THE ANALYSIS OF COTTON ACREAGE RESPONSE IN THE PRESENCE OF GOVERNMENT PROGRAMS

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Abstract

The focus of this study was to examine the nature of cotton acreage response in the presence of government programs and to develop a supply response model which would reflect the impact of major determinants of cotton acreage. The acreage response analysis for the period from 1975 to 1994 was conducted on the state level to recognize the differences in physical restraints, average yields, and returns above costs for different regions of the United States. The results of the empirical estimation indicated that a 10 percent increase in government payments to cotton relative to other crops would cause a 0.37 percent decrease in cotton acreage, *ceteris paribus*. This finding was consistent with the design of the U.S. farm policy and the results of the previous research.

Introduction

In the presence of changing government programs it is important to have an estimate of their impact on cotton production. Therefore, a major objective of this study was to formulate supply inducing variables that would adequately reflect the essence of government programs in conjunction with market information. Farm programs usually change every three to five years and tend to complicate supply estimation because relevant variables and structural parameters may change over time. The development of a generalized method for incorporating government program variables that would allow for continuous analysis of the time series data was one of the specific objectives of this study. In the time of changing market conditions and changes in government policy it was also important to develop an up-to-date information on regional supply elasticity for cotton.

Methodology

The integration of farm programs in crop supply response models has received considerable attention in previous research. Two basic approaches for supply analysis were usually followed: continuous analysis and disaggregated approach. A common base for the continuous analysis was the combination of changing market and policy conditions within the same supply response function. Houck and Subotnik introduced the concept of "effective support price" which was derived by adjusting price support for major crops to reflect the stringency of acreage control imposed on growers as a condition for obtaining this support. Bailey and Womack incorporated farm program provisions and market prices in a single supply-inducing variable--the effective price, which used the higher of the lagged-season average farm price or the loan rate. Shideed, White, and Brannen combined both market and support prices into one price expectation measure: conditional expected prices. Duffy, Richardson, and Wohlgenant used a weighted combination of expected market prices and government policy variables as a proxy for supply inducing prices. Michael Hanthorn used the higher of the loan rate or the expected price, expected yield, and variable production costs in calculating net revenues and argued that net revenues more accurately reflect relative returns to crops than prices in making the planting decisions. Bradley Crowder also used net returns for acreage response estimation where the expected net returns were constructed using a combination of lagged market and support prices and government program variables.

Morzuch, Weaver and Helmberger used a disaggregated approach for analyzing supply. Wheat supply function was estimated for quota, non-quota, and free market situation. A different set of variables was used for estimating supply function under different market conditions. Lee and Helmberger presented a theoretical model which introduced the program participation option in the farmer's acreage allocation decision. The model provided the basis for different expected supply elasticities under "free market" and "farm program" regimes. The supply function for the "free market"regime included lagged prices of corn and soybeans relative to the variable input price index, and trend. Supply response for the "farm program"regime included expected program payments and maximum acreage diversion in addition to variables specified for other years.

In this analysis several statistical tests were performed to check the data set for the presence of the structural change that could have been caused by changing market conditions. The results of the Chow test and the Cumulative Sum of Squares test suggested that there has been a structural change in the Southeast. Although the tests failed to reject the hypothesis of no structural change for the Delta states, other statistical measures (R-squared, t-statistics, signs of the coefficients) indicated the possibility of the structural change occurring. The structural change in the Delta and Southeast occurred in the early 1980s when worldwide demand for cotton declined. This induced production controls for cotton as means of reducing supply. Farm programs have been significantly altered through the introduction of the Acreage Response Program in 1982 that imposed costs on program participation in the form of acreage reduction requirements which were partially offset by attractive benefits via support payments. The lack of response to these changes in the West and Southwest can be

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explained by higher cotton profitability relative to competing crops and lower program participation rates. Data was aggregated for the period 1975-1994 for Southwest and West and for the period 1982-1994 for Delta and Southeast.

Model Specification

This study follows a theoretical framework described by Houck and Subotnik:

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

where A is cotton acreage planted; M represents the composite of all market economic forces which influence the planting decision; G represents all relevant government policy factors affecting farmers' decisions; and Z includes all other supply determinants and random effects.

