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ALTERNATIVE EMPIRICAL MEASURES OF THE SUPPLY EFFECT OF THE CORN PRICE SUPPORT PROGRAM[1]

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Abstract

A methodology for measuring the supply effect of price support programs using panel data on individual farms is developed and empirically implemented on a sample of 104 Illinois farms, observed over the period 1976-85. The supply effect measures require less restrictive assumptions than analyses based on aggregate time series data.

Corn

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Recent farm programs for major crops have had opposing effects on supply. These programs have required participating farmers to divert land from production to qualify for price support benefits. Price support benefits increase supply; the accompanying diversion requirements decrease supply. Past efforts to measure these effects (Houck and Ryan, Houck et al., Lee and Helmberger, Morzuch, Weaver, and Helmberger) have analyzed aggregate time series of the amount of land planted with crops in the farm programs.

This paper develops and empirically implements measures of the supply effect of farm programs using panel data on individual farms. This is a departure from the previous literature on the effects of farm programs on output in two respects: first, the aim is to measure how much supply was increased or decreased by farm programs in particular years rather than to measure the elasticity of output with respect to one or more policy instruments; second, the data set is a panel of individual farms rather than a panel of states or a national time series.

The individual farm analysis of this study has several advantages over previous aggregate approaches: one need not assume that programs operated in the same way over a long period of time, nor need one assume that the effect of particular price support variables (e.g., the target price) upon supply is either always positive or always negative. Problems caused by aggregating participants and nonparticipants do not arise. Finally, the aggregate studies typically ignore the yield component of output in measuring the supply effects of price support programs; an analysis at the individual farm level makes it possible to address some of the problems arising from correlation between diverted acreage and yields.

This paper is organized as follows: the first section contains the basic methodological contribution of this paper. This section analyzes the supply effects of price support programs by dividing them into effects on the yield component and the acreage component of total output; it then develops four measures of the supply effects of price support programs. The second section describes the data set The third section contains estimates of the supply effect measures. The paper concludes with suggestions for other applications of this methodology.

Measures of the Supply Effects of Price Support Programs

This section develops four measures of the supply effects of price support programs that require farmers to idle acreage in order to receive benefits. These measures decompose output into two components, acreage and yield per acre. All four measures assume that the supply effect can be represented algebraically as:

$$S_t = \sum_{i=1}^{N} \delta_{it}\left(O_{it}^{P} - O_{it}^{N}\right) \quad t = 1, \ldots, T \quad , \tag{1}$$

where i indexes farmers and t years, S_t is the supply effect in year t, δ_{it} is an indicator variable defined as:

$$\delta_{it} = 1, \text{ if farmer i participates in year t,}$$
$$= 0, \text{ otherwise,}$$

O_{it}^{P} is corn output for farmer i in year t if the farmer participates, and O_{it}^{N} is what corn output for the farmer would have been if the farmer had not participated and expected prices had remained the same. Thus the supply effect I investigate is the difference between what was actually produced by participants in the program and what they would have produced had there been no program but expected market prices had remained the same. For supply effect measures based on equation (1) it is necessary to determine what O_{it}^{N} would have been for participants.

Two assumptions about the difference between O_{it}^{P} and O_{it}^{N} lead to the first two supply effect measures. The first assumption, maintained throughout this paper, is that the land that, but for the corn program, would have been planted with corn would have had the same average yield per acre as the land that was actually planted with corn. The second assumption is that without the corn program, each participant would have planted corn on the land he idled as a result of the program, and otherwise would not have changed his allocation of tillable land between different crops. These two assumptions about the supply effect of farm programs on individual participants' output can be translated algebraically as:

$$O_{it}^{P} - O_{it}^{N} = D_{it}\, y_{it} \quad , \tag{2}$$

where y_{it} is farmer i's farm-average yield in year t, and D_{it} is the number of acres diverted by farmer i in year t in the corn program.[2] The first supply effect measure, S_t^1, follows from equations (1) and (2) and the fact that $D_{it} = 0$ when $\delta_{it} = 0$:

$$S_t^1 = \sum_{i=1}^{N} (D_{it}\, y_{it}) \quad , t = 1,\ldots, T \quad . \tag{3}$$

One difficulty with the measure S_t^1 is the fact that y_{it} will not be observed when the farm plants no corn.[3]

A simple measure of the supply effect of farm programs which replaces the individual farm data used in S_t^1 with easier-to-obtain aggregate data is the following:

$$S_t^2 = D_t^A y_t^A \quad , t = 1,\ldots, T \quad , \tag{4}$$

where y_t^A is average corn yield (in bushels per acre) across all farms and D_t^A is the aggregate number of acres diverted. In this case yields are always observed.

