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THE EFFECT OF ACREAGE REDUCTION PROGRAMS ON THE PRODUCTION OF CORN, WHEAT, AND COTTON: A PROFIT FUNCTION APPROACH

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INTRODUCTION

Acreage control policies have been used to support farm commodity prices since the 1930's. Their cost and effectiveness have been questioned almost as long. One problem is that commodity production is not reduced by the same percentage as diverted acreage. The difference between the naively expected reduction of output and actual reduction in output is termed slippage.

The primary causes of slippage are: 1) participating farmers tend to divert their least productive land; 2) participants and non-participants may apply more non-land inputs to the planted acreage; 3) some participating farmers do not comply with program provisions; and 4) non-participating farmers may increase their acreage of the controlled crop.

With the passage of the Food Security Act of 1985, questions on the effectiveness and cost of acreage reduction programs are of increased importance. By authority of the new act the Secretary of Agriculture has lowered the loan rates for wheat and feed grains for 1986. Since target prices are being maintained at 1985 levels, the difference between loan rates and target prices has increased. Participating farmers receive government payments based on the difference between the target price and the market price (or loan rate if it is higher).

The more inefficient the acreage reduction programs, i.e. the higher the levels of slippage, the less the reduction in total crop output. Smaller than expected decreases in production could lead to increased government expenditures on deficiency payments and commodity loans. Therefore, reliable estimates of production, given a diversion program, are necessary to accurately forecast farm program expenses.

Previous studies of slippage (such as Ericksen; Garst and Miller; Houck and Ryan; and Sharples and Walker) have dealt only with estimation of the effect of diverted acres on acres planted or harvested. That is, they concentrated on changes in acreage, rather than changes in actual production. Slippage estimates from these studies do not reflect program related changes in the average yield of a crop. In particular, these estimates do not capture increases in average yield per acre due to the likely decision by farmers to divert their least productive land. A second problem with past studies is that, in general, they have not included input and expected output prices. However, the announcement of a diversion program influences expected output prices. This in turn, affects farmers' decisions on input usage. For example, all farmers may increase usage of non-land inputs and non-participants may increase the acreage of the program crop.

The primary objective of this study was to estimate the effect of acreage reduction programs on production of specific crops, incorporating input prices and expected prices of own and competitive crops, and complementary products. This allowed for own and cross price effects of these programs to be estimated.

The crops chosen for analysis were corn, wheat, and cotton, with one equation specified for each. In addition, three other equations were added to the model: one for soybeans, one for "other crops", and one for livestock and poultry. Thus, a national model of six equations with production as dependent variables was constructed to examine the direct and indirect effects of diversion programs. Producers were assumed to be price takers and profit maximizers. A multioutput profit function approach was used because the supply equations are easily specified from the function. Therefore, unlike past studies, the structure used in this analysis is an optimizing framework derived from economic duality theory. The period of analysis was 1947-82.

ECONOMETRIC MODEL AND SPECIFICATION

The functional form of the profit function chosen for this study is the generalized Leontief. It is a flexible form in that it gives a second-order Taylor's approximation to an arbitrary profit function and imposes few restrictions on technology (Lopez).

In order to estimate the effect of acreage control programs on production, an aggregate profit function for U.S. agriculture was postulated. The independent variables are expected output prices, current input prices, and the quantities of fixed inputs. The generalized Leontief profit function as specified for this study is:

$$\Pi(p;L,D,T,A) = \sum_{j=1}^{8} \sum_{i=1}^{8} a_{ij}(p_i p_j)^{.5} + \sum_{i=1}^{8} b_i p_i L$$

$$+ \sum_{i=1}^{8} \sum_{k=1}^{3} c_{ik} D_k p_i$$

$$+ \sum_{i=1}^{8} d_i p_i T + \sum_{i=1}^{8} f_i p_i A_i \qquad (1)$$

where:

p_1 = avg. futures price of corn (cents/bushel);

p_2 = avg. futures price of wheat (cents/bushel);

p_3 = avg. futures price of cotton (cents/pound);

p_4 = lagged output price index for livestock, poultry, and products (1967=100);

p_5 = lagged output price index for crops other than corn, wheat, cotton, and soybeans (1967=100);

p_6 = lagged farm price of soybeans (cents/bushel);

p_7 = farm production inputs price index (1967=100);

p_8 = farm wage rate index (1967=100);

D_k = diverted acres of corn, wheat, and cotton, respectively (100,000 acres),(k=1,2,3);

T = smoothed farm productivity index (1967=100);

L = total cropland available for production (100,000 acres); and

A_i = allotment dummy for corn, wheat, and cotton, respectively, which equals zero when acreage allotments are in effect and one when they are not (i=1,2,3); A_i = 0 (i=4,...,8).

