FARM LEVEL CORN ACREAGE RESPONSE ESTIMATION

Perry J. Nutt, Michael R. Reed, and Jerry R. Skees

Abstract

This study reports results of an acreage supply equation using individual farm data and develops implications for bias introduced by use of aggregate data. The analysis shows that use of aggregate acreage response models underestimates the absolute value of price elasticities and the lagged adjustment process. Further, aggregated analyses cannot incorporate some variables found to be important in explaining from level acreage response.

Key words: acreage response, aggregation bias, individual farms.

Impetus for this analysis was derived from the need to incorporate farm level acreage decisions into a simulation model. In the process, it was discovered that no previous research had used farm-level data to model acreage decisions. Therefore, this study reports results of an acreage supply equation using individual farm data and develops implications for bias introduced by the use of aggregate data. Use of individual farm data should provide results which are more applicable for farm-level simulation since such data allow for inclusion of individual farm variables which are important to planting decisions, but cannot be measured accurately with aggregated data (e.g., farm level yield risk).

Simulation models are widely used by agricultural economists to investigate farm-level effects of policy changes (Held and Helmers; Patrick and Eisgruber; Richardson and Nixon; Skees, 1983). A key element in many of these simulation models is the farm decision on acreage devoted to various crops. Many of these simulation models have used the results of previous acreage response studies as model parameters. Data used in these acreage response studies reduce their applicability to analysis of individual farm decisionmaking.

Most previous research estimating corn acreage response functions has used national data (Houck and Ryan; Morzuch et al.). A recent trend has developed to use less aggregated data to estimate acreage elasticities (Reed and Riggins; Whittaker and Bancroft). However, even the most disaggregated studies use data which include 10-15 counties. Thus, aggregation bias is still present and this bias could be reduced using individual farm data.

MODEL SPECIFICATION

The typical specification for acreage response functions stems from Houck and Ryan:

$$(1)\ A = f(M, G, Z),$$

where A is annual acreage planted; M is market influences (e.g., recent own, cross, and input prices), G is government policy variables (e.g., target prices, loan rates, and diversion payments); and Z is the other noneconomic and random variables (e.g., crop rotations, and technology).

Acreage response studies typically use at least 20 years of observations to obtain parameter estimates for equation (1). Whittaker and Bancroft indicated that a time period of such length raises concerns due to problems in measuring technological change and to structural change in the acreage response coefficients. They used pooled time-series (12 years) and cross-sectional data (4 states) to estimate acreage response functions for the Midwest. This pooling of data decreased the number of yearly observations, so that measuring technology was less important, yet provided enough error degrees of freedom for

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accurate estimates. Still, their model was aggregated to the state level.

The model specification used in this study abstracts slightly from equation (1) due to the farm-level nature of the data. Under the belief that farmers make acreage decision on a percentage basis, rather than an absolute basis, given prices, governmental programs, and other considerations, the farmer decides to allocate a certain percentage of cropland to corn. The model estimated is:

$$(2) \qquad CA_{it} = f(ETP_t, APB_{t-1}, EPD_t, TA_{it}, CVR_i, CA_{it-1}),$$

where: CA_{it} = percentage of tillable acres planted in corn on farm i in year t,

ETP_t = the relative effective target price of corn in year t,

APB_{t-1} = the relative price of soybeans in year $t-1$,

EPD_t = the effective diversion rate in year t,

TA_{it} = the tillable acres on farm i in year t,

CVR_i = the ratio of the subjective coefficients of variation for corn and soybean yields on farm i, and

CA_{it-1} = percentage of tillable acres planted in corn on farm i in year $t-1$.

Relative prices are output prices divided by a fertilizer price index. The effective relative target price for corn is the relative price multiplied by the maximum percentage of corn base that may be planted to corn and still qualify for the government program. The effective diversion rate is the diversion payment per acre multiplied by the maximum percentage that can be diverted.