However, heterogeneity in yields poses a difficulty for the measure S_t^2. If yields are correlated with the amount of land diverted, then S_t^2 will be a misleading measure of the supply effect of farm programs.[4] S_t^1 will be preferred to S_t^2 as a measure of the supply effect when correlation exists between individual farmers' yields and the number of acres they divert.

The third supply effect measure drops the assumption that the acreage effect of farm programs is simply the number of acres diverted by farmers. To see why this is an important issue, consider the case of two farmers, A and B, identical in all respects until 1978. In 1978, on the basis of an entirely exogenous event, e.g., a coin toss, A becomes a corn program participant while B does not. What is the effect of the 1978 corn program on their output? Under the assumptions maintained throughout, B's output is unaffected by the program and the effect on A is proportional

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[2] Alternatively, one could write $O_{it}^N = O_{it}^P + D_{it}\, y_{it}$,which is an equation expressing what the participant would have produced had there been no program, a quantity which is not observed, in terms of observed quantities.

[3] In my dissertation, I develop a measure which predicts yields when y_{it} is unobserved.

[4] Weisgerber noted that there are two significant sources of variation in yields: across-farm and within-farm. He found that in the 1961-1966 programs, participation rates were higher in regions with lower quality land. This finding implies that the measure S_t^2 would have overestimated the supply effects of the programs in those years.

to the change in corn acreage due to the program. The focus is on A's corn acreage. How much did it rise or fall because of the program?

S_t^1 and S_t^2 answer this question by looking to the number of acres A diverted in 1978. These measures assume that without the program A would have planted the idled land with corn and planted the other land on his farm with the same crops he planted under the program. However, depending upon relative prices and expected price support payments, had he not participated in the program, A might have planted part of the idled land with soybeans instead.[5] In that case, diverted acreage would overstate the effect of the program on corn acreage.

The supply measure S_t^3, developed below, answers the question how much did A's corn acreage rise or fall because of the program by in essence taking B's behavior as a guide to what A would have done had he not participated in the corn program. According to S_t^3, the acreage effect is the difference between A's corn acreage and B's corn acreage. S_t^3 assumes that, had A been a nonparticipant, he would have done the same thing as an otherwise identical farmer who did not participate. In the example only O_{At}^P, A's acreage as a participant, and O_{Bt}^N, B's acreage as a nonparticipant, are observed. S_t^3 in essence sets O_{At}^N, which is not observed, equal to to O_{Bt}^N.

In practice, it is impossible to directly measure what the corn acreage of participants would have been by finding identical nonparticipants. Farmers and their farms differ according to both observable and unobservable characteristics which explain the variation in corn acreage across farms. In order to use information on nonparticipants' output to predict what participants' output would have been had there been no program, it is necessary to develop a specification for corn output which recognizes differences across farmers which affect their corn output.

As an example of why this is true, consider two farmers, C, a participant in the 1978 corn program, and D, a nonparticipant, where the participation decision was made exogenously. In this example, C and D are almost identical. Both farmed the same amount of land in 1977 and both expanded their operations in 1978 by renting new fields of exactly the same size. C and D differ in

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[5] For a theoretical treatment of this point, see Lee and Helmberger.

only two ways. They are located in different parts of the state and in 1977 soybeans were planted on one of the new fields while corn was planted on the other. Note that location is typically known while previous cropping decisions on newly rented land are typically unobserved.

According to the measure proposed above, the participation effect is the difference between C's and D's corn acreages. However, in this case, the measure may be flawed because only part of the difference in corn acreage may be attributable to the different participation decisions; part may arise from the difference in location, and part from the difference in previous cropping decisions. In this case, a specification aimed at determining what C's output would have been had there been no program by comparing his output to D's should take into account the factors other than the different participation statuses of the two farms which cause their corn output to differ.

I will consider the following issues in developing a specification for O^N_{it}: the appropriate dependent variable, what exogenous variables should be included, what properties the disturbances should have, and the problem of the endogeneity of the participation decision. These issues involve the decomposition of the total variation in farmers' acreage decisions into variation owing to observed exogenous variables, participation in the farm program, and unobserved disturbances.

