Conservation Tillage, Irrigation and Variety Selection Impacts on Cotton Quality Premiums, Discounts and Profitability: Evidence from the Gin

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Abstract

Fluctuating market prices, increasing production costs, and shifting mill demand, has made cotton markets more uncertain, making cotton quality a more important aspect of the profitability of cotton. The purpose of this research project is to examine the effect conservation tillage systems and variety selections have on cotton quality attributes and cotton profitability. Such information may be useful to agencies promoting conservation tillage systems for cotton producers. In addition, knowledge of these types of effects may help producers and gins maximize profits by providing guidance on variety selection and production decisions that improve cotton lint quality.

Introduction

Fluctuating market prices, increasing production costs, and shifting mill demand, has made cotton markets more uncertain, making cotton quality a more important aspect of the profitability of cotton. A common management strategy for improving profits has been to improve lint yields by adopting more input-intensive varieties or technologies and/or to identify optimal input use rates (to reduce usage) by examining the response relationship between cotton yield and a select number of inputs or factors (Britt et al., 2002). Ethridge and Davis (1982) show that cotton prices can vary with significant changes in quality attributes, which can have significant economic implications for the farmer when cotton prices are low, which has been the case for much of the past decade.

With an increase in demand for quality cotton by textile mills, firms are willing to pay a premium for stronger cotton with less variation in micronaire, improved uniformity in fiber length and lower levels of contamination (Bradow and Davidonis, 2000). Newer varieties of cotton promise to offer higher yield with improved quality, which has historically been seen as a trade off in the past (Kerby et al., 2007). Farmers have traditionally selected high yielding varieties with slightly lower quality characteristics due to their potential to provide higher net returns, but with fiber quality playing a more important role with cotton demand at the mill level, quality is playing a more central role (Bradow and Davidonis, 2000). On the other hand, some farmers have moved away from transgenic varieties to conventional varieties due to an improvement in lint quality and no technology fees, increasing potential returns.

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A number of agronomic factors, such as variety selection, water usage, fertilization methods and temperature regulation influence cotton quality and in turn can be influenced by the choice of tillage system (Bradow and Davidonnis, 2000). A limited amount of research has examined the relationship between cotton quality and tillage system using experimental data (Bauer and Frederick, 2005; Endale et al., 2004; Mert et al., 2006). The results from these studies are not conclusive.

The purpose of this research project is to examine the effect conservation tillage systems and variety selections have on cotton quality attributes and cotton profitability. The quality attributes of interest are those used in the cotton marketing loan program: color or grade, staple length, leaf content, micronaire, uniformity and fiber strength.

Materials and Methods

Economic Methodology

The market price for cotton is determined by the demand and supply for cotton on the world market. This price can be viewed as a collection of implicit prices that are determined by the quantity and quality of cotton in the market. These implicit prices are recognized in the industry as premiums and discounts for different quality attributes (Brown and Ethridge, 1995).

The U.S. Department of Agriculture administers and maintains a system of cotton quality information that is used in and relied upon in the marketing for cotton classification. The common attributes examined, include: color or grade (CG), staple length (SP), leaf content (F), micronaire (M), uniformity (U), fiber strength (ST) and trash (EM). Following Brown and Ethridge (1995) and Ethridge and Davis (1982), it is assumed that cotton price is a function of these quality attributes and follows a hedonic pricing model of the form:

$$P_i^c = f(CG, SP, M, ST, F, EM, U) = \beta_0 \left(\sum_{j=1}^{7} A_{j,i}^{\beta_j} \right) \epsilon_i , \qquad (1)$$

where the $A_{j,i}$'s are the seven quality attributes being examined and ε_i is a stochastic error term. This functional form is appealing because the β_j's are the price flexibilities with respect to the cotton quality attributes, or the percentage change in the price of cotton given a one percent change in one of the cotton quality attributes. It is these price flexibilities which will allow us to examine the impact of conservation tillage and other production practices on cotton profitability, through its affect on the price of cotton.

To incorporate production practices into equation (1) in order to assess their impact on cotton quality attributes and cotton profitability, it is assumed that $\beta_j = \gamma_{j,0} + \gamma_{j,1}N_i + \gamma_{j,2}I_i + \gamma_{j,3}R_i$, where *N* is a binary variable indicating if a farmer uses conservation tillage, I is a binary variable indicating if a farmer irrigates their cotton, and *R* is a binary variable indicating if a farmer plants a round-up ready variety of cotton.