The market forces component of the model includes all information on prices and costs that farmers receive from the market in the period prior to planting. This information helps farmers draw conclusions about potential profitability of alternative crops and make decisions on acreage allocation. With the current structure of the market system, where a number of sophisticated marketing techniques are available to farmers, it seems inadequate to use lagged market prices as an indication of farmers' expectations. In this study it is assumed that farmers make accurate predictions of the future price situation. Thus, the Gross Value of Production less cash expenses (Net Returns) in the current production period is used as a measure of short term returns to production. This is a better measure of the market forces than lagged or futures prices because it captures the variation in production costs, yields and other related factors, as well as prices received by farmers. Net returns to cotton were considered relative to returns to alternative crops (NR=NRcotton/NRothers). Net returns for alternative crops (NRothers) were calculated using a weighted average, where the returns to different crops were weighted by the acreage planted of the respective crops. The data on net returns were obtained from ERS, U.S. Department of Agriculture and included information for cotton, soybeans, corn, grain sorghum, wheat, barley, and alfalfa hay.

The impacts of government policy were reflected in two explanatory variables. The benefits of program participation were presented via the amount of direct payments to cotton producers. These included the sum of deficiency, diversion, disaster payments, payment-in-kind program, and marketing loan gains. The data on government program payments were obtained from Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture and included information for cotton, corn, grain sorghum, wheat, and barley. The GP variable was calculated as a ratio of program payments for cotton to government payments for other crops: GP = GPcotton/GPothers. The production controls were introduced via a number of acres that farmers had to divert from cotton production. This included acreage diverted under acreage reduction program, payment-in-kind program, paid land diversion, 50/92-0/92 provision, and conservation reserve program. Cumulative values of acreage for all diversion requirements for each state were used in regression analysis. The data were obtained from National Agricultural Statistics Service and Agricultural Stabilization and Conservation Service. One advantage of this variable specification is that it allows for a continuous analysis of different policy instruments over an extended period of time.

The dynamic nature of supply response was discussed by Marc Nerlove in 1956. Nerlove argued that dynamic approach "explains the data better, coefficients are more reasonable in sign and magnitude, and the calculated residuals indicate a lesser degree of serial correlation" than in static approach. One of the major reasons for it is that actual supply cannot adjust immediately to the desired or planned level due to asset fixity. This is especially true in cotton production because of amounts of required cotton-specific equipment. A dynamic adjustment was taken into account by including the lagged dependent variable as an explanatory variable.

The variation represented by Z is a random element which might reflect some specific farmers' objectives, level of crop production technology, and a number of other non-market and non-government phenomena, that are generally not measurable.

Model Description and Results

The theoretical framework described above was used for developing an acreage response model of the following functional form:

$$AREA_{it} = \beta_{i0} + \beta_{i1}AREA_{it-1} + \beta_{i2}DIV_{it} + \beta_{i3}GP_{it} + \beta_{i4}NR_{it} + \epsilon_{it}$$

where *i* refers to cotton producing states; *t* refers to time period where $t = 1$ represents 1975 and $t = 20$ represents 1994; $AREA_{it}$ is annual cotton planted acreage in thousands of acres in region *i* in time *t*; DIV_{it} is area diverted from cotton production in thousands of acres in region *i* in time *t*; GP_{it} is a ratio of government program payments for cotton to government program payments to competing crops in region *i* in time *t*; NR_{it} is a ratio of net returns per acre of cotton to net returns per acre of competing crops in region *i* in time *t*; e_{it} is a mean-zero, serially independent random variable with finite variance; b_{i0} - b_{i4} are the parameters of supply response.

The acreage response model was estimated for the period of study using the state-level data for 15 cotton producing states. The model was estimated using Ordinary Least Squares method. The statistical significance of the model was tested using F-statistic and the coefficient of multiple determination R-squared. The statistical significance of estimated parameters was determined using standard errors and two-tail t-tests. The models were tested and corrected for autocorrelation using an autocorrelation term with one lag. Multicollinearity was detected against high R-squared of the models with insignificant coefficients and large partial correlation coefficients among variables. The variables that did not significantly add to the explainability of the model were deleted from the equations. Economic validity of the models was evaluated by comparing the sign and the magnitude of estimated parameters with *a priori* expectations. The results of the empirical estimation are presented in Table 1.

