Journal of Agricultural and Applied Economics, 28,1(July 1996):203–210

Nonconstant Price Expectations and Acreage Response: The Case of Cotton Production in Georgia

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ABSTRACT

An adaptive regression model is used to examine the relative importance of cash and government support prices in determining cotton production over time. The results show that the cash price is more important as a source of price information for cotton producers than the government program price. The cash price was shown to have a greater influence on acreage response in every year, including periods thought to be dominated by government commodity programs.

Key Words: adaptive regression, cotton acreage response, price expectations.

Research on acreage response has always encountered the formidable challenge of identifying factors that influence producers' decisions under a constantly changing production environment. Among the most difficult of these factors to identify is the expected output price that drives the production decision. The potential returns to production are the primary driving forces behind acreage decisions (Nerlove). Thus, models of acreage or supply response must incorporate some measure of the expected output price. These price expectations are unobservable and are influenced by a wide variety of factors. Because this "supply-inducing" price is unobservable, researchers must develop proxies for use in empirical analyses.

It is not rational to assume that producers evaluate a single source of price information. Rather, considering improvements in market information and communication, expected prices may be a function of several criteria. Expected cash prices, government program payments, and futures prices are believed to be the components of price expectations used by producers (Chavas, Pope, and Kao). Several different formulations of producers' price expectations have been utilized in modeling supply or acreage response. Perhaps the most common is the use of historical cash prices (e.g., Askari and Cummings), including the "naive expectations" or one-year-lag specification. Other specifications found in the literature include futures prices (e.g., Gardner; Morzuch, Weaver, and Helmberger), combinations of cash and futures prices (e.g., Chavas, Pope, and Kao), and combinations of cash and government support prices (e.g., Duffy, Richardson, and Wohlgenant). Others have examined expectations of rates of return on assets (e.g., Ahrendsen). Recently, several studies have considered the choice of price expectation proxy (Shideed and White; Orazem and Miranowski; Antonovitz and Green; McIntosh and Shumway). Nonnested hypothesis tests were used in each of these investigations to determine which of the proxies was best from a model specification standpoint. In all four studies, the results were inconclusive.

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The authors would like to thank Jack Houston, Fred White, and two anonymous reviewers for comments on earlier drafts of this manuscript.

Most of the research on supply or acreage response has been based on the assumption that all price effects are constant throughout the period studied; notable exceptions include Lee and Helmberger, and McIntosh and Shideed. It is unlikely that the composition of producers' expectations is constant over an extended time period, given the many exogenous effects that influence agricultural prices. Producers likely alter the information mix used in formulating their price expectations over time due to (for example) changes in commodity programs. With continual changes in government programs, and variations in cash and futures prices, producer price expectations should be modeled as changing over time.

The objective of this research is to model price expectations for cotton production in Georgia. Specifically, the supply-inducing price expectation is modeled as a weighted average of market and government prices. A Cooley-Prescott adaptive regression model is used to examine price expectations for cotton acreage response in Georgia (Cooley and Prescott 1973a). The Cooley-Prescott model allows parameters to vary from period to period as determined by the data. This permits a more detailed analysis of how price expectations have changed over time, and how the emphasis has shifted between cash and government prices.

The Model

The model used to estimate acreage response for cotton, utilizing lagged cash and support prices as the supply-inducing price, is specified as follows:

$$(1)\quad AC = f(LAC, EDP, CPC, SPC, CPS),$$

where *AC* is acreage planted (million acres); *LAC* is acreage planted, lagged one period; *EDP* is the effective diversion payment for cotton; *CPC* is the season average cash price of cotton, lagged one period; *SPC* is the effective support price; and *CPS* is the season average cash price of soybeans, lagged one period. The above model assumes a partial adjustment process (Nerlove). Under the assumption of a partial adjustment process, producers adjust output intentions by a percentage of their ultimate desired acreage, assuming that the expected price—in our case some combination of lagged cash price and effective support price—will continue into the future.

