REGIONAL COTTON ACREAGE RESPONSE

Patricia A. Duffy, James W. Richardson, and Michael K. Wohlgenant

Abstract

An econometric model of cotton acreage response was estimated for four distinct production regions in the United States. This work builds on previous work in the area of supply response under government farm programs and provides up-to-date regionalized estimates of own-price elasticity of cotton acreage supply. The own-price variable used in this study is a weighted combination of expected market price and government policy variables. Results indicate regional similarity in response to own price but differences with respect to the prices of alternative enterprises. Differences in regional response to paid diversion are also indicated.

Key words: cotton, supply response, government programs.

To analyze the potential effects of changes in market structure, technology, or government programs, agricultural economists must have reliable, up-to-date estimates of the supply and demand elasticities for agricultural products. Estimating supply response in agriculture requires recognition of government farm programs which affect producers' decisions. Methods for incorporating government farm policy variables in agricultural supply response models have therefore received considerable attention in previous research (e.g., Houck and Subotnik; Houck and Ryan; Houck et al.; Ryan and Abel).

The major objective of this study was to estimate regional acreage supply response elasticities for cotton. Although recent studies have dealt with supply response for wheat (Morzuch, Weaver, and Helmberger; Bailey and Womack), corn, and soybeans (Lee and Helmberger), current information on supply elasticity for cotton is limited.[1] Because of the current market conditions for cotton and possible changes in government policy from deficit reduction strategies, it is important that up-to-date estimates of acreage response for cotton be developed.

The specific objectives of this study were: (a) to specify and estimate regional cotton acreage response equations, and (b) to develop estimates of acreage response elasticities by region and for the U.S. as a whole. Because cotton is a government program commodity, it was necessary to include variables for government program provisions in the supply response equations.

METHODOLOGY

Development of Policy Variables

Two general approaches to estimating supply response in the presence of farm programs can be taken. The first involves grouping years in which similar programs were in effect and performing separate regression analyses on each group. Morzuch, Weaver, and Helmberger followed this approach in modeling planted acreage response for wheat and found that acreage did not respond positively to own-price in years with allotments and quotas. The advantage of this approach is that disaggregation of the time series allows changes in the farm programs to be reflected in the structural parameters. The major disadvantage, as Rausser and Just point out, is that some policy instruments were used for a very short period, making the information gained through historical observation of their impact extremely limited. Another disadvantage to the applied researcher is that this approach could severely limit the degrees of freedom in estimation.

Lee and Helmberger used a disaggregated

[1] Recently, Shumway estimated supply response for Texas field crops, including cotton. He found an own-price elasticity of 0.25 for cotton and a cross-price elasticity of −0.74 for sorghum. Although this is an important contribution in estimating supply response for cotton, the one-state study was not designed to be comprehensive.

Patricia A. Duffy is an Assistant Professor, Department of Agricultural Economics and Rural Sociology, Auburn University; James W. Richardson is a Professor, Department of Agricultural Economics, Texas A&M University; and Michael K. Wohlgenant is an Associate Professor, Department of Economics and Business, North Carolina State University.

approach in modeling acreage response for corn and soybeans in four Corn Belt states. They divided the period 1948–1980 into a "farm program regime" and a "free market regime" and performed separate regressions. They used a pooled cross-section and time-series approach which circumvents the problem of limited degrees of freedom.

Other studies (Bailey and Womack, Shumway) have incorporated farm program provisions and market prices into a single supply-inducing price. This approach is frequently more applicable to a given problem because of the previously mentioned disadvantages of disaggregation.

In this study, an aggregated approach was taken. The Lee and Helmberger pooled cross-section and time-series approach was not used in this model because it is less likely that parameters are the same across disparate regions of the United States than across states in the same region. Alternative enterprises differ across regions, and it was not known *a priori* if regional response to price and policy provisions would be the same.

In the development of policy variables, the basic methodology used by Houck and Subotnik was followed. Alternative policies were represented by different levels of the same policy variable, the effective support price. Houck and Subotnik defined the effective support price (PS^e) as:

(1) $PS^e = r * PA$

where PA is the announced support price (or target price) and r is an adjustment factor which embodies the planting constraints. When the price support is available without restrictions, r is equal to 1. As restrictions become tighter, r moves toward 0.

For set-aside requirements, "r" is fairly simple to calculate. However, from 1954 through 1977 plantings and/or payments were limited by a marketing quota. Houck and Subotnik maintained that under an allotment or quota system, "r" could be approximated by the ratio of permitted acreage to desired acreage at the announced support level. Unfortunately, desired acreage is unknown and must be approximated. As a proxy for desired acreage, Houck and Subotnik suggested using the planted acreage during the last year in which no acreage restrictions were imposed.

Unfortunately, if many years have passed since the last year of unrestricted plantings, it would be unlikely that this adjustment procedure would provide a good approximation. In the late seventies and early eighties, when cotton plantings were essentially unrestricted, acreage reached a maximum of 14.5 million acres. Setting desired acreage at the 1953 level of 26.8 million acres throughout the 25-year period would result in substantial underestimation of the effective support price. In this study, the approximate desired acreage for cotton was made to decrease linearly over time so that by 1980 desired acreage equaled actual acreage in that year. This method is intuitively more appealing than using a 1953 base of 26.8 million to represent desired acreage in the 1970's.