The dependent variable chosen is the fraction of total tillable acreage planted to corn. This is a simple way to control for the size of the farm. Total corn output can be decomposed as follows:

$$O = CA\ y = \left(\frac{CA}{TA}\right) TA\ y \,, \qquad (5)$$

where O is corn output, CA is corn acreage, TA is total tillable acreage (and therefore CA/TA is the fraction of tillable land planted with corn), and y is farm-average yield in bushels of corn per acre. The equation which models the decision regarding the fraction of land that is planted with corn is a linear function:

$$\left(\frac{CA}{TA}\right)_{it} = \alpha_t + \beta_t\, \delta_{it} + X_{it}\Gamma_t + u_{it}\,,\ t = 1, \ldots, T \quad , \qquad (6)$$

where X is a vector of exogenous variables, u is an error term, and δ is as previously defined. It is assumed that the only difference between participants and nonparticipants lies in the value of β_t.

Since programs change every year, it is necessary to specify a different effect for each year.

The exogenous variables included in equation (6) are dummy variables for location (crop production regions) and an index of average soil quality of the farm. The rationale for including these variables is that the allocation of land between different crops depends upon the joint production function of those crops. This function in turn depends upon soil types, rainfall, temperature, and solar radiation. The latter characteristics should vary according to the crop production region and the soil quality rating. The intercept term in the acreage equation summarizes the impact of prices and other variables which are constant across farms in a given year but vary over time. Specification (6) allows the differences between regions to change over time. The disturbance term in the model will capture the impact of unobserved variables.

To derive the supply effect from equation (6), I assume that the decisions on the total number of tillable acres in the farm and on its yield per acre are made independently of the participation and corn planting decisions. The difference in acreage allocation that the program makes is, from (6), β_t. Under the independence assumptions, the output of farmer i if he does not participate in the farm program is

$$O_{it}^{N} = TA_{it}\, y_{it} \left(\alpha_t + X_{it}\Gamma_t + u_{it}\right) , \tag{7}$$

and the output of farmer i if he does participate is

$$O_{it}^{P} = TA_{it}\, y_{it} \left(\alpha_t + \beta_t + X_{it}\Gamma_t + u_{it}\right) , \tag{8}$$

Using equations (1), (7), and (8), the supply effect becomes

$$S_t = \beta_t \sum_{i=1}^{N} \delta_{it} \left(TA_{it}\, y_{it} \right) . \tag{9}$$

S_t^3 is derived by multiplying an estimate of β_t by the sum in the right-hand-side of (9):

$$S_t^3 = \widehat{\beta}_t \sum_{i=1}^{N} \delta_{it} \left(TA_{it}\, y_{it} \right) . \tag{10}$$

The final supply effect measure, S_t^4, modifies S_t^3 by allowing the participation effect to depend on the size of the farm. Equation (6) can be altered to allow participants' acreage to depend on tillable acreage as follows:

$$\left(\frac{CA}{TA}\right)_{it} = \alpha_t + \left(\beta_t + \pi_t TA_{it}\right) \delta_{it} + \mathbf{X}_{it}\Gamma_t + u_{it} \qquad (11)$$

The derivation of the supply effect resulting from specification (11) is analogous to that which produced equation (10) from specification (6). The result is:

$$S_t^4 = \hat{\beta}_t \sum_{i=1}^{N} \delta_{it}\left(TA_{it} y_{it}\right) + \hat{\pi}_t \sum_{i=1}^{N} \delta_{it}\left(TA_{it}^2 y_{it}\right) \qquad (12)$$

The rationale for specification (11) is this: because typically not all the land they operate belongs to a single individual, large farms will in general consist of two or more ASCS farms, while smaller farms may only consist of one ASCS farm. Therefore larger farmers will have more discretion than smaller farmers over what proportion of their land to enter in the farm program.