The model to be estimated can be written as

$$(2)\quad AC = b_0 + b_1LAC + b_2EDP + b_3CPC + b_4SPC + b_5CPS,$$

where $b_1 \ldots b_5$ correspond to the model parameters to be estimated. Because we wish to derive the relative weights for each price, the following equation is used:

$$(3)\quad b_3 + b_4 = a_1.$$

This allows us to estimate separate weights for both the cash and support prices in the same manner as Chavas, Pope, and Kao. Unlike their study, however, we are primarily interested in the relationship between market and government prices, and thus have not included futures prices in our analysis.[1] By applying equation (3), the parameter estimates can be obtained without nonlinear regression. The individual price weights, a_2 and a_3, are calculated as

$$(4)\quad a_i = \frac{b_j}{a_1}, \qquad i = 2, 3; \quad j = 3, 4,$$

such that $a_2 + a_3 = 1$. The assumption that the individual price weights will sum to one is not imposed, but is necessary in order for the weights to have a coherent interpretation.

Data

Annual state-level data for Georgia for the period 1950 through 1990 were used in this study. The acreage planted data were obtained from the U.S. Department of Agriculture's (USDA's) *Agricultural Statistics.* Two additional USDA sources were used to compile the monthly average cash prices received: *Georgia Agricultural Facts* and *Agricultural Prices.* To deflate the price data, we used a national index of prices paid by farmers for all production items, derived from the USDA's *Agricultural Prices.*

The government program variables used in this

[1] Gardner, examining cotton acreage response, found that futures prices and lagged cash prices were good substitutes in estimation, yielding similar elasticities.

study were constructed as in Houck et al. and as updated by McIntosh. Effective support prices and diversion payments were calculated by reducing the target price, loan rate, or diversion payment by the percentage acreage restriction in order to reflect their equivalent value if no restrictions were required. (For further details on this calculation, see Houck et al.)

Estimation Method

The adaptive regression model assumes the parameters to be estimated are affected by and are the sum of both transitory (in the current period) and permanent (continuing into the future) changes. The model treats the transitory disturbance in the intercept as the customary additive error term. The permanent elements of parameters are allowed to fluctuate over time without inclination of returning to a mean value (Cooley and Prescott 1973b). The time-varying parameter model is constructed as follows:

$$(5)\quad y_t = X_t'\beta_t, \qquad t = 1, 2, \ldots, T,$$

where y_t is the tth observation relating to the dependent variable, X_t is a k component vector of explanatory variables, and β_t is a k component vector of parameters which are variable. The changes in the parameters over time are hypothesized as

$$(6)\quad \beta_t = \beta_t^p + u_t,$$
$$\beta_t^p = \beta_{t-1}^p + v_t,$$

where p signifies the permanent component of the parameters. Both u_t and v_t are identically and independently distributed with mean vectors of zero and covariance structures such that

$$(7)\quad \text{cov}(u_t) = (1 - \gamma)\sigma^2\Sigma_u,$$
$$\text{cov}(v_t) = \gamma\sigma^2\Sigma_v,$$

with $0 \leq \gamma \leq 1$. Σ_u and Σ_v are assumed known up to scale factors and provide inference concerning the relative variability of the parameters. The relative significance of the permanent element of parameter variation is gauged by the unknown parameter, γ. As the value of γ becomes larger, more emphasis is attributed to permanent changes.

The goal of estimation is to derive estimates for γ, σ^2, and the permanent components of β_t. Since the procedure for computing the parameters is continuous, the maximum likelihood function cannot be defined. However, the likelihood function is defined for the parameter process at some point in time; thus, the process can be "stopped" at a specific point to obtain estimates of the unknown parameters. The log likelihood function at a particular point may be written as follows:

$$(8)\quad L(Y;\beta,\sigma^2,\gamma,X) = -T/2\Big(\ln(2\pi) + \ln(\sigma^2) + 1/T\ln|\Omega_{(\gamma)}|\Big) - 1/2\sigma^2(Y - X\beta)' \cdot \Omega_{(\gamma)}^{-1}(Y - X\beta).$$

By partially maximizing the log likelihood function with respect to β and σ^2, and substituting these into (8), we can obtain the concentrated likelihood function (Cooley and Prescott 1976):

$$(9)\quad L_c(Y;\gamma) = -T/2(\ln(2\pi) + 1) - T/2\ln(\sigma^2_{(\gamma)}) - 1/2\ln|\Omega_{(\gamma)}|.$$