Data

Data was obtained at the gin level to examine the farm level impact of management practices on cotton quality and profitability. Data was secured from a large cotton gin serving northern Alabama, central-southern Tennessee and extreme northwest Mississippi for all cotton bales processed from 1997 to 2004. Data from 2001 was not used due to missing data for that year. The dataset was large covering 21,650 bales from 190 farmers' fields in 1997; 36,665 bales from 222 farmers' fields in 1998; 34,362 bales from 356 farmers' fields in 1999; 42,859 bales from 339 farmers' fields in 2000; 47,693 bales from 396 farmers' fields in 2002; 54,292 bales from 336 farmers' fields in 2003; and 2004 bales from 385 farmers' fields in 2004. The dataset included indicator variables for: farm; field number; use of conservation tillage; use of irrigation; variety planted; yield statistics; ginning statistics; cotton quality attributes using HVI classification; and loan discount amount using the Commodity Credit Corporation (CCC) loan premium and discount schedule for the year the cotton was ginned.

Much of the cotton sold at the gin is sold in mixed lots to mills. These lots may be of varying quality and contain a large number of bales. The buyer purchases the lot at a fixed or negotiated price per pound for the entire lot (Ethridge and Davis, 1982). While these prices would allow us to more directly determine the implicit prices for different quality attributes in the market, they do not allow us to examine how different production choices potentially affect cotton prices and in turn farmer profitability, given the mixed lots usually are made up of cotton from multiple producers and variety types. Thus, in order to examine the impact on cotton profitability, prices are calculated using the CCC national market loan rate for cotton ($0.52) plus the CCC loan premium/discount provided by the gin (see http://www.fsa.usda.gov/ for rates). Given the national loan rate is fixed, changes in cotton prices for this analysis will directly reflect fluctuations in cotton premiums/discounts from changes in cotton quality attributes.

Statistical Analysis

The double log form of equation (1) is estimated as a linear generalized estimating equations model for each year using PROC GENMOD in SAS. This modeling approach allows for correlated data and provides coefficient and standard error estimates that are robust to misspecification of the variance-covariance matrix (Hedeker and Gibbons, 2006). It is likely that quality characteristics of cotton bales from the same field are correlated due to environmental, climatic, agronomic and management factors. Thus, observations from cotton bales from the same cotton field are treated as repeated observations and it is assumed that the correlations between these observations are the same, or exchangeable. Psuedo R^2 are estimated for each regression following Magee (1990).

Results and Discussion

Price flexibilities (β_l's) are reported in Table 1 along with fit statistics for each regression performed. Psuedo R^2 values ranged from 0.64 to 0.80 indicating a relatively good fit to the observed data. Base price flexibilities ($\gamma_{l,0}$) are reported for each quality attribute in Table 1 with the corresponding additive effect from using conservation tillage ($\gamma_{l,1}$), irrigation ($\gamma_{l,2}$) and/or a round-up ready variety ($\gamma_{l,3}$).

Table 1: Estimation Results and Elasticity Estimates for 1997-2000, 2002-2004.