There are two reasons why this increased flexibility for large farmers might lead them to reduce the proportion of corn acreage on their farms less than small farmers, thereby making specification (6) inappropriate. First, suppose the program reduces the ratio of corn acreage to total acreage on all participating ASCS farms by an equal amount. Then the supply effect will be smaller for farmers who are participating on only part of their land than for farmers who are participating on all of their land. Second, if a farmer does not enter all of his land into the price support program, program rules do not limit his total corn acreage. Under the post-1981 rules, the corn acreage base on any single ASCS farm sets an upper bound on the number of acres the farmer can plant with corn if he enters that ASCS farm in the corn program. However, a farmer who keeps part of his land outside the program can plant as much corn as he wishes on the non-program acreage. This consideration should be especially relevant when the ratio of the expected soybean price to the expected corn price is low; in that case, the corn acreage base constraint is more likely to be binding.[6] Though both arguments suggest π_t should be positive, it is difficult to empirically separate these two reasons for differences in the acreage effect between small and large farms.[7] According to this logic, larger farms will be more likely to participate than smaller farms, but the output of larger farms will be proportionately less affected by the program than smaller farms' output.

There is an important difference between the corn output decision described so far and farmers' actual decision making processes. In reality, the participation decision is not an exogenous choice thrust upon farmers; they make the decision themselves. This fact makes the estimation problem more complicated. Since decisions on participation and acreage are made simultaneously, the participation decision may be correlated with the unobserved components of the acreage equation. In this case, $E(u_{it} \mid \delta_{it}) \neq 0$ and the OLS estimates will be biased. A remedy for the endogeneity problem is to use instrumental variables which are correlated with the participation decision but uncorrelated with the error terms.

The supply measures developed here are likely to overstate the true magnitude of the supply effects of price supports for several reasons. First, they do not take price effects into account. It seems likely that the programs shifted the aggregate supply curve to the left, and therefore raised expected prices of corn. Higher expected prices presumably raised the corn output of both participants and nonparticipants, meaning that O_{it}^N is overestimated. Therefore the effect of the programs on participants' output is overstated. Furthermore, the increase in nonparticipants' output owing to the programs is entirely ignored. Second, participants presumably idled the lowest quality land in their farms whenever possible; the assumption maintained in all the supply measures reported here has been that yields on diverted land would have been the same as yields on the land that remained in production. Third, idling land increases its future fertility and may aid pest-control efforts; these dynamic effects are not taken into account.

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6 See Lee and Helmberger, who incorporate this acreage base constraint into their theoretical model.

7 Both of these arguments apply with greater force to the post-1981 programs. In the 1978-79 programs, all farmers had considerable discretion over how much land to plant with corn.

The Data Set

The data set used in this study comes from the records of the Illinois Farm Business Farm Management Association (FBFM). Garcia, Offutt, and Sonka and Hornbaker, Dixon, and Sonka used the same data set. The records are for farm operators, rather than for landlords or individual plots of land. The data set contains information on, among other things, tillable acreage, acreages of each crop, acreage diverted in government programs, soil quality, location, total assets, and interest payments for 161 cash grain farms in each year from 1976 to 1985. I identify participants in the farm program as those who diverted land from production. Unfortunately, the data does not indicate for which program the farmers are diverting land—the corn or the wheat program. Thus some farmers who divert land may not be participating in the corn program. Accordingly, the empirical analysis concentrates on a subsample of the original 161 farmer data set, consisting of the 104 farmers who did not plant wheat in any year after 1977. For these farmers, there can be no doubt that those setting aside land were indeed participating in the corn program.

Construction of the Supply Effect Measures

In this section, I construct the four measures of the farm program supply effect developed above. I use the FBFM sample and examine the six years between 1976 and 1985 when diversion programs were in operation, i.e., 1978-79 and 1982-85. Measures S_t^1 and S_t^2 can be constructed without recourse to regression techniques. Measures S_t^3 and S_t^4 require estimation of acreage equations (6) and (11). The assumption that farm-average yields are independent of the participation decision underlies all of the reported measures.[8] I turn first to the problem of estimating equation (6). (The issues involved in estimating (11) are very similar.)