Information about the farm program provisions in effect during the 1959–83 period is presented in Table 1. This information was used to calculate the effective support price. The actual formulae used for these calculations are presented in Appendix 1. During the 1961–63 period, the effective government program price was determined by multiplying the announced price (33.04¢/lb. in 1961) by the ratio of acreage allotment to "desired" acreage (18.46/23.2 in that year). In 1959–60 and again in 1964–70, producers were offered a choice between a high price support tied to a relatively small allotment or a lower price support with a higher allotment. For these years, a simple average of the two possible effective program prices was used.

In 1971 and 1972, cotton producers were guaranteed the announced loan rate on all production as long as acreage equal to 20 percent of the allotment of 11.5 million acres was devoted to soil-conserving uses. If a producer stayed within the allotment, an additional payment of 15¢/lb. was guaranteed. The 1973 program was similar, but the 20 percent acreage reduction provision was dropped.

The 1973 farm bill was enacted during a period of unusually high demand for U.S. agricultural commodities and supply control was deemphasized. The period from 1973 through 1981 was largely free-market oriented, but farm programs continued to provide protection from down-side risk and hence remained important to producers.

From 1974 to 1977, Commodity Credit Corporation (CCC) loans were available on all production while deficiency payments were available on the allotment. The effective policy price in these years was calculated by adding the loan rate to the "effective" deficiency payment (the per pound deficiency payment multiplied by the ratio of allotment acreage to desired acreage). From 1978 to 1981, the farm program for cotton involved a support price and deficiency payments based on actual production. The deficiency payments could be

TABLE 1. GOVERNMENT PROGRAM PROVISIONS FOR COTTON, 1959-1983

Year	Loan Rate	Deficiency Payment	Desired Acreage	Allotment	Acreage Reduction
	...............cents/lb...............		.................million acres..................		
1959	34.10/28.40[a]		24.3	16.30/17.35	
1960	32.42/26.63		23.8	16.30/17.35	
1961	33.04		23.2	18.46	
1962	32.47		22.7	18.46	
1963	32.47		22.1	16.25	
1964	30.00/33.50		21.6	16.20/10.80	
1965	29.00/33.35		21.0	16.20/10.80	
1966	21.00/30.42		20.5	14.20[b]/10.85	12.5%
1967	20.25/31.78		19.9	14.20[b]/10.85	12.5%
1968	20.25/32.49		19.4	16.20/10.85	5%
1969	20.25/34.98		18.9	16.20/10.85	
1970	20.25/37.05		18.3	17.15/11.67	
1971	19.50	15.00	17.8	11.50[c]	20%
1972	19.50	15.00	17.2	11.50[c]	20%
1973	19.50	15.00	16.7	10.00[c]	
1974	27.06	10.94	16.1	11.00[c]	
1975	36.12	1.88	15.6	11.00[c]	
1976	38.92	4.28	15.0	11.00[c]	
1977	44.63	3.17	14.5	11.00[c]	
1978	48.00	4.00[d]			
1979	50.23	7.47[d]			
1980	48.00	10.40[d]			
1981	52.46	18.41[d]			
1982	57.08	13.92[d]			15%
1983	55.00	21.00[d]			20%

[a] When two loan rates and allotments are listed, the higher loan rate is tied to the reduced allotment.
[b] Allotment reduced for acreage reduction program in effect.
[c] Allotment used only for deficiency payment.
[d] Represents the maximum deficiency payment (Target Price - Loan Rate).

limited by a national allocation factor if total U.S. acreage exceeded an announced national program acreage. The lower bound on the national allocation factor was 80 percent. In this analysis, the lower bound was used to develop the effective deficiency payment. In 1982, program participation became linked to an acreage reduction program. A 15 percent reduction of base acreage was required for 1982 and a 20 percent reduction for 1983.

The diversion payment program is an acreage reduction program that is difficult to incorporate into "r." Following Ryan and Abel, a separate policy variable, the effective diversion payment, was used in this study. Ryan and Abel defined the effective diversion payment as:

(2) $DP = W * PR$

where DP is the effective diversion payment, PR is the payment rate ($/unit of yield), and W is a weight reflecting the percentage of acreage eligible for diversion.In this study, effective diversion payment was defined similarly, but an expected per acre payment rate was used instead of a per pound payment rate to reflect regional differences in payment rates based on different yields. The per acre rate was found by multiplying the per pound rate by lagged yield. The 1983 PIK program was treated as paid diversion with PR equal to the loan rate (55¢/lb.).

Supply-Inducing Prices for Cotton

When support prices are high relative to market prices as in the 1960's, the support price should perform well in measuring supply response. In years such as the mid to late 1970's when the support prices are low relative to market prices, it would be expected that producers would respond, at least in part, to the market prices. If a disaggregated approach such as that used by Lee and Helmberger is either infeasible or not desired, a method must be found for allowing a single series to represent producers' response price.