Globally maximizing the log likelihood function (8) is parallel to maximizing the concentrated likelihood function (9). Equation (9) can be evaluated over a number of points within the $0 \leq \gamma \leq 1$ range. Thus, an estimate of γ (e.g., g) should be chosen such that

$$(10)\quad L_c(Y; g, X) \geq L_c(Y; \gamma_i, X)\ \forall\ i.$$

Cooley and Prescott (1976) demonstrate that (10) provides a consistent estimator of γ; this indicates that the estimates of β and σ^2 are asymptotically efficient. As Cooley and Prescott suggest, it is reasonable to assume, *a priori,* that the importance of both permanent and transitory changes is equivalent for all parameters. This assumption implies that the matrices of Σ_u and Σ_v are equal. Furthermore, they propose that if changes in the parameters are not assumed to be correlated, then both matrices can be assumed to be diagonal. While the partial adjustment model may introduce autocorrelation, Ward and Meyers have shown that the adaptive regression model can ameliorate statistical problems such as serial correlation. (For more complete details on the adaptive regression model, see the Cooley and Prescott works cited.)

Table 1. Parameter Estimates and Standard Errors for Georgia Cotton, 1950–90

Year	$\hat{\gamma}$[a]	INT	*LAC*	*EDP*	*CPC*	*SPC*	*CPS*
1950	.98	0.00899	0.15368	−0.00145	0.85676	0.53833	−0.01685
		(0.21122)	(0.11878)	(0.88743)	(0.22954)**	(0.26798)*	(0.03808)
1951[b]	.00	0.06357	0.71414	−1.72622	0.48031	0.05831	−0.04310
		(0.07978)	(0.06943)**	(0.95538)*	(0.15169)**	(0.17744)	(0.01658)**
1952	.98	0.04220	0.23624	−0.11914	0.79789	0.38523	0.02750
		(0.18961)	(0.07887)**	(0.82947)	(0.19442)**	(0.22658)*	(0.02246)
1958	.60	−0.25505	0.36785	−0.43031	0.79073	0.71020	−0.07924
		(0.13114)*	(0.10386)**	(0.74618)	(0.21361)**	(0.20884)**	(0.03280)**
1960	.28	−0.03941	0.50873	−1.56326	0.80907	0.19312	−0.06308
		(0.11520)	(0.09034)**	(0.79497)*	(0.18857)**	(0.19261)	(0.03047)**
1961	.24	−0.03837	0.52213	−1.39127	0.81499	0.03882	−0.04720
		(0.11767)	(0.08648)**	(0.88961)	(0.18362)**	(0.19199)	(0.02879)
1968	.26	−0.11217	0.52123	−0.70267	0.74322	0.41926	−0.02804
		(0.10223)	(0.08711)**	(0.88271)	(0.16712)**	(0.19896)**	(0.01843)
1969	.46	−0.13862	0.45098	−1.37777	0.97082	0.33191	−0.02877
		(0.09641)	(0.08670)**	(0.81297)*	(0.15931)**	(0.19519)*	(0.01939)
1970	.20	−0.00366	0.55888	−1.47950	0.83559	0.07515	−0.03763
		(0.08763)	(0.08246)**	(0.84900)*	(0.16751)**	(0.19023)	(0.01944)*
1978	.68	−0.24792	0.35326	−0.47127	0.73215	0.30643	−0.03391
		(0.10687)**	(0.13598)**	(0.86790)	(0.18415)**	(0.18616)	(0.02023)
1979	.92	−0.02807	0.30272	−1.46430	0.61562	−0.04206	−0.02774
		(0.08310)	(0.15338)*	(0.81140)*	(0.14534)**	(0.18572)	(0.01926)
1980	.74	0.04125	0.25066	−0.70307	0.68565	−0.06114	−0.04537
		(0.07906)	(0.16171)	(0.91524)	(0.20459)**	(0.20249)	(0.02211)**
1981	.82	0.14322	0.14633	−0.48654	0.47725	−0.03791	−0.04175
		(0.07611)*	(0.16878)	(0.88176)	(0.19972)**	(0.16817)	(0.02249)*
1982	.76	0.17418	0.28197	−0.74545	0.54471	0.00315	−0.06123
		(0.07828)**	(0.16900)	(0.96894)	(0.20756)**	(0.16492)	(0.02275)*
1983	.94	0.32750	0.17791	−1.72039	0.48171	−0.19856	−0.09256
		(0.08624)**	(0.18931)	(0.81020)**	(0.18987)**	(0.13306)	(0.02294)**
1987	.98	0.14751	0.15284	−0.29265	0.68736	0.34036	−0.09278
		(0.10190)	(0.12415)	(0.94917)	(0.23141)**	(0.15114)**	(0.01971)**
1988	.98	−0.11081	0.24323	−0.45305	0.65008	0.27404	0.00311
		(0.11198)	(0.16469)	(0.89439)	(0.22402)**	(0.16368)	(0.02060)
1989	.98	0.10500	0.19529	−0.49208	0.64147	0.11695	−0.03707
		(0.12432)	(0.18074)	(0.89330)	(0.22973)**	(0.20290)	(0.02342)
1990	.98	0.02162	0.14657	−0.07297	0.66927	0.24383	−0.01799
		(0.14478)	(0.18304)	(0.94213)	(0.22491)**	(0.21584)	(0.03120)