One way to account for autocorrelation in equation (6) is to stack the ten cross-section equations for the ten years into a seemingly-unrelated-regressions (SUR) system. Disturbances in

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8 In my dissertation I tested this assumption by estimating fixed-effect yield equations in which dummy variables for participation were included as regressors. The null hypothesis that farm-average yields are unaffected by participation in the price support program amounted to a test of the hypothesis that the coefficients on the participation dummies were equal to zero. The null hypothesis was accepted at the 5% significance level for every program and the joint hypothesis that all programs had zero effect on yields was also accepted.

these equations are distributed independently across individuals and correlation over time is treated by regression packages as correlation across equations (MaCurdy). Since farmers make the participation decision at the same time they decide on corn acreage, it is prudent to treat participation as endogenous to the acreage equation. Consequently, I use an instrumental variables procedure along the lines suggested by Heckman and MaCurdy to obtain consistent estimates of the β_t's. The instruments are a yearly intercept term (which summarizes prices and the value of program incentives common across farmers in a given year), tillable acreage, dummy variables for location, the soil rating, a measure of the farmer's debt-to-asset ratio, and polynomials of these variables.[9]

The acreage equations actually estimated include a complication caused by the special character of the 1983 PIK program. Under PIK, farmers had, in most cases, the option of withdrawing their entire corn base from production. In the 1983 equation a dummy variable, δ_{83i}^{W}, is included to indicate if a farmer chose this option. The definition of δ_{83i}^{W} is

$$\delta_{83\,i}^{W} = 1, \text{ if farmer i both participated in the 1983 program and planted no corn,}$$
$$= 0, \text{ otherwise.}$$

If δ_{83i}^{W} were not included, the coefficient on participation in 1983 would confound the impact of the total acreage base participation option with that of the regular acreage reduction program.

Table 1 contains estimates of the acreage effects for the equations in levels in the SUR framework for specifications (6) and (11). These are instrumental variable estimates, produced by

[9] The justifications for using these variables as instruments are as follows. Both the farmer's financial status and the size of his farm may affect his participation decision. Farmers with high debt-to-asset ratios may be encouraged by their creditors to participate in farm programs in order to guarantee a minimum cash flow. Because of scale economies in grain storage, larger farmers may benefit more than small from the FOR program. Larger farms are also more likely to contain fields which are of poor quality relative to the average quality of land on the farm, making larger farmers more likely to participate. The reason is that the expected price support payment for an ASCS farm depends on the program yield, and therefore on the average quality of land on the farm, while the opportunity cost of the program is the return above variable costs of the most marginal land on the farm. Larger farms have more fields than smaller farms and therefore are more likely to have one which it pays to idle (Rausser, Zilberman, and Just). Several studies of price support programs have found that participants' farms are on average larger than nonparticipants' (Johnson and Short, Lin, Johnson, and Calvin, Vermeer, and Chambers and Foster). Location and soil quality may also influence participation because physical qualities of land may affect the relationship between variable costs and average yields. The attractiveness of deficiency and diversion payments to farmers depends in part on this relationship. Physical characteristics may also affect the variance of output. High-variance farmers may be more likely to use the insurance provided by farm programs.

three-stage least squares, with all instruments employed in each equation.[10] There is substantial, positive cross-equation correlation in the estimates of the stacked equations in levels, which is consistent with the existence of a strong permanent component in the disturbances. Row (1) contains estimates of β_t in equation (6). These estimates can be interpreted as the difference between participants' and nonparticipants' corn acreage, expressed as a percentage of total tillable acreage. According to these results, price support programs in three years, 1982, 1983, and 1984, had significantly negative effects on corn acreage. The estimates of the participation effect are negative but insignificantly so in the other years. The point estimates of the acreage effects range in size from about +1% in 1979 (when only one farmer participated in the program) to -22% and -48% for the farms that diverted some and all, respectively, of their corn acreage in 1983.

Table 1: Instrumented Equations in Levels

Parameter	1978	1979	1982	1983	Whole[a]	1984	1985
(1) β_t	-0.0105	0.0128	-0.0366	-0.2191	-0.4873	-0.0642	-0.0289
	(0.0212)	(0.0411)	(0.0165)	(0.0310)	(0.0637)	(0.0124)	(0.0161)
(2) β_t	-0.0316	0.0141	0.0169	-0.2276	-0.2191	-0.0939	-0.0631
	(0.0722)	(0.0411)	(0.0484)	(0.0445)	(0.2258)	(0.0165)	(0.0186)
π_t	0.0298		-0.0863	0.0233	-0.3977	0.0473	0.0573
(x 1000)	(0.1061)		(0.0761)	(0.0552)	(0.4376)	(0.0193)	(0.0173)
(3) $\beta_t + \pi_t MA_t$ [c]	-0.0120	0.0141	-0.0349	-0.2144	-0.4907	-0.0674	-0.0308
	(0.0212)	(0.0411)	(0.0166)	(0.0311)	(0.0638)	(0.0123)	(0.0154)
MA_t [b]	659	411	601	562	502	559	563
Number of Participants	6	1	12	75	5	76	88

Notes: Standard errors are in parentheses.