One method is to allow the higher of "expected market price" or the effective support price to represent the supply-inducing price. Shumway used this method with the expected market price formulated as a distributed lag. The major disadvantage of the "either/or" approach is that in years when the lagged (or distributed lag) market price was higher than the support price, the government policy is assumed to have no effect on producer decisions. Because the farm program represents a guaranteed minimum price regardless of market conditions at harvest, the government program can be important even in years of anticipated high market prices.

Bailey and Womack used a more complicated specification of supply-inducing price. When "expected" market price was above the effective support price, expected market price was used as the supply-inducing price. In years when the effective support price was higher than the expected market price, they used a program participation weighted combination of effective support price and expected market price. The expected market price used in their work was a simple lag. The Bailey-Womack specification of supply-inducing price is based on the assumption that program participants respond only to the effective support price while nonparticipants respond only to expected market price.

Romain also developed a formula for supply-inducing price that included both the effective support price and the expected market price. Unlike the Bailey-Womack specification, however, his model always placed at least some weight on the effective support price. Weights in his model were based on the difference between the expected market price and the effective support price. If the effective support price was higher than the expected market price, the effective support price was the supply-inducing price. Otherwise a weight was calculated in the following manner. First, the ratio (PPR) of expected market price (EP^m) and effective support (PS^e) was calculated:

(3) $PPR = EP^m/PS^e$.

The price ratio (PPR) shows the extent by which the expected market price exceeds the effective price support. Next, a weight (WG) was calculated:

(4) $WG = 1/(1 + PPR)$.

The weight was used to calculate the supply-inducing price (SP^e) via the following formula:

(5) $SP^e = WG * PS^e + (1 - WG) * EP^m$.

This nonlinear WG formulation allows increasingly more weight to be placed on the expected market price as the expected market price increases with respect to the effective support price.[2] Alternative formulations of the supply-inducing price could be developed. Romain's formulation was chosen for this study, however, because it is believed to be a better representation of the supply-inducing price for cotton than the "either/or" approach used by Shumway or the Bailey-Womack specification. Neither the Shumway nor the Bailey-Womack approach places any weight on government policy when expected market price is anticipated to be higher than the support. It is believed that risk-averse producers respond, at least in part, to the guaranteed minimum price even when market price is expected to be high. In the relatively free market years of the mid to late 1970's, for example, the cotton program did not require reductions in acreage and all producers were eligible for benefits. The advantage of the Romain formula is that the guaranteed minimum price influences supply, but as the expected market price becomes increasingly high relative to the effective support price, the role of the effective support price in determining supply response diminishes.

For expected market price, Romain used a complex formula of geometric lags and futures price. In this study, the Bailey-Womack approach of using a simple lagged market price was used. This approach was preferred to a more complex specification for several reasons. Futures prices were not deemed appropriate for this study because they do not capture regional quality differences that are important in cotton pricing. In Gardner's original work using futures prices in acreage response, results for cotton changed very little when lagged market price was used instead of futures price.[3] Because Gardner's results indicate that at the national level the one year lagged price performs as well as the futures price, a geometric lag approach was not taken.

Model Specification

Four cotton producing regions in the United States are defined as: (a) the Southeast (Alabama, Georgia, North Carolina, South Carolina, Virginia, and Florida); (b) the Delta (Arkansas, Louisiana, Missouri, Mississippi,

[2] Romain actually used a somewhat more complex formula for expected price when market price was above the effective support price but below the loan rate. The added complexity of this specification is thought to add very little to the formulation of supply-inducing price because, in those years, market price is generally determined by the loan rate. Houck and Ryan found a high correlation between effective support price and lagged market price during the 1949-69 period, suggesting that policy was modified based on immediate past experience.

[3] The parameter estimates on own-price changed by less than 3 percent under the alternative specifications. Gardner concluded that the lagged price and the futures price are good substitutes in cotton supply response.

and Tennessee); (c) the Southern Plains (New Mexico, Oklahoma, and Texas); and (d) the Southwest (Arizona and California). Cotton acreage used in this study is total planted acreage of all varieties. In most states, only upland cotton is produced. Although some Pima cotton is grown in the Southern Plains and Southwest, the question of a differential acreage response for this type of cotton was not addressed in this study because Pima cotton comprises only a small percentage of total cotton acreage in these regions. In 1985, Pima cotton accounted for about 3 percent of cotton acreage in the Southwest, and less than 1/2 of 1 percent of cotton acreage in the Southern Plains.

The regional acreage response equations are of the general form:

$$(6)\quad PA_{it} = a_i + b_iSPC_{it} - c_iEPO_{it} + d_iPA_{it-1} - e_iADP_{it} + f_iT_t + U_{it}$$

where PA_i is thousands of planted acres in region i, SPC_i is the supply-inducing price in region i (¢/lb.), EPO_i is the supply-inducing price of a competing enterprise ($/unit), ADP_i is the effective per acre diversion payment for cotton in dollars, T is a linear trend variable valued at 1 in 1959, U is an error term, and t is a time subscript. Market price used in formulating the supply-inducing cotton price was the regional market-year average price received for all cotton. The regional averages were developed by using share of regional production to weight state average prices. The supply-inducing prices of competing crops were constructed in a similar fashion to those for cotton (Duffy, Appendix A). All prices were deflated to 1970 dollars using the producer price index. The competing enterprise was corn in the Southeast, soybeans in the Delta, wheat in the Southwest, and sorghum in the Southern Plains.[4]

The inclusion of the lagged dependent variable on the right hand side of (6) indicates that a partial adjustment approach was hypothesized. This assumption was used in recognition of the fixed costs of switching out of (or into) cotton production. Harvest equipment in particular is specialized, making short-run adjustment expensive.