Notes: Standard errors are in parentheses. Single and double asterisks denote significance at the .10 level and the .05 level, respectively. INT denotes intercept, *LAC* is the lagged acreage planted, *EDP* is the effective diversion payment, *CPC* is the lagged cash price for cotton, *SPC* is the effective support price for cotton, and *CPS* is the lagged cash price for soybeans.

[a] Maximum likelihood estimation was performed for $0 \leq \hat{\gamma} < 1$ in increments of 0.02. Note that if $\hat{\gamma} = 1$, estimates cannot be obtained due to singularity of the variance-covariance matrix.

[b] For years when $\hat{\gamma} = 0$, the parameter estimates and standard errors are identical. This occurred for the following years: 1951, 1953–57, 1959, 1962–67, 1971–77, and 1984–86. Because parameter estimates and standard errors for these years are identical to those from 1951, they have been omitted from this table for space considerations.

Results

Results from the adaptive regression model are illustrated in table 1. Table 1 includes the estimates of γ and the permanent components of β as well as the approximate standard errors for β. Estimated cotton acreage response elasticities of *CPC*, *SPC*, and *CPS* with respect to cotton acreage were calculated by utilizing each period's β estimate and respective price and quantity data over the full observation set. The estimated acreage response elasticities are shown in table 2.

Table 1 shows that the parameter estimates for lagged acreage (*LAC*) were significant at the .10 level or better for most observations, as were the parameter estimates for effective diversion payments (*EDP*), the cash price for cotton (*CPC*), and the cash price for soybeans (*CPS*). *EDP* had the expected negative sign for all observations, and *CPC* the expected positive sign. *CPS* had the expected sign at all observations except two (1952 and 1988). The parameter estimate for the support price of cotton (*SPC*) was significant at the .10 level or better for only six out of 41 observations. In addition, the *SPC* estimates had incorrect signs in four observations (1979, 1980, 1981, and 1983).

For the period 1975 through 1984, the elasticity estimates in table 2 are uncharacteristically high relative to the other observations. This is due, in part, to the negative signs for the parameter estimates of support price in 1979, 1980, 1981, and 1983. The negative signs violate the coherence assumption on the parameter weights, i.e., the assumption that the individual parameter weights will sum to one. In each of these cases, the parameter estimates used to calculate the elasticities are not significantly different from zero. For the other observations in this range, the elasticities were large because cotton production in Georgia decreased during this period due to drought conditions and the payment-in-kind (PIK) program. The drought conditions and the PIK program caused the acres planted to cotton to decrease. This, in turn, causes the elasticities to increase.

The relative weights of *CPC* and *SPC* with respect to the supply-inducing price are presented in table 3. The weights as well as $\hat{\gamma}$ and the elasticity estimates from table 2, averaged over "program" and "nonprogram" years, are shown in tables 4 and 5, respectively. Years in which acreage control programs were in effect were considered program years, while nonprogram years coincided primarily with market influences. Program years were presumed to be 1950, 1954–58, 1961–73, 1978–79, and 1983–90. Nonprogram years were considered to be 1951–53, 1959–60, 1974–77, and 1980–82 (as in Lee and Helmberger).

