PRODUCER RETURNS FROM COTTON STRENGTH AND UNIFORMITY: AN HEDONIC PRICE APPROACH

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Abstract

Implicit (hedonic) producer prices for fiber strength uniformity were estimated for the southwest U.S. cotton market using seemingly unrelated regression and market sales data from 1983/84 and 1984/85. Fiber strength and length uniformity had significant effects on the price of cotton, but price was less responsive to both attributes than anticipated. Producer prices were most responsive to fiber length and micronaire and least responsive to color and strength. The market at the producer level appears to be making effective price adjustments with respect to factors such as fiber color, trash content, micronaire, fiber length, and location, but strength and length uniformity premiums and discounts are smaller than those paid by end users.

Key words: hedonic prices, cotton quality, seemingly unrelated regression.

In a market economy, the value of a commodity is determined in a marketing system in which efficiency depends on the quantity and quality of information exchanged among participants. For the cotton market at the producer level, this information, and thus price, has relied on a grading system based on three fiber quality attributes: (1) grade—a composite of trash content, smoothness of the ginned fiber, and whiteness; (2) fiber length; and (3) micronaire—a measure of fiber fineness and maturity (U.S. Department of Agriculture).

Grade and fiber (or staple) length were determined by human senses for many years, and micronaire, measured with an instrument, was added to the grading system in the mid-1960s. In the late 1970s, the USDA began adopting a High Volume Instrument (HVI) system for evaluating cotton fiber, transferring the primary emphasis from human judgment to instrument measurements on fiber length, strength, length uniformity, micronaire, and color (Ethridge et al.). The HVI technology generates previously unavailable data on fiber strength and length uniformity, but those characteristics are not yet part of the official USDA grading system. The HVI system has had its greatest use in Texas and Oklahoma, where more than 90 percent of the cotton was evaluated with this system in 1985.

Cotton price premiums and discounts are reported daily for grade, fiber length, and micronaire, but market values for strength and length uniformity are not reported. Buyers and sellers depend on price knowledge for production and marketing decisions, and until they understand the contributions of strength and length uniformity to price, production and marketing efficiency are likely to be suboptimal. Furthermore, technological changes in textile manufacturing may make HVI information on strength and length uniformity increasingly important. Fiber strength may be the most important fiber property because it makes a major contribution to yarn strength (Duessen). Length uniformity may be important because it reduces processing waste and yarn breakage (Glade et al.). The objective of this study was to determine the individual contributions of strength and length uniformity to producer prices of cotton lint. The model developed to achieve the objective also provided for estimation and analysis of the differences between program loan prices and market prices. These differences have implications for accumulation of certain qualities of cotton in Commodity Credit Corporation storage.

The method used to achieve this objective was hedonic price estimation. The development

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The authors acknowledge the contributions of Sujit Roy, Bob Davis, John Price, Joel Hembree, Dale Shaw, Harvin Smith, the editors, and three anonymous reviewers of this paper.

This research was supported by the Agricultural Marketing Service, USDA, and the Natural Fibers and Food Protein Commission of Texas.

Texas Tech University College of Agricultural Sciences Publication No. T-1-235.

of analysis on hedonic prices, the implicit prices of attributes or characteristics of a commodity, began with analysis of prices of industrial goods (Court; Griliches). Price studies concerned with cotton characteristics date to the early part of this century (Taylor), but an analysis using a specific hedonic price model on an agricultural commodity did not appear until 1982 (Ethridge and Davis). Subsequently, other hedonic analyses have been published on potatoes (Carl et al.), barley (Wilson), rice (Brorsen et al.), and cotton (Hembree et al.).

Data for this analysis were from HVI evaluated cotton produced in Texas and Oklahoma and sold through the Telcot electronic marketing system during marketing years 1983/84 and 1984/85. The data set contained 40,741 mixed lot (a lot consisting of varying numbers of bales, each with different quality attributes) sale observations from August 1, 1983, to June 12, 1985. Observations were from five warehouse locations: Altus, Oklahoma, and Corpus Christi, Lubbock, Plainview, and Sweetwater, Texas. Sales consisted of 1982, 1983, and 1984-crop cotton. Cotton produced in 1983 (1984) was sold primarily in marketing year 1983/84 (1984/85).