The data used in this study were for the 1959 to 1983 time period. Data for acreage, yield, and market price were from the USDA's *Statistics on Cotton and Related Data 1980, Supplement for 1982 to Statistics on Cotton and Related Data,* and *Crop Production, 1983 Annual Summary.* Loan rates and target prices were obtained from Starbird.

The four equations as originally estimated using OLS are reported in Table 2. The own-price variable was significant in the Southeast, the Southern Plains, and the Southwest, but not in the Delta. Penn and Irwin also estimated a coefficient of own-price for the Delta region that was not statistically significant. A comprehensive explanation for the lack of measurable response to price in this region would require additional research, possibly including a survey of producer attitudes towards production alternatives.

The cross-price variable was significant in the Southeast and the Southern Plains. Trend was significant and negative in the Southeast and Delta, positive but not significant in the Southern Plains, and positive and significant in the Southwest. This indicates that cotton production has been moving from the East to the West over the period of the data which is consistent with USDA conclusions (Starbird).

The paid diversion variable was negative in all of the equations and significant in all but the Southeast. The negative sign is consistent with the design of the paid diversion program. Lagged acreage was significant in all regions but the Delta, again indicating a difference in producer decision making in this region relative to other regions.

The high Durbin h for the Southern Plains suggested a problem of serial correlation in this data series. The combination of autocorrelation and lagged dependent variable results in biased parameter estimates because the error term is correlated with a regressor. Additionally, it was expected that contemporaneous correlation existed across equations making Generalized Least Squares (GLS) appropriate.

Because the acreage response equation for the Southern Plains contains a lagged dependent variable, the usual correction for auto-

[4] An alternative formulation with soybeans as the competing enterprise in the Southeast was estimated. This estimate was:

$$SEPLAC = 1288 + 16.50{*}SPC - 253.87{*}EPO - 10.30{*}ADP - 34.03{*}T + .57{*}PA_{t-1}$$

where SEPLAC is southeast planted acreage, SPC is supply-inducing price of cotton, EPO is the supply-inducing price of soybeans, ADP is the weighted per acre deficiency payment, T is a linear trend (1959=1), and PA_{t-1} is lagged acreage. This specification resulted in significance at the 5 percent level on all paramters but ADP which was significant at the 10 percent level. This model was fitted because soybeans may be a better substitute in some, but not all, of the Southeast states. The parameter estimates did not change radically under the new specification which indicated that soybeans and corn work equally well, hence, the original specification was retained.

TABLE 2. OLS ESTIMATES OF COTTON ACREAGE BY REGION, 1959–83[a]

Region	INT	SPC	EPO	ADP	T	PA_{t-1}	R^2	Durbin h	Durbin Watson	Mean acreage
	Explanatory variables									
	estimated coefficients									
Southeast	1335	21.00	−598.52	−7.82	−40.98	.52				
	(0.019)	(0.018)	(0.018)	(0.186)	(0.024)	(0.005)	.95	.79		1521 thous.
Delta	4031	16.23	−190.99	−44.16	−52.15	.12				
	(0.005)	(0.571)	(0.459)	(0.008)	(0.036)	(0.642)	.68		2.19[b]	3569 thous.
Southern Plains	3566	109.21	−2671.63	−132.4	45.68	.38				
	(0.033)	(0.024)	(0.026)	(0.002)	(0.019)	(0.025)	.80	2.77		6557 thous.
Southwest	−455	39.14	−222.71	−9.14	39.75	.42				
	(0.254)	(0.005)	(0.153)	(0.006)	(0.002)	(0.008)	.88	.97		1391 thous.

[a] The variables in the equations are defined as:

INT—the intercept; SPC—the supply-inducing price of cotton (1970 cents per pound); EPO—the expected price of a competing enterprise (1970 dollars); ADP—the expected per acre deficiency payment (1970 dollars); T—trend; PA_{t-1} —lagged acreage.

Numbers in parentheses are significance levels for two-tailed tests.

[b] The Durbin h could not be calculated because of the high variance on the lagged dependent variable. An equivalent test (Judge et al., p. 219) allows rejection of the hypothesis of autocorrelation.

regression could not be applied directly. The method described by Wallis was used to develop an instrumental variable for the lagged dependent variable and then Parks' three-stage Aitken model was fitted to the system. This procedure corrects for both autocorrelation and contemporaneous correlation. Results from a Monte-Carlo study by Kmenta and Gilbert suggest that, for finite samples, this method is superior to both OLS and the seemingly unrelated estimators. In this study Parks' procedure was applied in the following manner: (a) Yule-Walker (Anderson, p. 174) equations were used to estimate rho for the Southern Plains equation with the instrumental variable, (b) a Prais-Winsten transformation of all variables in the equation was performed, and (c) the system consisting of the transformed Southern Plains equation and the original equations for the other three regions was estimated by GLS. These estimates are reported in Table 3.