Price Flexibilities	1997	1998	1999	2000	2002	2003	2004
Color/Grade Base	-0.131*	-0.106*	-0.073*	-0.036*	-0.133*	-0.068*	-0.165*
	(0.011)	(0.007)	(0.005)	(0.013)	(0.023)	(0.009)	(0.033)
No-Till Effect	0.016	0.026*	0.013*	-0.000	-0.134*	-0.008	0.051
	(0.022)	(0.011)	(0.007)	(0.014)	(0.028)	(0.010)	(0.033)
Round-Up	0.025	0.014	0.014*	-0.076*	-0.210	0.001	0.000
Ready Effect	(0.030)	(0.010)	(0.007)	(0.008)	(0.183)	(0.007)	(0.000)
Staple Base	0.223*	0.457*	1.090*	1.569*	1.106*	1.089*	0.612*
	(0.039)	(0.029)	(0.054)	(0.078)	(0.109)	(0.072)	(0.130)
No-Till Effect	-0.074	-0.026	0.138*	-0.071	-0.273*	-0.073	0.145
	(0.056)	(0.057)	(0.06)	(0.088)	(0.125)	(0.078)	(0.130)
Round-Up	-0.183*	-0.052	0.001	0.467*	0.255	-0.076	-0.001*
Ready Effect	(0.078)	(0.053)	(0.048)	(0.105)	(0.213)	(0.048)	(0.000)
Micronaire Base	0.181*	0.123*	-0.026	-0.133*	-0.339*	0.154*	-0.104*
	(0.027)	(0.020)	(0.027)	(0.044)	(0.058)	(0.038)	(0.044)
No-Till Effect	0.095*	0.057*	0.041	0.278*	0.107*	0.007	0.108*
	(0.045)	(0.025)	(0.044)	(0.050)	(0.062)	(0.040)	(0.044)
Round-Up	-0.092	-0.130*	-0.115*	0.013	-0.158	0.081*	0.000
Ready Effect	(0.104)	(0.025)	(0.042)	(0.177)	(0.124)	(0.020)	(0.001)
Strength Base	0.132*	0.096*	0.043*	0.129*	0.065*	0.073*	0.185*
	(0.022)	(0.014)	(0.021)	(0.038)	(0.039)	(0.017)	(0.042)
No-Till Effect	-0.029	0.002	0.019	0.000	0.097*	0.052*	-0.021
	(0.031)	(0.022)	(0.024)	(0.040)	(0.040)	(0.019)	(0.042)
Round-Up	0.052	0.001	-0.010	0.183*	-0.033	-0.006	-0.000
Ready Effect	(0.044)	(0.22)	(0.023)	(0.068)	(0.040)	(0.014)	(0.000)
Leaf Content Base	-0.108*	-0.110*	-0.076*	-0.055*	-0.023*	-0.100*	-0.052
	(0.009)	(0.008)	(0.012)	(0.009)	(0.010)	(0.011)	(0.013)
No-Till Effect	-0.008	-0.004	0.013	-0.023*	-0.27*	0.019	-0.016
	(0.012)	(0.014)	(0.013)	(0.011)	(0.010)	(0.012)	(0.013)
Round-Up	-0.024	-0.003	-0.017*	-0.067	0.003	0.016*	-0.001*
Ready Effect	(0.019)	(0.012)	(0.009)	(0.067)	(0.007)	(0.005)	(0.000)
Uniformity Base	0.147*	0.054*	-0.024	0.351*	0.075	0.237*	-0.062
	(0.017)	(0.028)	(0.050)	(0.070)	(0.069)	(0.057)	(0.223)
No-Till Effect	0.103	-0.036	-0.045	-0.158*	0.012	-0.049	0.164
	(0.086)	(0.053)	(0.060)	(0.078)	(0.078)	(0.060)	(0.225)
Round-Up	-0.024	0.137*	0.102*	-0.655*	0.007	0.005	0.001*
Ready Effect	(0.142)	(0.049)	(0.057)	(0.264)	(0.073)	(0.035)	(0.000)
Extraneous Matter	-0.006*	-0.007*	-0.007*	-0.008*	-0.011*	-0.004*	-0.003*
Base	(0.000)	(0.000)	(0.000)	(0.001)	(0.003)	(0.001)	(0.001)
No-Till Effect	-0.000	-0.000	0.001*	0.001	0.005*	-0.002*	-0.003*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.003)	(0.007)	(0.001)
Round-Up	0.000	0.000	-0.000	0.001	-0.004	0.000	-0.000
Ready Effect	(0.001)	(0.000)	(0.000)	(0.001)	(0.004)	(0.001)	(0.000)
				Fit Statistics			
Pseudo R^2	0.64	0.67	0.68	0.74	0.64	0.80	0.73
Number of Observations	21650	35665	34362	42859	47693	54292	57892

* Indicates statistical significance at the P = 0.10 level. Numbers in parentheses below estimates are their standard errors.

As expected, following the CCC loan premium and discount schedule, the base price flexibilities for color grade, leaf content and extraneous matter are negative, meaning as the values of these attributes increase (attribute declines, reducing quality) cotton prices will decline. In contrast, the base price flexibilities for staple, strength and uniformity (when statistically significant) are positive, meaning as the values of these attributes increase (attribute improves, increasing quality) cotton prices will improve. For micronaire, a measure of the cotton fiber fineness and maturity, the sign of the base price flexibility changes based on the year, which likely arises due to the nonlinear relationship between micronaire level and its associated CCC premium/discount. When micronaire is outside the range 3.5 to 4.9 it receives a discount (http://www.fsa.usda.gov/). A note of interest when examining the results is that from 1997 to 2004 an increasingly higher percentage of fields (from 38 to 96 percent) were managed using conservation tillage methods.