MODEL

The farm price of cotton lint may be characterized as having two principal components: loan price and premium over the loan. Loan price is a price floor set annually under cotton program provisions and depends on location and grade, length, and micronaire values. The cotton may have a premium if the market price is above the loan price. The premium over the loan component may be affected by strength and length uniformity, not considered in loan prices, as well as other fiber quality attributes and general market supply and demand conditions. The model was based on the identity:

(1) $P = LP + PREM$

where:

P = producer price of cotton, \$/lb.,
LP = loan price, \$/lb., and
PREM = premium over loan price, \$/lb.

Changes in market factors and loan rate differences between crop and marketing years were included as binary indicator variables. The structural equations for the loan price and premium over the loan were:

(2) $LP = f(TRA, COL, LEN, MIC, CY, WL)$

and

(3) $PREM = q(TRA, COL, LEN, MIC, STR, UNI, MY, SD, WL, TS, RED, BLS)$

where:

TRA = average of trash content index for the lot (first digit of the grade code, which ranges from 2 to 8 with 2 being the least amount of trash);
COL = average of color index for the lot (second digit of the grade code, which ranges from 0 to 5 with 0 being the whitest);
LEN = average fiber length for the lot in 32nds of an inch;
MIC = average micronaire reading for the lot (continuous scale with almost all cotton in the 2.6 to 5.3 range);
CY = crop year indicator variables (C1 = 1 if crop year 1982; C2 = 1 if crop year 1983; if C1 and C2 are both 0, crop year is 1984);
WL = indicator variables for warehouse location (W1 = 1 if warehouse is Altus, OK; W2 = 1 if warehouse city is Plainview, TX; W3 = 1 if warehouse city is Sweetwater, TX; if W1, W2, and W3 are all 0, warehouse location is Lubbock or Corpus Christi, TX, between which there were no differences in loan or market prices);
STR = average strength reading for the lot in grams/tex (a textile industry measure of tensile strength of fibers and yarns);
UNI = average length uniformity reading for the lot measured as the ratio of mean fiber length (M) to the mean length of the longest one-half of the fibers (UMH), or mean/upper half mean ratio (M/UHM);
MY = indicator variable for marketing year (MY = 1 if marketing year is 1983/1984, 0 if 1984/85);
SD = sale date within marketing year with August 1 = 1, July 31 = 365;
TS = indicator variable for type of sale [TS = 1 if type sale is regular offer, an open-bid sys-

tem, 0 if firm offer, a seller asking price system (Ethridge)];

RED = percentage of bales in the lot reduced in grade due to excess bark; and

BLS = number of bales of cotton in the lot.

Data are summarized in Table 1.

TABLE 1. MEAN VALUES OF COTTON QUALITY AND SALES DATA IN THE HEDONIC PRICE MODEL, TEXAS AND OKLAHOMA, 1983/84 AND 1984/85

Variable	Units	Marketing Year		
		1983/84	1984/85	Combined
Price (P)	($/lb.)	.5993	.4589	.5354
Loan price (LP)	($/lb.)	.4092	.4134	.4111
Premium (PREM)	($/lb.)	.1901	.0455	.1243
Trash (TRA)	Index (2–8)	4.9	4.5	4.7
Color (COL)	Index (0–5)	2.4	1.8	2.1
Length (LEN)	32nd in.	31.8	31.5	31.6
Micronaire (MIC)	Scale (2.6–5.3)	3.9	3.2	3.5
Strength (STR)	grams/tex	24.9	25.5	25.1
Uniformity (UNI)	M/UHM	78.9	78.3	78.6
Sale date (SD)	No.	152[a]	175[b]	162
% reduced in grade for excess bark (RED)	%	32.6	33.7	33.1