[a] The column labeled "Whole" contains parameter estimates of the acreage effect in 1983 for those farmers who took the whole base option in 1983 on all of their land, i.e. planted no corn in response to the PIK program. The acreage effect for these farmers is the sum of the coefficients on δ_{83i} and δ^{W}_{83i}.

[b] MA_t is the mean tillable acreage of participating farmers in year t. For the "whole" column, MA_t is the mean tillable acreage of farmers who took the whole base option.

[10] This procedure is valid if the instruments are exogenous to each and every equation.

Row (2) contains estimates of β_t and π_t in equation (11). (In 1979 only one farmer in the sample participated in the corn program; hence π_t could not be identified.) The parameter estimates and standard errors for π_t have been multiplied by 1000 to facilitate the presentation. Because π_t is significantly greater than zero in 1984 and 1985, these estimates indicate that larger farmers diverted proportionately less than smaller farmers in those years. This result is as expected. 1982 and the whole base option in 1983 are anomalous cases in which larger farmers diverted proportionately more than smaller farmers. However in neither case is π_t significantly less than zero. As predicted, size does not appear to matter in 1978 and 1979.

The fact that, at least in 1984 and 1985, the program-induced reduction in corn acreage was not strictly proportional to the size of the farm is relevant both for empirical measurement of farm program supply effects and for theoretical models of individual farmer decision-making. Theoretical discussions have explicitly considered size only in the context of the participation decision (Rausser, Zilberman and Just (1984), Foster (1986a,1986b)). These papers have not discussed the question whether the effect of farm programs on participants' supply differs systematically according to farm size.

Row (3) contains the estimated acreage effects from specification (11) for farmers whose tillable acreage was the mean for participants in the relevant year, $\beta_t + \pi_t MA_t$. Note that while neither the estimated coefficient for β_t nor that for π_t in 1982 is significantly different from zero, the estimated acreage effect for 1982 participants of average size is significantly less than zero. Note as well that the acreage effect of the 1985 program for the mean size participant becomes significantly negative in this specification. Thus, according to estimates of specification (11), farm programs had significantly negative effects on corn acreage for mean size participants in the years 1982 through 1985.

These estimates are fairly robust to alternative estimation schemes. Two alternatives are cross sections estimated separately for each year and first-differenced equations estimated in the

SUR framework. First-differenced equations are appropriate when fixed effects are present. Results for these approaches, which do not differ substantially from the estimates reported in Table 1, are contained in a longer version of this paper (Howland).

The estimates of the parameters on participation in the different years can be translated into estimates of the supply effects of each of the programs. Table 2 contains the four supply effect measures, with bushels of corn as the unit of measurement. Table 3 reports the same results, but with the measures expressed as percentages of total corn output in the given year.

Table 2: Supply Effect Measures
(bushels of corn)

Measure	1978	1979	1982	1983	1984	1985
S_t^1	-22141	-856	-39942	-867496	-258233	-370161
S_t^2	-23828	-917	-40735	-970278	-260208	-370115
S_t^3	-4991	731	-40189	-868638	-376748	-236355
	(10057)	(2346)	(18089)	(123081)	(72935)	(131385)
S_t^4	-4732	807	-44159	-839324	-359658	-181882
	(10789)	(2350)	(19000)	(125235)	(73382)	(126578)

Standard errors are in parentheses.

Table 3: Supply Effect Measures
(percentage of total output in the given year)

Measure	1978	1979	1982	1983	1984	1985
S_t^1	-0.61	-0.02	-0.89	-43.67	-6.62	-7.79
S_t^2	-0.65	-0.02	-0.91	-48.85	-6.67	-7.79
S_t^3	-0.14	0.02	-0.90	-43.73	-9.65	-4.98
	(0.27)	(0.06)	(0.40)	(6.20)	(1.87)	(2.77)
S_t^4	-0.13	0.02	-0.99	-42.26	-9.21	-3.83
	(0.29)	(0.06)	(0.42)	(6.30)	(1.88)	(2.66)

Standard errors are in parentheses.

