues, 1963-1986.

_____. News. ASCS Certification Reports: Cotton, Feed Grain, Wheat Acreage. 1978, 1979, 1982-1984.