[a] December 30, 1983
[b] January 22, 1985

There are conceptual reasons (Neeper) and prior empirical evidence to suggest nonlinear relationships between price and each of the fiber quality attributes. The conceptual basis for nonlinearity is decreasing marginal productivity of a useful quality attribute. The expected effect of MIC on price is to increase, then decrease, as MIC increases because excessive coarseness or fineness of cotton can deter processing performance. A priori, loan price and market price are expected to increase at a decreasing rate with increases in LEN and MIC (due to decreasing marginal productivity of both characteristics), decrease at a decreasing rate with COL (the marginal undesirability of discoloration eventually diminishes), and decrease at an indeterminate rate with TRA (see Ethridge and Mathews). The specific form of nonlinearity is an empirical question, depending in part on the range of observed data. Quadratic and natural logarithm forms were evaluated for COL and LEN in the LP equation. The logarithm forms (LCOL and LLEN) provided the best fit and were used for the expected nonlinear relationships. However, use of the logarithm form for color resulted in observations on 32 of 40,773 lots of cotton not being used because of 0 values for the color code. Micronaire and trash were specified in quadratic form (Ethridge and Davis; Ethridge and Mathews; Ethridge et al.; Hembree et al.). Slope and intercept shifter indicator variables for crop year (C1 and C2) were included with each of the quality variables to identify differences in the quality premiums/discounts among the three years and differences in the general levels of loan price. Warehouse location indicator variables were included as intercept shifters to account for the expected LP level differentials; no premium/discount (slope) differentials by location were expected. The slope and intercept shifter parameters in the LP equation may be positive or negative.

Loan prices are based on historical market price-quality relationships and are specified by the U. S. Department of Agriculture in advance of the production and marketing of the crop. Premiums (and discounts) from the loan price reflect current market conditions, including variations from historical price-quality relationships as reflected in loan prices, and are established by market forces while the crop is being marketed. The TRA, COL, LEN, and MIC variables in the PREM equations were expressed as differences from the two-year (1983/84–1984/85) means for these measures (DTRA, DCOL, DLEN, DMIC). Strength was expressed in the PREM equation in logarithm form (LSTR) and length uniformity in quadratic form. Both variables were expected to cause prices to increase at a decreasing rate. Value of fiber strength was expected to increase over the entire range of strength, but at a decreasing rate. However, fiber length distribution may become too uniform for efficient spinning into yarn. Effect of size of the lot of cotton on PREM was also evaluated (Ethridge and Davis) with longer lots hypothesized to bring higher prices. Location intercept shift variables were included in the PREM equation for the same reason as in the LP equation. The type of sale variable identified the Telcot sale as regular offer, in which the cotton is offered for bidding, or as firm offer, in which the producer specifies an asking price. However, all market prices in the analysis were actual sale prices. Percent reduction in grade due to bark, pieces of stem in the lint, was included to evaluate discounts in excess of that already included in the trash price adjustment (grade reflects an adjustment for bark, but bark is also identified separately on the official classification cards). Sale date was included to control for any price trend within a marketing year. Expected parameter signs for the PREM equation were positive for LSTR, UNI, and BLS, negative for UNI^2, and indeterminant for the remaining variables. The market may dictate positive or negative premiums over the loan for individual fiber characteristics (TRA, COL, LEN, MIC) as they deviate from the fiber characteristics at a given time.

The estimation procedure for the analysis was seemingly unrelated regression (SUR) as proposed by Zellner. When two or more independent equations have nonzero correlations among error terms across equations, SUR provides estimators which are asymptotically more efficient than those obtained by application of ordinary least squares to each equation (Johnston). Correlation of error terms across equations was expected because both LP and PREM are affected by some of the same supply and demand forces (i.e., LP by historical and PREM by current market forces). In fact, the correlation across models was $-0.34(\neq 0)$ and SUR was the appropriate technique.

TABLE 2. SEEMINGLY UNRELATED REGRESSION HEDONIC PRODUCER PRICE COEFFICENTS FOR COTTON IN THE SOUTHWESTERN U.S., MARKETING YEARS 1983/84 AND 1984/85

Equation					
Loan Price			Premium Over Loan		
Independent Variable	Coeff.	t-value	Independent Variable	Coeff.	t-value
Constant	−.87095	−134.37	Constant	−.53447	−2.86
TRA	−.01984	−41.13	DTRA	.02035	147.48
TRA^2	−.00169	−35.96	DCOL	.00832	36.58
LCOL	−.04595	−116.70	DLEN	−.00245	−27.44
LLEN	.27398	157.23	DMIC	−.00942	−28.24
MIC	.24054	148.67	SD	−.00062	−185.50
MIC^2	−.02681	−109.36	MYSD	.00083	387.52
C1*TRA	.00408	6.15	W2	.00092	2.77
C2*TRA	.00459	22.67	W3	−.00614	−14.66
C1*LCOL	−.02691	−14.14	TS	−.00869	−25.36
C2*LCOL	−.02865	−50.96	RED	−.00004	−11.54
C1*LLEN	.01892	11.31	LSTR	.02763	16.66
C2*LLEN	.00557	10.04	UNI	.01654	3.47
C1*MIC	−.01843	−15.70	UNI^2	−.00011	−3.71
C2*MIC	−.00739	−17.58			
W1	−.00111	−5.76			
W2	−.00103	−4.70			
W3	.00476	17.16			