The results of statistical estimation tend to support Nerlove's partial adjustment hypothesis. The coefficient of the lagged area (A-1) was expected to be positive and of a magnitude less than 1.0. The lagged area variable was significant at 90 percent significance level and had an expected sign and magnitude in all states except Mississippi. One reason for this response could be a combination of competing crops on large farms in the Mississippi Delta. This crop mix allows farmers to reallocate certain amounts of land from one crop to another without any additional costs.

The model showed an inverse relationship between cotton acreage planted and acreage diverted from cotton production in compliance with farm programs. The diverted acreage coefficient (DIV) was significant in all states except New Mexico and had the expected sign and magnitude. The value of the coefficient equal to -1.0 would indicate a 100 percent program participation and acreage reduction proportional to program provisions. The obtained (DIV) coefficients for Arkansas (-0.69), Mississippi (-0.95), Texas(-0.86), Oklahoma (-0.66), California (-0.89), Arizona (-0.86) were less than 1. These results suggest that program participation rate was not 100 percent in these states. The same parameters for Alabama (-2.03), Florida (-2.36), North Carolina (-4.83), South Carolina (-1.32), Georgia (-1.75), Louisiana (-1.08), Missouri (-1.07), and Tennessee (-1.34) were all greater than 1.0. These estimated coefficients for the DIV variable were large in the Southeast, suggesting that acreage planted was very sensitive to diversion provisions and indicating that participation rates in these states were high. This result may also indicate a decreasing trend in cotton plantings in this region. The DIV variable coefficient in Arkansas was rather low (-0.69), which probably reflects the base-building strategy characteristic for this state in 1990-1994 time period. The DIV variable coefficient for Oklahoma was low (-0.66) because of the low program participation rates in this state. Overall, the estimated parameters of this variable were consistent throughout the regions.

Government program payments (GP) were found to be a significant determinant of cotton acreage in most states. The estimated negative sign of GP suggests that supply shifters induced by production control policy were dominant in the period of study. For example, the obtained GP coefficients for Florida, Alabama, and North Carolina suggest that a 10 thousand dollar decrease in government payments would result in a 4.7, 5.8, and 22.1 thousand acre increase in cotton plantings, respectively. However the changes in government program payments may have ramifications on the amount of land diverted from cotton production, therefore these elements should be viewed in conjunction with each other. Government program payments variable was not significant in Texas, Oklahoma, and California at 90 percent level of significance.

The net returns (NR) variable was significant in Mississippi, Tennessee, New Mexico, California, and Arizona at 25 percent significance level. This implies that government program influence was not powerful enough to completely eliminate the impact of the market price movements in these states. The NR coefficient estimates suggest that a 1 dollar per acre increase in net revenues for cotton relative to competing crops would bring about a 5.96, 1.61, 0.98, and 4.14 thousand acre increase in cotton plantings, respectively, in Tennessee, New Mexico, California, and Arizona, and a 15.59 thousand acre decrease in Mississippi. These findings indicate that the cotton industry in the West was more market-oriented than the Eastern states. The negative sign of NR variable in Mississippi was not expected. A possible explanation for this sign could be the whole-farm planning on large Mississippi farms. Mississippi producers collect their revenues not only from cotton sales and government payments for cotton, there are also revenues and governments payments from other crops, such as rice and corn, that also contribute to farm income. In this situation it is hard to separate cotton from the whole-farm crop combination and doing that may yield contradictory results (as is the case with NR). Therefore, cotton revenues should always be viewed in conjunction with other crops.

All state and annual data was pooled to conduct cross-sectional and time-series analysis. Given a high measured value of the partial correlation coefficient between lagged area (A(-1)) and diversion (DIV) (0.58), the diversion variable (DIV) was not included in the equation as a potential source of multicollinearity. All variables that were not significant at the 90 percent significance level were deleted from the equation. The equation was estimated in log-linear form as it reduced the variation in the error term, which corrected the heteroscedasticity problem. An autocorrelation term with one lag (AR(1)) was introduced to correct for possible autocorrelation. The final equation had a following functional form:

$$\underset{}{AREA} = \underset{(3.2287)}{0.185} + \underset{(103.91)}{0.98} \ln AREA_{(t-1)} - \underset{(-4.541)}{0.037} \ln GP - \underset{(-4.128)}{0.23} AR(1) + \epsilon$$

where AREA is annual upland cotton acreage planted in thousands of acres; GP is a ratio of government program payments for cotton to government program payments for competing crops in dollars per acre; AR(1) is autocorrelation term; numbers in parenthesis are t-values.