The GLS estimates differed from the OLS estimates in several respects. Some parameters of the Southern Plains equation changed perceptibly. The coefficient for sorghum price (EPO) was more than halved and the coefficient of lagged acreage declined substantially. The coefficient of own-price did not change dramatically, however, nor was its significance lost. In the Southeast equation, the significance on own-price dropped while the significance on cross-price increased. In the Southwest equation, the parameter estimate for wheat price declined in an absolute sense with a corresponding drop in significance. Changes in equations other than the Southern Plains were due solely to the application of the Seemingly Unrelated Regressions procedure. Given the small sample size (18 degrees of freedom in the OLS estimates), such changes are not unusual.

Because the acreage response equations are partial adjustment models, both short-run and long-run elasticities can be developed. These elasticities, based on Parks' model, are reported in Table 4. The elasticities were developed for the sample mean and for 1981, a representative recent year in which no PIK

TABLE 4: SHORT- AND LONG-RUN PRICE ELASTICITIES BY REGION

Region	Cotton		Alternative Enterprise	
	Short-Run	Long-Run	Short-Run	Long-Run
Southeast				
sample mean	0.273	0.573	−0.500	−1.050
1981	0.529	1.111	−0.936	−1.967
Delta				
sample mean	0.116	0.149	−0.10[a]	−0.13
1981	0.130	0.167	−0.11	−0.14
Southern Plains				
sample mean	0.425	0.587	−0.22	−0.31
1981	0.331	0.458	−0.17	−0.24
Southwest				
sample mean	0.672	1.080	−0.09[a]	−0.15
1981	0.417	0.670	−0.05	−0.08
Weighted Estimate of Elasticity[b]				
sample mean	0.349	0.517		
1981	0.311	0.461		

[a] Parameter not significant in any specification.

[b] Weights for the Southeast, Delta, Southern Plains, and Southwest are, respectively, 0.117, 0.274, 0.503, and 0.106 for the mean; 0.054, 0.218, 0.580, and 0.148 for 1981.

TABLE 3. GENERALIZED LEAST SQUARES ESTIMATES OF REGIONAL COTTON ACREAGE, 1959-83[a]

Region	Explanatory Variables					
	INT	SPC	EPO	ADP	T	PA_{t-1}
			estimated coefficients			
Southeast	1569	14.07	−640.24	−9.19	−46.11	.52
	(0.006)	(0.110)	(0.014)	(0.137)	(0.028)	(0.004)
Delta	3426	14.35	−128.55	−37.47	−46.11	.22
	(0.013)	(0.631)	(0.623)	(0.025)	(0.074)	(0.375)
Southern Plains	2927	102.57	−1314.09	−145.33	46.04	.28
	(0.117)	(0.019)	(0.248)	(0.001)	(0.251)	(0.073)
Southwest	−495	31.50	−75.39	−9.96	44.55	.38
	(0.194)	(0.013)	(0.588)	(0.004)	(0.003)	(0.018)

Weighted R^2 for System: .95

(1) F-test for approximately proportional own-price effect using sample means as weights: $F(3,64) = 0.98$
(2) F-test for equal coefficients on lagged dependent variables: $F(3,64) = 1.08$
(3) Joint F-test for (1) and (2): $F(6,64) = 1.34$
(4) F-test for approximately proportional effect of diversion payments using sample means as weights: $(F(3,64) = 4.33$

[a] Variables defined in Table 2. Numbers in parentheses are asymptotic significance levels for two-tailed tests.

program was in effect. Acreage weighted total U.S. own-price elasticities were also developed. A short-run elasticity of 0.349 was calculated for the sample mean and 0.311 for 1981. The weighted long-run elasticities of acreage response were 0.517 at mean levels and 0.416 for 1981.

These estimates are in the general range of previous estimates. Nerlove's adaptive expectations model applied to cotton acreage over the period 1910 to 1932 resulted in an elasticity of 0.67. By contrast, Gardner's work for the same data period resulted in substantially lower estimates of elasticity, 0.24 in the short run and 0.26 in the long-run. In a 1970 study, Dudley et al. used a double-log specification to estimate regional acreage response elasticities of 1.29 for the Southeast, 0.45 for the Delta, 0.41 for the Southwest, and 0.41 for the West.[5] Shumway's own-price elasticity of total supply response for Texas in 1979 was 0.25 which is somewhat lower than the short-run elasticity of 0.331 for 1981 reported here for the Southern Plains, but not dramatically so.