Using Hotelling's Lemma, the derived output supply equations are as follows:

$$Y_i = \frac{\partial \Pi}{\partial p_i} = \sum_{j=1}^{8} a_{ij}P_{ij} + b_iL + \sum_{k=1}^{3} c_{ik}D_k + d_iT + f_iA_i$$

$(i=1,...,6)$ (2)

where:

$P_{ij} = (p_j/p_i)^{.5}$

Y_1 = production of corn (million bushels);

Y_2 = production of wheat (million bushels);

Y_3 = production of cotton (million pounds);

Y_4 = output index for livestock, poultry, and products (1967=100);

Y_5 = output index for all crops other than corn, wheat, cotton, and soybeans (1967=100); and

Y_6 = production of soybeans (million bushels).

The symmetry conditions of the profit function imply that $a_{ij} = a_{ji}$. These conditions were imposed on the model via linear restrictions.

The futures prices (P_{ij}; i=1,2,3) are a ten day average of contracts due two months after harvest begins. The inclusion of futures prices as proxies for expected output prices (Gardner), allows for separation of price induced effects from other effects of acreage diversion programs. This overcomes shortcomings of some previous models of slippage which did not include prices and, therefore, may have misspecification errors.

Diverted acreage (D_k) is represented by the acres removed annually from production in the diversion programs during the years 1956 to 1982. The smoothed productivity index (T) is the

USDA index of farm productivity adjusted to remove the random effects of weather. It is included as a proxy for technological change. The allotment dummy variables (A_i) capture additional restraints that were placed on acreage planted under some farm programs. Although compliance with allotment program provisions was not always mandatory, eligibility for additional price supports was an incentive for some farmers to restrict their acreage.

ESTIMATION AND RESULTS

The equation system was estimated using Zellner's Seemingly Unrelated Regression (SUR) method. By utilizing the correlation of the disturbance terms it is possible, through SUR estimation, to obtain estimates of coefficients that are asymptotically more efficient than those obtained by estimating each equation with OLS (Zellner). In addition, SUR permits the use of symmetry restrictions inherent in the profit function approach.

The results of the SUR estimation are presented in Table 1. All regression coefficients for the acreage allotment dummy variables (A_i) are significant and positive. This means that relaxing this type of acreage control has a positive effect on production.

With the exception of cotton, both the available land variable and the technology index have, as expected, a direct influence on production.

Estimated price elasticities of production were calculated

Table 1. Results of SUR Estimation for Production Model*

Coefficient of	Equations for Production: Corn	Wheat	Cotton	Livestock	Crops	Soybeans
Corn Price		-412.89 (433.21)	-1843.5 (938.67)	1.20 (5.36)	-14.32 (8.65)	-1034.4 (366.42)
Wheat Price	-412.89 (433.21)		-154.55 (561.97)	-1.89 (3.21)	18.42 (5.20)	-682.54 (201.21)
Cotton Price	-1843.5 (938.67)	-154.55 (561.97)		7.36 (8.37)	-2.50 (13.68)	17.13 (464.70)
Livestock Price	1.20 (5.36)	-1.89 (3.21)	7.36 (8.37)		-23.07 (2.85)	-1.88 (2.76)
Other Crop Price	-14.32 (8.65)	18.42 (5.20)	-2.50 (13.68)	-23.07 (2.85)		.612 (4.58)
Soybean Price	-1034.4 (366.42)	-682.54 (201.21)	17.13 (464.70)	-1.88 (2.76)	.612 (4.58)	
Input Price	8252.0 (2970.8)	3313.3 (1151.9)	1966.7 (2387.6)	-8.05 (12.11)	11.60 (17.59)	4025.6 (949.88)
Wage Rate	-4788.9 (2714.5)	-2334.1 (998.62)	-3282.5 (2039.6)	28.77 (9.20)	10.13 (13.59)	-3198.7 (842.66)
Corn Diversion	-5.47 (1.18)	-.093 (.412)	3.42 (2.03)	.010 (.005)	.024 (.008)	-.685 (.283)
Wheat Diversion	3.32 (1.77)	-1.88 (.586)	.609 (2.89)	-.005 (.007)	-.012 (.011)	.702 (.394)
Cotton Diversion	4.44 (4.74)	2.04 (1.53)	-24.19 (7.85)	-.003 (.019)	-.031 (.031)	.362 (1.06)
Allotment Dummy	398.54 (171.02)	181.23 (64.51)	1432.2 (358.35)			
Land Available	1.03 (.591)	.560 (.217)	-2.59 (1.08)	-.001 (.002)	.006 (.004)	.503 (.138)
Smoothed Productivity	97.88 (14.00)	35.85 (4.71)	-15.19 (24.61)	.489 (.061)	.377 (.083)	40.37 (3.22)
Intercept	-9841.0 (3879.3)	-4096.0 (1329.7)	24862.0 (6362.0)	55.22 (16.14)	28.72 (23.62)	-4511.8 (916.26)
R^2	.942	.938	.749	.988	.910	.979