Equation (2) is consistent with the assumption that the profit-maximizing farmer bases the corn acreage decision on the effective relative corn price (in year t) because the target price is known before planting and provides a reasonable estimate of the price for the upcoming year. Lagged soybean prices are included because soybeans are the major supply substitute and market prices for soybeans rarely fall to governmental support levels. Both prices are deflated by a fertilizer price index (as a measure of input prices) to conform with the neoclassical microeconomic postulate that profit functions are homogeneous of degree one in prices; therefore, input demand relationships (which the acreage decision is an example) are homogeneous of degree zero in prices (Varian).

Government program variables enter the specification through the effective target price and diversion payment rate. High effective diversion payment rates encourage producers to reduce corn acreage and comply with government feed grain programs.

Total cropland acreage is included to capture the effects of farm size on input constraints and diversification. As cropland acreage increases, timeliness of planting becomes a constraint that may encourage a smaller percentage for corn. Further diversification may also cause farmers to reduce the percentage of their cropland planted in corn. Thus, as a farm's total cropland acreage increases, the percentage of acreage devoted to corn should fall.

In the past, researchers have not had the luxury of incorporating risk into acreage response models because aggregated data do not lend themselves to risk estimates. However, it is likely that farmers consider the relative risk of one crop versus another in their acreage choice. The coefficient of variation, CVR, reflects the farmer's perception of relative yield risk for corn versus soybeans. As this ratio increases across farms, the percentage of tillable acres devoted to corn is expected to decrease.

The lagged percentage of cropland devoted to corn is included to capture two conflicting effects. The first effect is crop rotation. If a large percentage of cropland is devoted to corn in one year, the next year's percentage might be reduced for rotational purposes (hence, a negative sign). The second effect is a partial adjustment process, where producers do not immediately react to variables, such as expected prices (hence, a positive sign). The coefficient for CA will be the net of these two offsetting influences. Thus, no *a priori* sign is hypothesized.

DATA AND METHODS

The data set included observations from 1974 through 1982 for 27 farms participating in the Farm Business Analysis Program in the Ohio Valley region of Kentucky. The area price for soybeans was the average price received by farmers in the Ohio Valley. Data for the effective target price and diversion payment rate were obtained from *Feed Situation* (USDA). The fertilizer price indices were obtained from prices published by the

Kentucky Crop Reporting Service. These indices were weighted on the assumption that nitrogen, phosphorus, and potassium were applied at a 3:1:1 ratio for corn and 0:1:1 ratio for soybeans. The coefficient of variation for crop yields from these farms was derived using triangular distributions developed from subjective data supplied by the farmers (Skees, 1986).[1]

Residuals from the ordinary least squares estimation of equation (2) were tested for heteroskedasticity by farm and for serial correlation over time. The autocorrelation parameter had to be estimated using aggregate data for the Ohio Valley region because of the few (14 at most) time series observations for individual farms. The estimated first order autocorrelation parameter was not significantly different from zero at the 5 percent level using the Cochrane-Orcutt test. The assumption of homoskedasticity was rejected at the 5 percent level using Bartlett's test, so the data were transformed using the procedure outlined by Kmenta (p. 509).

RESULTS

Table 1 shows the estimated coefficients, standard errors, and mean shortrun elasticities of equation (2). The signs of the estimated coefficients are consistent with *a priori* expectations and are significantly different than zero at the 1 percent level.

The elasticity of the percentage of corn acreage with respect to the relative target price of corn is 0.64, while the elasticity with respect to the relative price of soybeans is −0.47 (both calculated at the mean). These elasticities are higher than those obtained by Reed and Riggins, 0.56 and −0.32, respectively, using aggregate data on the absolute acreage of corn from the same region.[2] The difference is likely due to the effects of aggregation, where aggregate area data "average out" much of variation in acreage response by individual farmers. This averaging out is acceptable when the resultant elasticities are applied to aggregate problems, but not if the elasticities are used to mimic individual farm behavior.

The coefficient for the effective diversion rate is significantly different from zero, but the elasticity is rather small. However, large percentage changes in the effective diversion rate are not unusual, since the diversion rate was zero for many years. The effective diversion rate went from zero to .02 in 1978, which means, given the results of this study, that the percentage of acreage devoted to corn went down by 14 percentage points, which is a substantial reduction.