The primary estimates of interest are the "effects" parameters in Table 1. These effects are the change in the price flexibilities given different production/management decisions. When an "effect" is the same (different) sign as the base price flexibility for a given quality attribute, the result is an increase (decrease) in the percent change (positive or negative) in the cotton price given a one percent change in the value of the quality attribute. Using conservation tillage methods (no-till effect) had a significant effect on all the quality parameters, but in different years. The only consistent effect was on micronaire over the years. It seems as the use of conservation tillage increased over time, variability in micronaire decreased, reducing the price flexibility and the impact on the price of cotton. Along these same lines, as the number of fields with residue left on the soil surface increased, discounts for extraneous matter increased. Use of conservation tillage increased the absolute values of the price flexibilities for fiber strength and leaf content in two of the seven years examined, as well. The effects for irrigation and round-up ready, while significant for different attributes in different years are not consistent.[2] For irrigation, Enciso et al. (2003) found no significant effects from increasing irrigation on cotton quality attributes. The results concerning the use of round-up ready varieties could be due to the ever changing availability of new technologies available on the market and the wide number of varieties utilized. Further intense study of specific varieties is needed.

Conclusions

Cotton prices guide the production and marketing decisions made by farmers directly impacting cotton profitability. Cotton quality attributes play an important part in determining cotton lint demand by textile mills, which in turn affects cotton prices and the implicit price for cotton quality attributes (Ethridge and Hudson, 1998). The impact of management factors, such as conservation tillage, can directly affect these implicit prices, potentially impacting cotton production decisions. While the impact of using conservation tillage, irrigation and/or round-up ready varieties is variable from year to year, it may be important to know the impact of these management practices on cotton quality attributes and prices in past years to help predict the impact on future cotton cropping decisions.

References

[2] The effects for irrigation are not shown in Table 1 due to space limitations, but are available from the authors upon request.

Bauer, P.J. and J.R. Frederick. Tillage Effects on Canopy Position Specific Cotton Fiber Properties on Two Soils. *Crop Science*. 45: 698 – 703.

Bradow, J.M. and G.H. Davidonis. 2000. Quantitation of Fiber Quality and the Cotton Producer-Processing Interface: A Physiologist's Perspective. *Journal of Cotton Science*. 4: 34 – 64.

Britt, M.L., O.A. Ramirez and C.E. Carpio. Effects of Quality Considerations and Climate/Weather Information on the Management and Profitability of Cotton Production in the Texas High Plains. *Journal of Agricultural and Applied Economics*. 34: 561 – 583.

Brown, J.E. and D.E. Ethridge. 1995. Functional Form Model Specification: An Application to Hedonic Pricing. *Agricultural and Resource Economics Review*. 24: 166 – 173.

Enciso, J.M., B.L. Unruh, P.D. Colaizzi and W.L. Multer. 2003. Cotton Response to Subsurface Drip Irrigation Frequency Under Deficit Irrigation. *Applied Engineering in Agriculture*. 19: 555 – 558.

Endale, D.M., H.H. Schomberg and M.L. Cabrera. 2004. Tillage and N-Fertilizer Source Effects on Cotton Fiber Quality. Proceedings of the 26th Southern Conservation Tillage Conference, Raleigh, North Carolina, June 8 – 9, 2004: 49 – 57.

Ethridge, D.E. and B. Davis. 1982. Hedonic Price Estimation for Commodities: An Application to Cotton. *Western Journal of Agricultural Economics.* 7: 293 – 300.

Ethridge, D. and D. Hudson. 1998. Cotton Market Price Information: How it Affects the \ Industry. *Journal of Cotton Science*. 2: 68 – 76.

Hedeker, D. and R.D. Gibbons. 2006. Longitudinal Data Analysis. Hoboken, NJ: John Wiley and Sons, Inc.

Kerby, T.A., D.W. Albers, K.E. Lege, T.R. Speed and J.C. Bosch. 2007. Varietal Contributions to Changes in Yield and Fiber Quality in Recent Decades. Paper presented at the World Cotton Research Conference – 4, Lubbock, TX, 10 – 14 September, 2007. Available online: http://wcrc.confex.com/wcrc/2007/techprogram/P1681.HTM.

Magee, L. 1990. R^2 Measures Based on Wald and Likelihood Ratio Joint Significance Tests. *The American Statistician*, 44: 250 – 253.

Mert, M., E. Aslan, Y. Akiscan, M. Emin Caliskan. Response of Cotton (*Gossypium hirsutum* L.) to Different Tillage Systems and Intra-Row Spacing. *Soil and Tillage Research*. 85: 221 – 228.