The relative weights for the market and government program prices (table 3) show that the market price receives a higher weight. This suggests that, on a state aggregate level, the market price is the dominant source of price information for cotton

Table 2. Estimated Own-Price and Cross-Price Elasticities of Georgia Cotton Acreage with Respect to Cotton and Soybean Prices, 1950–90

Year	Own-Price Elasticity (*CPC*)	Own-Price Elasticity (*SPC*)	Cross-Price Elasticity (*CPS*)
1950	0.59339	0.28042	−0.11464
1951	0.32171	0.02819	−0.21115
1952	0.44438	0.18071	0.11621
1953	0.26909	0.03116	−0.19111
1954	0.34734	0.03313	−0.24607
1955	0.43833	0.03340	−0.30889
1956	0.44431	0.03355	−0.26643
1957	0.62636	0.04628	−0.38473
1958	1.42287	0.87501	−0.99329
1959	0.55441	0.03713	−0.28331
1960	0.85858	0.11742	−0.39412
1961	0.78394	0.02558	−0.28724
1962	0.48943	0.03667	−0.30089
1963	0.51284	0.03579	−0.33003
1964	0.51350	0.02492	−0.36483
1965	0.49546	0.02568	−0.39435
1966	0.69579	0.03310	−0.54145
1967	0.57974	0.04160	−0.72051
1968	0.93797	0.24991	−0.33643
1969	1.04337	0.20471	−0.34385
1970	0.77850	0.05031	−0.43272
1971	0.43416	0.05825	−0.55273
1972	0.51379	0.05103	−0.46912
1973	0.56594	0.05374	−0.78896
1974	0.88101	0.05240	−0.77887
1975	1.38380	0.14326	−2.15274
1976	1.10282	0.09590	−0.86371
1977	1.37854	0.11644	−1.24418
1978	3.03404	1.22004	−1.74071
1979	2.12530	−0.12362	−1.05888
1980	2.02888	−0.14949	−1.33437
1981	1.43681	−0.09819	−1.26907
1982	1.17703	0.00761	−1.62445
1983	1.45412	−0.47877	−2.80257
1984	1.15727	0.08525	−1.22183
1985	0.68129	0.04203	−0.64993
1986	0.74373	0.03010	−0.61275
1987	0.95496	0.54778	−1.22414
1988	0.77557	0.33119	0.03371
1989	0.85107	0.14724	−0.65041
1990	0.74381	0.25621	−0.17225

Table 3. Relative Price Weights for Georgia Cotton Acreage, 1950–90

Year	*CPC*	*SPC*	Overall Coefficient
1950	0.61412	0.38587	0.39509
1951	0.89173	0.10826	0.53862
1952	0.67439	0.32560	1.18311
1953	0.89173	0.10826	0.53862
1954	0.89173	0.10826	0.53862
1955	0.89173	0.10826	0.53862
1956	0.89173	0.10826	0.53862
1957	0.89173	0.10826	0.53862
1958	0.52682	0.47317	1.50093
1959	0.89173	0.10826	0.53862
1960	0.80730	0.19269	1.00219
1961	0.95453	0.04546	0.85380
1962	0.89173	0.10826	0.53862
1963	0.89173	0.10826	0.53862
1964	0.89173	0.10826	0.53862
1965	0.89173	0.10826	0.53862
1966	0.89173	0.10826	0.53862
1967	0.89173	0.10826	0.53862
1968	0.63934	0.36065	1.16247
1969	0.74522	0.25477	1.30272
1970	0.91748	0.08251	0.91075
1971	0.89173	0.10826	0.53862
1972	0.89173	0.10826	0.53862
1973	0.89173	0.10826	0.53862
1974	0.89173	0.10826	0.53862
1975	0.89173	0.10826	0.53862
1976	0.89173	0.10826	0.53862
1977	0.89173	0.10826	0.53862
1978	0.70495	0.29504	1.03858
1979	1.07333	−0.07333	0.57355
1980	1.09790	−0.09790	0.62450
1981	1.08629	−0.08629	0.43933
1982	0.99424	0.00575	0.54786
1983	1.70126	−0.70126	0.28314
1984	0.89173	0.10826	0.53862
1985	0.89173	0.10826	0.53862
1986	0.89173	0.10826	0.53862
1987	0.66882	0.33117	1.02771
1988	0.70345	0.29654	0.92411
1989	0.84579	0.15420	0.75842
1990	0.73296	0.26703	0.91309

producers, and that government support prices impact production decisions, but to a lesser extent.