To assess the estimates of the supply effects, first compare S_t^1 to S_t^2 using either table. The estimates of S_t^1, which do take into account across-farm variations in yields, are, except in 1983, very close to those for S_t^2, which do not.[11] The near equality of S_t^1 and S_t^2 in other years indicates that, for this sample, diverted acreage and farm-average yields are uncorrelated. In other

[11] In 1983, five farmers took the whole base option of the PIK program and planted no corn. Yields were not observed for these farmers in 1983; therefore the effect on their output is not included in S_t^1 or S_t^3.

words "slippage" in yields across farms did not occur—farms which diverted land were just as productive as farms which did not divert land.

Next, compare S_t^3 and S_t^4 to S_t^1 and S_t^2. Hypothesis tests can be performed comparing S_t^3 and S_t^4 to S_t^1 and to a supply effect of zero. For the years 1978 through 1983, the supply measure S_t^3 is preferable to S_t^4; for 1984 and 1985, S_t^4 is preferable to S_t^3. The reason is that in the earlier years the coefficients on π_t are insignificantly different from zero, while in 1984 and 1985 they are significantly positive. The null hypothesis that supply effects in a given year were zero will be rejected whenever the same hypothesis for the participation parameter of that year is rejected. Thus, according to S_t^3, the 1982, 1983, and 1984 programs caused significant reductions (at the .05 significance level) in the supply of corn for this sample.

The estimates of S_t^3 in 1982 and 1983 are close to the corresponding estimates of S_t^1 for those years. Put another way, these results indicate that the reductions in corn acreage caused by the 1982 and 1983 corn programs were about equal to the amount of land diverted in those programs. The point estimates of S_t^4 for the 1984 and 1985 programs indicate that the measure S_t^1 understates the 1984 supply effect and overstates the 1985 supply effect, though one cannot reject the hypothesis that the two S_t^4 measures are equal to the values given by the corresponding S_t^1 measures. Nevertheless, the contrast between the 1984 and 1985 programs is striking. All parameters of the 1984 and 1985 programs (including the target price, loan rate and diversion requirements) were the same. A comparison of futures prices at planting time in the two years suggests that the expected deficiency payment for corn was at least 15 cents per bushel higher in 1985 than in 1984.[12] In the sample, more farmers participated (and diverted more acreage) in 1985, but the 1985 program reduced total corn output by less than the 1984 program.

The comparison of supply effect measures in Table 3 leads to conclusions on two sets of

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[12] A rough estimate of the expected deficiency payment is the expected price at harvest minus the target price. Since the deficiency payment is a kind of option and is based on the market price averaged over the five months after the harvest, the estimate is imprecise. The high and low prices for the December contract on the Chicago Board of Trade were \$3.025 and \$2.855 in March 1984 and \$2.68 and \$2.6075 in March 1985 (Chicago Board of Trade).

issues. First, the comparison provides evidence that farm programs affect the output of nonprogram crops. Because S_t^4 is greater than S_t^1 in 1984 and less in 1985, it appears that reductions in corn acreage exceeded total diverted acreage in 1984 and fell short of diverted acreage in 1985. Hence acreage of nonprogram crops was also affected by the programs in those years. This evidence that nonprogram crops are affected by farm programs supports assertions made in the theoretical literature (Lee and Helmberger, Love, Rausser, and Freebairn).

The second issue concerns what supply measures to use in gauging the output effects of farm programs. The results are mixed. For the earlier years, 1978 through 1982, the simple measure S_t^1 is in accordance with the more sophisticated measure S_t^3. For 1983 it is necessary to make an adjustment for the fact that corn yields are not observed for some farmers. For 1984 and 1985, S_t^1 apparently understates and overstates, respectively, the supply reductions caused by the corn programs of those years.

Conclusion

The methodology presented above is a promising tool for analyzing the impact of farm programs on supply. The resulting supply effect measures answer a basic, but often overlooked, question, "By how much did the corn diversion program reduce supply?" while avoiding problems associated with aggregate time series methods. The individual farm panel method does not require that farm programs be essentially the same over long periods of time, nor does it face difficulties that arise when one must aggregate the supply responses of participants and nonparticipants.

This method could be used as a tool to compare the impact of price support programs on different types of farms, e.g., livestock as opposed to cash grain, and on farms in different parts of the country. Results of comparative studies on the supply effect of farm programs could suggest interesting questions for future theoretical and empirical work on price support programs.

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