Adjusted R-Square for System = .93
No. of Observations = 40,741

FINDINGS

The SUR results of the loan price and premium over the loan rate equations are shown in Table 2. The C1 and C2 intercept shifter variables in the LP equation and W1 and BLS in the PREM equation were not statistically significant at the .10 level of significance and were eliminated from the final model. All remaining coefficients were significant at the .01 level, and all had signs consistent with expectations.

In the LP model, the loan price was greater in crop year 1984 (1984/85 marketing year) than in 1983. Loan price decreased at an increasing rate as TRA increased, and LP discounts for TRA ($\partial LP/\partial TRA$) were smaller in 1983 than in 1984. The 1982 TRA loan discounts were between those for 1983 and 1984. Loan price decreased at a decreasing rate as COL increased, and LP discounts for COL were greater in 1983 than in 1984. Loan price increased at a decreasing rate, then decreased as MIC increased, and LP discounts for lower micronaire were greater in 1984 than in 1983. Loan prices were lower in Altus and Plainview and higher in Sweetwater than in Lubbock and Corpus Christi.

In the PREM equation, market payments over loan were lower in 1984 than in 1983 for TRA, COL, LEN, and MIC. Premiums over loan increased as TRA, COL, and LEN increased and decreased as MIC increased, indicating that market discounts for TRA, COL, and MIC were less than loan discounts and market premiums for LEN were less than loan premiums. Thus, market price was less sensitive to each traditional fiber quality attribute than loan prices anticipated. The market paid a premium over loan of .09¢/lb. ($.43/480-lb. net weight bale) for cotton located in Plainview (W2), almost offsetting the .10¢/lb. discount in the loan price. Cotton stored in Sweetwater was discounted .61¢/lb. below the loan, reversing the .48¢/lb. premium in the loan price. Cotton in the Altus market (W1) maintained its .11¢/lb. discount specified in loan prices. The price differences among warehouse locations indicate transportation or other marketing cost differentials. Cotton sold through firm offer brought .87¢/lb. more than cotton sold through regular offer. Parameters for SD and MYSD show that premiums over loan (and prices) exhibited a positive trend in the 1983/84 marketing year and a negative trend in 1984/85. Cotton reduced in grade due to excess bark was discounted .004¢/lb. in addition to the price reduction associated with the grade (trash) reduction.

Relationships between producer price and strength and length uniformity were derived from the PREM equation but may also be examined via identity (1) (i.e., combining the LP and PREM equations). As strength increased, producer price increased at a decreasing rate. A one gram/tex increase in fiber strength from the mean strength of 25.1 grams/tex increased the price received by .11¢/lb. The quadratic relationship between price and uniformity exhibited a negative slope at a lower uniformity ratio than anticipated from opinions of textile technologists but consistent with a prior study. Prior indications from textile manufacturers suggested a direct relationship between manufacturing usefulness and uniformity over the entire range of uniformity (Duessen). This analysis found that higher uniformity over a 73 M/UHM ratio decreased producer price, a result consistent with results of the study by Hembree et al., which found an inverse relationship between uniformity and price paid by manufacturers over the range of data for that study (74-81 M/UHM ratio). Further comparison with that study suggests that price premiums for strength received by producers in the southwestern U.S. are less than 10 percent of the strength premiums paid by textile manufacturers. On the other hand, producer price discount for length uniformity at the mean value for UNI (78.6) was .08¢/lb. ($\partial P/\partial UNI = .01654 - .00022\ UNI$) compared to .91¢/lb. for each M/UHM discount by textile manufacturers as reported in the Hembree et al. study. These comparisons suggest that the price signals are not being relayed effectively through the marketing system. A difference in price level between the two pricing points is expected, but if the marketing system is conveying market signals efficiently, the producer should receive the same message about the market premium/ discount for quality characteristics as is generated at the final pricing point. It should be noted that the Hembree et al. study covered (1) a cross section of all U. S. regions, (2) a longer period of time (1977/78-1983/84), and (3) only domestic mill use and prices of cotton.