* Prices were normalized by the price of the output--See equation (2); Symmetry restrictions imposed; Standard errors in parentheses.

at the variable means for output and input prices. The own elasticities for corn, wheat, cotton and soybeans are -.027, .158, .504, and .377, respectively. The negative corn elasticity does not conform to *a priori* expectations and may be due in part to the failure of the productivity index to reflect the substantial improvements in corn production technology over the period of analysis.

The estimated coefficients of the acreage diversion variables and what has been termed in this study as "partial" slippage coefficients for production (SC_p) are shown in Table 2. All diversion coefficients are significant and have the expected negative sign.

Table 2. Estimated Diversion Coefficients and Corresponding "Partial" Slippage Coefficients

Diversion Variable	Diversion Coefficient	SC_p
Corn	-5.47	.312
Wheat	-1.88	.343
Cotton	-24.19	.496

"Partial" slippage coefficients in Table 2 are calculated as follows: SC_p is equal to one minus the absolute value of the quotient of the diversion coefficient divided by the average crop yield per acre for the program years (1956-82).

The SC_p of .312 (or a slippage of 31.2%) for corn, for example, means that for each percent increase in diverted acres, corn production fell by .688 percent (i.e., 1 - .312). Other SC_p values indicate that production slippage is 34% for wheat, and nearly 50% for cotton.

It is important to note that this partial coefficient of slippage reflects only the yield effect of farmers diverting their least productive land, and any non-compliance that may have occurred. Therefore, the total effect of these diversion programs is greater than indicated by these partial slippage coefficients. The inclusion of futures prices in this model allowed for separation of price-induced responses to the program from the diversion coefficients. The price coefficients should be capturing any increase in input usage or increase in acreage by non-participants.

The primary point here is that slippage cannot be expressed as a single coefficient, as presented in previous studies and often used by policymakers. A system of equations, as utilized in this analysis, more correctly accounts for both direct and indirect effects of the programs and allows for prediction of slippage, given input and expected output prices.

SUMMARY AND CONCLUSIONS

The Farm Security Act of 1985 underscores the role that acreage reduction programs continue to have in agricultural policy. The ability to accurately forecast production changes, when acreage diversion programs are in effect, is necessary to estimate government expenditures.

This study has made several improvements over past studies on the effects of acreage reduction programs. These include:

1) estimating changes in production, thereby accounting for the yield changes associated with diversion programs (past studies only estimated acres planted or harvested; 2) taking the multioutput profit function approach which uses an optimizing framework based on duality theory; 3) including relevant own, competitive and complementary product prices; 4) including input prices; and 5) using the SUR estimation procedure to obtain estimated coefficients that are asymptotically more efficient.

There are, however, some shortcomings of this analysis. The input price indices and the indices for other crops, and for livestock and poultry products are highly aggregated. Multicollinearity is a problem among some of these variables. In addition, there is likely some simultaneity between diverted acreage and the output and input prices. The amount of acreage to divert is primarily determined by program provisions, but the decision to participate is certainly influenced by prices. Future studies on slippage, especially for cotton, should examine possible estimation improvements by using regional models. This approach could provide improved estimates of slippage, which would be expected to vary by region, and could help to overcome shortcomings created by highly aggregated data.

Slippage is a complex issue involving such factors as: the quality of land diverted; the increase in acreage planted by non-participants; the increase of non-land inputs by all farmers in response to a rise in expected output price; and the cross commodity effects brought about by changes in expected prices. The traditional approach of applying a single slippage coefficient to all conditions may be misleading. Therefore, this study sought through the use of a system of equations, to improve over previous efforts, the procedure for estimation of the effect of diversion programs on crop production. Hopefully this, in turn, will lead to more accurate prediction of farm program expenditures.

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