The model explained more than 96 percent of the variation in upland cotton acreage planted (R-squared = 0.961, Adjusted R-squared = 0.96, F-statistic = 2427.88). All coefficients were significant at 90 percent level of significance and had expected signs. The results of the empirical estimation indicated that a 10 percent increase in government payments to cotton relative to other crops would cause a 0.37 percent decrease in cotton acreage, *ceteris paribus.* This finding is consistent with the design of the farm policy. The coefficient of the lagged area is positive with a magnitude less than 1.00 (0.98) which supports Nerlove's partial adjustment hypothesis. The value of the lagged area coefficient can also be interpreted as a "cotton base" which has remained unchanged from year to year. The autocorrelation term corrects for the negative serial correlation in the model. Overall results provide statistical evidence that the selected variables were effective in measuring variability in cotton acreage response during the period of study.

Concluding Comments

In general, this study provides reasonable results suggesting that the procedure used to reflect the impact of government programs on cotton acreage provides a useful tool for supply analysis. However, the Federal Agricultural Improvement and Reform (FAIR) Act of 1996 significantly changed the structure and the scope of government involvement in agriculture. With this change in government policy, the supply response is also likely to change. It is expected that agricultural production will become more market oriented and, therefore much more variable. In this situation the results of this study can be used for policy analysis as an insight on the effects of government programs on cotton production.

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Table 1. State-Level Cotton Acreage Response Estimation (1982-1994 for Delta and Southeast, 1975-1994 for Southwest and West).

State	Constant	A(-1) 1/	DIV 2/	GP 3/	NR 4/	AR(1) 5/	R^2	Adj R^2
-								
				DELTA				
AR	1221.98	0.11	-0.69	-1.90		0.94	0.91	0.87
	(0.59)	(0.69)	(-2.39)	(-1.01)		(4.77)		
LA	610.63	0.44	-1.08	-0.68		-0.36	0.97	0.95
	(8.71)	(5.87)	(-8.34)	(-9.88)		(-1.12)		
MS	1459.91		-0.95	-1.92	-15.59		0.96	0.93
	(43.55)		(-11.2)	(-7.21)	(-1.64)			
MO	149.54	0.68	-1.07	5.44		-0.41	0.96	0.94
	(4.39)	(7.38)	(-2.98)	(-7.16)		(-1.29)		
TN	293.22	0.65	-1.34	-3.81	5.96	0.48	0.98	0.97
	(7.07)	(12.03)	(-5.62)	(-9.08)	(2.72)	(-1.30)		
				SOUTHEAST				
AL	134.87	1.21	-2.03	-0.58			0.92	0.89
	(1.17)	(6.21)	(-2.20)	(-1.14)				
FL	25.37	0.87	-2.36	-0.47			0.89	0.86
	(2.10)	(4.68)	(-2.18)	(-1.91)				
NC	167.56	0.97	-4.83	-2.21			0.84	0.78
	(2.47)	(5.96)	(-2.10)	(-1.47)				
SC	103.10	0.68	-1.32	-1.90			0.93	0.91
	(4.53)	(5.99)	(-4.15)	(-3.76)				
GA	116.16	1.24	-1.75	-3.53			0.92	0.90
	(1.14)	(6.81)	(-2.25)	(-1.17)				
				SOUTHWEST				
TX	5502.86	0.21	-0.86			0.45	0.85	0.82
	(7.56)	(0.83)	(-6.21)			(5.38)		
OK	255.45	0.56	-0.66			-0.08	0.70	0.64
	(3.37)	(3.71)	(-3.39)			(-1.89)		
				WEST				
NM	30.94	0.72	-1.32	1.61			0.70	0.64
	(2.16)	(5.46)	(-1.46)	(1.11)				
CA	1124.83	0.22	-0.89		0.98	0.47	0.81	0.76
	(7.52)	(1.97)	(-5.45)		(1.25)	(5.12)		
AZ	204.64	0.58	-0.86	-0.04	4.14		0.82	0.77
	(3.60)	(4.96)	(-5.15)	(-3.17)	(1.82)			

Numbers in parenthesis are t-values.

1/ Upland cotton acreage planted lagged one year.

2/ Area diverted from cotton production according to farm program requirements.

3/ Ratio of government program payments for cotton to government program payments for competing crops.

4/ Ratio of net returns for cotton to net returns for competing crops.

5/ Autocorrelation term.