The cross-price elasticity was relatively large in the Southeast region, indicating the importance of relative price changes. If changes in farm programs or in market conditions affect both cotton and feed grains proportionally, the cross-price effect could dominate in the Southeast. Cross-price effects were also important in the Southern Plains, although the estimated own-price effect was larger. Cross-price effects were not significant in the Delta or the Southwest. This result may be due to collinearity in prices.[6]

F-tests were performed on the system to test several hypotheses regarding equal proportional responses to regressors. The first of these (Table 3) is a test of equal proportional effect of own-price on planted acreage in the short-run. Because the equations are linear, coefficients on own-price would be larger in the regions with more cotton acreage even if the proportional effects were similar. The sample mean acreages were used to develop approximate "weights" for the own-price coefficients, and then cross-equation restrictions were tested. For example, the mean acreage of 6,557 thousand in the Southern Plains is 4.7 times as large as mean acreage of 1,391 thousand in the Southwest. If both regions responded in a proportional manner to price changes, the own-price coefficient in the Southern Plains equation would be approximately 4.7 times as large as the own-price coefficient in the Southwest. Because these "proportionality" hypotheses can be formulated linearly, a simultaneous test for propor-

[5] Dudley et al. reported a significant own-price response for the 1960–69 period when planted acreage was regressed on lagged own-price (undeflated), lagged soybean price (undeflated), and the minimum required diversion. A similar specification over the full period of the data in this study did not result in a significant, positive own-price parameter.

[6] The condition number suggested by Belsley et al. was calculated for all regions. The condition numbers ranged from 353 for the Southeast to 699 for the Southern Plains. Although "large," these numbers are below the "critical" 900 suggested by Belsley et al. Ancilliary regressions were also run and correlation coefficients were computed. Results indicate that correlation between the price series may be a problem for the Southwest equation, but not for the Delta.

tional response to own-price across all regions can be easily obtained.

Because the sample mean is a random variable, this test cannot be construed as a test of equal elasticity across regions (see Miller et al.). The tests of proportionality based on the sample mean are therefore approximate and should not be interpreted as definitive tests. However, if the hypothesis of an approximately equal proportional effect is not rejected, a pooled estimate of elasticity can be obtained from a restricted GLS model.[7] The pooled elasticity, based on approximate proportionality, would provide a useful check against the acreage-weighted elasticity previously developed.

The F-statistic of 0.98 indicated that the hypothesis of a proportional own-price response cannot be rejected. A restricted version of the GLS model (Table 5) was therefore estimated, and the resulting pooled short-run elasticity was 0.36, which is not dramatically different from the weighted estimate (Table 4). The small increase from the weighted estimate was expected. Because the relatively small coefficient on own-price in the unrestricted Delta equation had high variability, the other regions dominated in the pooled estimate.

Because of the lagged adjustments hypothesis, long-run coefficient on own-price would be calculated as b/(1-g), where b is the estimated coefficient of own-price and g is the coefficient of lagged acreage. A direct test of approximately proportional long-run coefficients would involve a complicated test using nonlinear combinations of the parameters. An alternative test was therefore run for equal coefficients on the lagged dependent variables. This hypothesis could not be rejected at the 5 percent level, nor could a joint test of proportional coefficients of own-price and equal coefficients of lagged acreage. Restricted GLS was therefore used to develop a pooled estimate of long-run elasticity (Table 6). The long-run restricted elasticity of 0.64 is higher than the weighted estimate of 0.52. The low coefficient on lagged acreage in the Delta equations was again dominated by the less variable estimates of the other regions.[8]

A final test for approximately proportional effect of the diversion payments was rejected at the 5 percent level (Table 3). These tests indicate that the hypothesis of approximately equal regional responses to changes in the supply-inducing price cannot be rejected but that there is a difference in regional response to paid diversion. At the mean, the Southern Plains is most responsive to paid diversion with an estimate of slightly more than 2 percent of acreage removed from production for each $1.00 per acre of the weighted diversion payment. Approximately 1 percent of acreage is diverted for each dollar in the Delta region, while less than 1 percent is diverted in the Southeast and Southwest. The higher responsiveness to paid diversion in the Southern Plains may be explained by the low returns after cash expenses in that region relative to other regions (see USDA, *Economic Indi-*

TABLE 5. GENERALIZED LEAST SQUARES ESTIMATES OF COTTON ACREAGE WITH ONE RESTRICTION, 1959 - 83[a]

	Explanatory Variables					
Region	INT	SPC	EPO	ADP	T	PA_{t-1}
			estimated coefficients			
Southeast	1451 (0.009)	19.37 (0.002)	−696.36 (0.007)	−8.33 (0.170)	−39.19 (0.033)	.53 (0.004)
Delta	2635 (0.018)	45.05 (0.002)	−150.54 (0.563)	−34.87 (0.033)	−36.69 (0.124)	.18 (0.469)
Southern Plains	3232 (0.070)	83.43 (0.002)	−1139.62 (0.303)	−150.62 (0.001)	22.13 (0.299)	.30 (0.049)
Southwest	−223 (0.470)	17.75 (0.002)	−0.45 (0.997)	−10.45 (0.002)	34.61 (0.005)	.48 (0.002)

Estimate of pooled elasticity at the sample mean: 0.36

[a] Restricted so that the coefficients of own-price are approximately proportional at the sample mean.
Variables defined in Table 2. Numbers in parentheses are asymptotic significance levels for two-tailed tests.

[7] It should be remembered that this pooled elasticity is derived from a pretest estimator. The sampling performance of pretest estimators is discussed in Judge et al., p. 63.