Farms with larger total cropland acreages tend to reduce the percentage of corn acres. Thus, hypotheses on the input constraint and the role of diversification are supported. The elasticity indicates that a 10 percent increase in total cropland will reduce the percentage devoted to corn by 2.2 percent. The average farm in the sample included 954 acres, with 44.2 percent devoted to corn. Thus, if that farm increased in size by 10 percent, corn acreage would fall from 44.2 to 43.3 percent.

Perceptions regarding relative yield risk have a significant impact on acreage choice. The estimated elasticity for relative yield risk means that a farm with a 10 percent higher relative yield risk for corn versus soybeans will plant 4.8 percent fewer acres to corn.

TABLE 1. ESTIMATES OF CORN ACREAGE RESPONSE FOR THE OHIO VALLEY REGION OF KENTUCKY, 1974-1982[a]

Item	ETP_t	APB_{t-1}	EPD_{it}	TA_{it}	CVR_i	CA_{it-1}
Coefficient	26.40	−5.84	−7.00	−.0001	−.21	.526
Standard error	9.03	1.83	1.57	.00002	.039	.049
Mean elasticity	.64	−.47	−.05	−.22	−.48	.52
R^2		.94				

[a] All variables were significant at the .01 level. Variables are defined as: ETP = relative effective target price, APB = relative price of soybeans, EPD = effective diversion rate, TA = tillable acres, CVR = ratio of the coefficients of variation for corn/soybean yields, and CA = percent of tillable acres planted to corn.

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[1] Each of the farmers was interviewed and asked to give his best assessment of: (1) the lowest yield possible; (2) the most likely outcome; and (3) the highest yield possible. Procedures presented in Law and Kelton were used to develop the first two moments:

Mean = (L + M + H) /3

and

Variance = $(L^2 + M^2 + H^2 - LM - LH - MH) / 18$, where L= low yield, M= most likely yield, and H= high yield.

[2] Reed and Riggins' corn acreage supply elasticities were larger than those obtained by Whittaker and Bancroft. Houck and Ryan did not report elasticities in their study.

The range in the subjective ratio of corn to soybean yield coefficients of variation for the farms analyzed was from 0.509 to 2.091. Thus, the farmer with the lowest subjective relative risk in corn yields would devote 33 percentage points more acres to corn than the farmer with the highest relative yield risk for corn.

The coefficient for the lagged percentage of corn acreage suggests that the partial adjustment process is more important than crop rotation in determining corn acreage. Forty-eight percent of the adjustment toward long-run equilibrium occurs within 1 year (1 − 0.52), which is larger than the adjustment coefficient found by Reed and Riggins. This difference in results is also likely due to the less aggregated data. Lagged corn acreage for an individual farm should be less correlated with current acreage because of rotational considerations. These rotational considerations are averaged out when acreages are summed across farms.

Based on the partial adjustment coefficient, the longrun elasticity of corn acreage supply is 1.32 and the cross-elasticity with respect to soybeans is −0.97. These estimates are smaller than those obtained by Reed and Riggins for the same area, 2.07 and −1.19, respectively, due to the faster adjustment process.

CONCLUSIONS

Future analyses of farm-level behavior should use parameters developed from empirical research using individual farm data. That is the only way accurate measures of farm policy impacts can be obtained. Overall, the results of this research provide increased support for more disaggregated analysis so that more accurate acreage response coefficients can be obtained.

Results of this study consistently show that results from aggregate acreage response models are biased due to underestimation of the absolute value of price elasticities and the lagged adjustment process. Farmers were found to be more responsive to corn and soybean prices, and the farm-level adjustments toward long-run equilibrium occurred at a faster rate.

Aggregated analyses cannot incorporate some variables this study found important in explaining acreage response. Relative subjective yield risk was significantly related to acreage decisions. Variations in yield risk between crops cannot be incorporated into aggregated models because there are no cross-sectional units to estimate yield dispersion. The dependent variable, percentage of acres devoted to corn, cannot be used in aggregated models because no data exist on tillable acres beyond the farm level.

Overall, this research contributes much to the literature on acreage response in that appropriate data have been used with respect to modelling farm-level decisions. By pooling cross-sectional and time series data, problems associated with changing acreage response parameters and technological change have been mitigated. Other researchers should recognize these advances and proceed with further analyses consistent with the procedures developed.

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