Producer price flexibilities with respect to each fiber characteristic were calculated to compare responsiveness of strength and length uniformity to the other fiber characteristics (Table 3). In general, producer price was most responsive to variations in fiber length and micronaire and least responsive to variations in color and strength. Prices were much more responsive to variations in micronaire in 1983/84, probably due to the greater availability of the most desirable micronaire (4.2) and the resulting tendency of the market to discount more heavily for lower micronaire. In general, producer price elasticities for trash, color, length, and micronaire are consistent with those obtained by Ethridge and Davis. However, producer price responsiveness was not consistent with responsiveness of prices paid by textile manufacturers; Hembree et al. found that textile manufacturers' cotton prices were most, rather than least, responsive to fiber strength.

TABLE 3. PRODUCER PRICE RESPONSIVENESS TO VARIATIONS IN FIBER QUALITY ATTRIBUTES AT MEAN VALUES OF VARIABLES[a]

	Price Elasticity [b] With Respect to:					
Year	TRA	COL	LEN	MIC	STR	UNI
1983/84	−.07 (4.9)	−.09 (2.4)	.34 (31.8)	1.37 (3.9)	.05 (24.8)	−.11 (78.9)
1984/85	−.14 (4.5)	−.07 (1.8)	.43 (31.5)	.42 (3.2)	.06 (25.5)	−.12 (78.3)

[a] Mean values for variables are shown in parentheses.
[b] Calculated as $(\partial P/\partial X)(\bar{X}/\bar{P})$ where X is TRA, COL, LEN, MIC, STR, or UNI and $\bar{X}$ and $\bar{P}$ are mean values.

CONCLUSIONS

The primary purpose of this study was to estimate the premiums (discounts) of two fiber properties currently excluded from the official USDA grading system for cotton: strength and length uniformity. Producer price was broken into two principal components, loan price and premium over the loan, and these were estimated simultaneously using seemingly unrelated regression (SUR). As a consequence of the model structure, knowledge of the divergencies between loan and market prices and the extent to which loan price factors explain market price were obtained also. The price-quality relationships in this study are for a specified time period and geographic area; therefore, inferences drawn for other areas and future (past) time periods should be approached with caution.

The results show that as fiber strength increases, holding other factors constant, producer price increases at a decreasing rate. Producers receive higher prices for high strength cotton, but the marginal return decreases as strength increases. As length uniformity increases, producer price of cotton increases up to a uniformity ratio of 73; then price declines as uniformity increases. This result is inconsistent with conventional wisdom of textile technologists, but it is consistent with the findings of a previous study of effect of length uniformity on prices (Hembree et al.). Further comparisons with that study reveal that strength premiums and uniformity discounts are much smaller at the first sale point in the marketing channel than at the final pricing point, inferring that the market is not relaying information efficiently. The reason is not obvious, but a plausible explanation relates to the numerous dimensions of cotton quality. The maze of quality dimensions and their associated values may produce confusion for buyers and sellers such that their response is to price on quality averages. This also suggests that more complete and accurate price reporting on all of the relevant fiber characteristics would increase market efficiency.

Several other conclusions may be drawn about the operation of the market. While the matrix of loan prices serves as a price floor, the market appears to be adjusting the levels of premiums and discounts. These adjustments presumably reflect current and local market supply and demand conditions. Premiums over loan varied with levels of fiber color, trash content, fiber length, and micronaire and were different in each case for the two selected years. The warehouse location analysis indicated that the market agreed with loan price differences for location in some instances (e.g., Altus, OK) and adjusted the loan price differences in other instances (e.g., Plainview and Sweetwater, TX).

The study has implications for the discounts/premiums established by the U.S. Department of Agriculture. Loan discounts/premiums in the southwestern U.S. cotton market for the quality measures included in the loan may cause government stocks accumulation to be disproportionate in some quality groups when market prices approach loan rates. In addition, at least two additional quality variables, fiber strength and length uniformity, should be reflected in the loan premiums and discounts for loan values to be consistent with market signals.

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