[8] Another set of tests was run for proportional response with 1981 acreage rather than sample mean as the base. Restricted versions of the model based on 1981 acreage were estimated. These estimates resulted in a pooled short-run elasticity of 0.36 and a long-run elasticity of 0.60.

TABLE 6. GENERALIZED LEAST SQUARES ESTIMATES OF COTTON ACREAGE WITH TWO RESTRICTIONS, 1959–83[a]

	Explanatory Variables					
Region	INT	SPC	EPO	ADP	T	PA_{t-1}
	estimated coefficients					
Southeast	1715	18.86	−678.44	−7.70	−48.73	.44
	(0.001)	(0.003)	(0.006)	(0.201)	(0.001)	(0.001)
Delta	1996	43.87	−311.51	−30.22	−24.03	.44
	(0.023)	(0.003)	(0.167)	(0.054)	(0.231)	(0.001)
Southern Plains	2308	81.23	−1026.88	−152.97	20.90	.44
	(0.137)	(0.003)	(0.350)	(0.001)	(0.323)	(0.001)
Southwest	−161	17.28	−11.80	−11.06	37.06	.44
	(0.597)	(0.003)	(0.925)	(0.001)	(0.001)	(0.001)

Estimate of pooled long-run elasticity at sample mean: 0.64

[a] Restricted so that coefficients of own-price are approximately proportional at sample mean and parameters on lagged acreage are equal.
Variables defined in Table 2. Numbers in parentheses are asymptotic significance levels for two-tailed tests.

cators of the Farm Sector, Costs of Production, 1985).

SUMMARY AND CONCLUSIONS

In this study, supply-inducing regionalized prices were developed for cotton. These prices were formulated as nonlinear functions of effective support prices and lagged market prices. Acreage response equations for four cotton-producing regions in the United States were estimated and used to develop estimates of supply elasticties.

Own-price elasticities of supply at the mean ranged from 0.116 (Delta) to 0.672 (Southwest) in the short-run and 0.149 (Delta) to 1.080 (Southwest) in the long-run. An acreage weighted short-run elasticity of 0.35 at the mean was calculated as well as a long-run elasticity of 0.52.

When the hypothesis of approximately equal proportional response to own-price was tested, it could not be rejected. Hence, a pooled estimate of short-run supply response was estimated. This elasticity was found to be 0.36. Similarly, a pooled long-run elasticity of 0.64 was estimated.

The acreage supply estimates showed that the price of a competing enterprise was a significant factor in acreage determination in the Southeast and Southern Plains. Thus, lowering the government payment for cotton alone could result in a decrease in acreage, but jointly lowering government payments for cotton and competing crops may not result in the desired acreage reduction.

The parameter of effective diversion payments was negative and significant in every region indicating that diversion payments may be effective in lowering acreage. Finally, it appears that the Southern Plains is more receptive to paid diversion than the other regions.

Results from this study should be useful in evaluating the effects of future farm program changes or changes in the market prices relative to the effective support prices. Given the current design of the farm program, a lower market price even when combined with a reduced loan rate may not result in a desired reduction in cotton acreage because the target price, if unchanged, will continue to be the supply-inducing price. To reduce the government costs of the cotton program, the supply control provisions of the 1985 farm bill will continue to be necessary unless market prices rebound dramatically.

REFERENCES

Anderson, T. W. *The Statistical Analysis of Time Series,* New York: John Wiley & Sons, Inc., 1971.

Bailey, K. W., and A. W. Womack. "Wheat Acreage Response: A Regional Econometric Investigation." *So. J. Agr. Econ.*, 17,2(1985):171–80.

Belsley, D. A., E. Kuh, and R. W. Welsh. *Regression Diagnostics*. New York: John Wiley, 1980.

Dudley, G. E., J. R. Donald, and R. G. Barlowe. "Yield and Acreage Implications for U.S. Cotton." *Cotton Situation,* CS–247, August, 1970.

Duffy, P. A. "An Analysis of Alternative Farm Policies for Cotton." Unpublished Ph.D. Thesis, Texas A&M University, College Station, Texas, December, 1985.

Gardner, B. L. "Futures Prices in Supply Analysis." *Amer. J. Agr. Econ.*, 58,1(1976):81–84.

Houck, J. P., M. E. Abel, M. E. Ryan, P. W. Gallagher, R. G. Hoff, and J. B. Penn. "Analyzing the Impact of Government Programs on Crop Acreage." USDA-ERS, Technical Bulletin No. 1548, August, 1976.

Houck, J. P., and M. E. Ryan. "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs." *Amer. J. Agr. Econ.*, 54,2(1972):184–91.

Houck, J. P., and A. Subotnik. "The U. S. Supply of Soybeans: Regional Acreage Functions." *Agr. Econ. Res.*, 21(1969):99–108.

Judge, G. G., W. E. Griffiths, R. C. Hill, and T. Lee. *The Theory and Practice of Econometrics.* New York: John Wiley, 1980.

Kmenta, J., and R. F. Gilbert. "Estimation of Seemingly Unrelated Regressions with Autoregressive Disturbances." *J. Amer. Stat. Assoc.*, 63(1970):186–96.