The average expectation weights given in table 4 are consistent with program and nonprogram influences. The average value of *SPC* (.134) under

Table 4. Average Values of Weighted Coefficients for Georgia Cotton Acreage over Program and Nonprogram Periods, 1950–90

	Cash Price (*CPC*)	Effective Support Price (*SPC*)
Program	0.86537	0.13462
Nonprogram	0.90852	0.09147

Notes: The program years are 1950, 1954–58, 1961–73, 1978–79, and 1983–90. The nonprogram years are 1951–53, 1959–60, 1974–77, and 1980–82. (These categories are defined as in Lee and Helmberger.)

program years exhibited a greater impact on cotton acreage relative to nonprogram years (.091). The average magnitude of lagged cash price (*CPC*) exhibited a greater effect on cotton acreage in nonprogram years (.908) compared to program years (.865). This result is expected, since market forces were believed to dominate during those years. On average, the weighting within the supply-inducing price (table 4) indicated that emphasis increased to effective support prices in program years and to lagged cash prices in nonprogram years. However, cash prices were found to have a greater influence on acreage response of cotton than were support prices in every year. The significance of lagged cash price for soybeans (*CPS*, table 1) supports the conclusions of Duffy, Richardson, and Wohlgenant concerning the importance of alternative enterprises for cotton in the Southeast.

Table 5 provides the $\hat{\gamma}$ and elasticity estimates with respect to program and nonprogram years. The average own-price elasticity of *SPC* was more price responsive in program compared to nonprogram years, indicating influential effects of government programs in this model.

The voluntary nature of government programs is the contributing factor that best explains the difference in acreage response price elasticities for a program versus nonprogram comparison. An individual's participation decision depends on the returns from participation compared to nonparticipation. It seems reasonable to assume that producers would be more responsive to program stipulations relative to free-market forces when considering the opportunity costs involved in participation (e.g., land set-aside programs) and how these costs may

Table 5. Average Values of $\hat{\gamma}$ and Own- and Cross-Price Elasticities for Georgia Cotton Acreage over Program and Nonprogram Periods, 1950–90

	$\hat{\gamma}$	Own-Price Elasticity (Cash)	Own-Price Elasticity (Support)	Cross-Price Elasticity
Program	0.31724	0.66994	0.11199	−0.43800
Nonprogram	0.29833	0.62940	0.05897	−0.41920

Notes: Refer to notes to table 4.

vary among producers. This argument is analogous to the "indifference price" for program participation logic developed by Lee and Helmberger.

The contention by Pope concerning commodity supply increases under government programs argues that producers most likely do not have similar subjective expectations of price. Pope noted that announced support prices truncate the aggregate distribution of price expectations and induce, *ceteris paribus,* aggregate output to rise.

Both *EDP* and *SPC* were significant in nonprogram periods. This conclusion simultaneously supports Romain's contention of governmental influence during nonprogram years and refutes the notion of temporal disaggregation.

Conclusions

This study has examined the effects of both producers' price expectations and government programs on acreage response over time. The results were analyzed over program and nonprogram years from 1950–90. The estimated model utilizing lagged cash and support prices suggests that government program variables had more of an impact in program years, whereas market forces appeared to be more dominant in nonprogram periods (table 4). Furthermore, acreage response with respect to cotton support prices was shown to be more own-price responsive in program years, possibly reflecting the influences of opportunity costs and subjective price expectations on the participation decision.

Program variables were also significant in nonprogram periods, suggesting stabilization and risk management effects of government programs. Producers were more own-price responsive to support prices under program versus nonprogram years. The estimates of $\hat{\gamma}$ fluctuated between program and nonprogram periods. This implies that historical programs have had permanent effects on acreage response throughout time.

By allowing supply-inducing price information to vary over time, this study differs from previous research. Based on the parameter estimates and their approximate standard errors, inference concerning estimates of *EDP, CPS,* and inclusive supply-inducing prices is more indicative of producer response and government programs when allowing the parameters to vary over time, thus refuting the notion of parameter constancy. Agricultural production practices are subject to permanent structural changes due to such factors as commodity policies, environmental regulations, and consumer preferences (to name a few). The assumption of parameter constancy is not valid when examining aspects of agricultural production that are directly influenced by these factors.

Given the dynamic nature of government programs over time, ignoring the differences in empirical estimation between program and nonprogram periods not only may result in inefficient estimates, but also may preclude a thorough analysis of how producers have responded to expected price information. The latter argument could have significant implications concerning future governmental policy analysis with respect to the evaluation of previously implemented programs. In allowing parameter variation over time, this study yields greater precision in examining various impacts on supply response.

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