Lee, D. R., and P. Helmberger. "Estimating Supply Response in the Presence of Farm Programs." *Amer. J. Agr. Econ.*, 67,2(1985):193–202.

Miller, S. E., O. Capps, Jr., and G. J. Wells. "Confidence Intervals for Elasticities and Flexibilities from Linear Equations." *Amer. J. Agr. Econ.*, 66,3(1984):392–95.

Morzuch, B. J., R. D. Weaver, and P. G. Helmberger. "Wheat Acreage Supply Response under Changing Farm Programs." *Amer. J. Agr. Econ.*, 62,1(1980):29–37.

Nerlove, M. "Estimates of the Elasticities of Supply of Selected Agricultural Commodities." *J. Farm Econ.*, 38(1956):496–509.

Parks, R. W. "Efficient Estimation of a System of Regression Equations When Disturbances Are Both Serially and Contemporaneously Correlated." *J. Amer. Stat. Assoc.*, 66(1967):500–09.

Penn, J. B., and G. D. Irwin. "A Simultaneous Equation Approach to Production Response: Delta Region." *So. J. Agr. Econ.*, 3,1(1971):115–21.

Prais, S. J., and C. B. Winsten. "Trend Estimators and Serial Correlation." Chicago: Cowles Commission Discussion Paper No. 383, 1954.

Rausser, G. C., and R. E. Just. "Principles of Policy Modeling in Agriculture." *Modeling Agriculture for Policy Analysis in the 1980's,* Kansas City, Missouri: Federal Reserve Bank of Kansas City, 1981. pp. 139–74.

Romain, R. F. "A Commodity Specific Simulation Model for U.S. Agriculture." Unpublished Ph.D. Dissertation, Texas A&M University, College Station, December, 1983.

Ryan, M. E., and M. E. Abel. "Corn Acreage Response and the Set-Aside Program." *Agr. Econ. Res.*, 25(April, 1973):45–55.

Shumway, R. C. "Supply, Demand, and Technology in a Multiproduct Industry: Texas Field Crops." *Amer. J. Agr. Econ.*, 65,3(1983):748–60.

Starbird, I. R. "Cotton: Background for 1985 Farm Legislation." USDA-ERS, Agriculture Information Bulletin, Number 476, p. 2.

U.S. Department of Agricultural, Economic Research Service, Crop Reporting Board. *Crop Production, 1983 Annual Summary*. Washington, D.C., 1984.

U.S. Department of Agriculture, Economic Research Service. *Economic Indicators of the Farm Sector, Cost of Production, 1985*. Washington, D.C., August, 1986. p. 85.

U.S. Department of Agriculture, Economic Research Service. *Statistics on Cotton and Related Data 1980.* Washington, D.C., March, 1980.

U.S. Department of Agriculture, Economic Research Service. *Supplement for 1982 to Statistics on Cotton and Related Data.* Washington, D.C., October, 1982.

Wallis, K. F. "Lagged Dependent Variables and Serially Correlated Errors: A Reappraisal of Three-Pass Least Squares." *Rev. Econ. Stat.,* 49(1967):555-67.

APPENDIX 1. CALCULATION OF THE EFFECTIVE SUPPORT PRICES OF COTTON, 1959–83

Year	Formulae	Effective Support Price
1959	.5*{ (16.3/24.3)*34.10 + (17.35/24.3)*28.4 }	=21.6
1960	.5*{ (16.3/23.8)*32.42 + (17.35/23.8)*26.63 }	=20.8
1961	(18.46/23.2)*33.04	=26.3
1962	(18.10/22.7)*32.47	=25.9
1963	(16.25/22.1)*32.47	=23.8
1964	.5*{ (16.2/21.6)*30.0 + (10.85/21.6)*33.5 }	=19.7
1965	.5*{ (16.2/21.0)*29.0 + (10.85/21.0)*33.35 }	=19.8
1966	.5*{ (16.2/20.5)*.875*21 + (10.85/20.5)*30.42 }	=15.3
1967	.5*{ (16.2/19.9)*.875*20.25 + (10.85/19.9)*31.78 }	=15.8
1968	.5*{ (16.2/19.4)*.95*20.25 + (10.85/19.4)*32.49 }	=17.1
1969	.5*{ (16.2/18.9)*20.25 + (10.85/18.9)*34.98 }	=18.8
1970	.5*{ (17.15/18.3)*20.25 + (11.67/18.3)*37.05 }	=21.3
1971	19.5*(17.8 - 2.3)/17.8 + 15*(11.5/17.8)	=26.7
1972	19.5*(17.2 - 2.3)/17.2 + 15*(11.5/17.2)	=26.9
1973	19.5 + 15*(10/16.7)	=28.5
1974	27.06 + 10.94*(11/16.1)	=34.5
1975	36.12 + 1.88*(11/15.6)	=37.4
1976	38.92 + 4.28*(11/15.0)	=42.0
1977	44.63 + 3.17*(11/14.5)	=47.0
1978	48 + (4*.8)	=51.2
1979	50.23 + (7.47*.8)	=56.2
1980	48 + (10.4*.8)	=56.3
1981	52.46 + (18.41*.8)	=67.2
1982	71*.85	=60.4
1983	76*.8	=60.8