ABSTRACT

CHO, HYUNJUNG. An Innovative Hedonic Pricing System for US Cotton Based on HVI Quality Measures and Market Factors.(Under the direction of Dr. Moon W. Suh.)

Hedonic pricing system for US cotton was developed based on HVI quality measures and market factors by employing multi-stage hedonic models. In addition, efforts have been made to create ***Composite Cotton Quality Indices*** (CCQIs) aimed at improved cotton selection, pricing, storage/retrieval, and laydown formation and enhanced product qualities.

Following a preliminary analysis on the performance of the current discounts/premium scheme for cotton pricing and the enormous biases discovered, a first stage hedonic pricing system was developed as an alternative to the current pricing practice. The data employed for this study consist of 1086 matching pairs of weekly data on eight HVI quality measures and the cotton prices based on the CCC loan schedules obtained for five crop-years; 2000/2001 - 2004/2005, covering ten states. The first-stage hedonic model developed has shown that the fit was highly satisfactory, reducing or eliminating the biases uncovered from the preliminary analysis. While higher values in the two-digit color codes were found to be most detrimental to values of the cotton, higher fiber length and strength values were shown to be the most important determinants of their marginal implicit prices.

A set of Composite Cotton Quality Indices (CCQI) was created from the covariance structure of eight HVI quality measures and their relationship with their matching cotton prices. Two CCQI’s, one from color factors and the other from physical factors of cotton, were found to be almost as good as the case when all eight HVI quality

measures were used, explaining 84% of the total cotton price variation, thus validating the concept of creating and applying the CCQIs.

In the second state hedonic model employed for studying the effects of supply factors on the HVI cotton qualities, the results had shown that the temperature and rainfall during harvest seasons significantly affected the color quality, fiber length and strength.

Overall, the multi-stage hedonic models developed and the CCQIs newly created and applied were proven to be highly satisfactory for cotton pricing as alternatives to the current pricing methods, and facilitate innovative cotton classification and bale management systems for cotton and cotton textile industries.

An Innovative Hedonic Pricing System for US Cotton Based on HVI Quality Measures and Market Factors

By

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DEDICATION

To my parent, Ban-Seok Cho and Young-Ae Cho who love me completely without complete understanding for me

BIOGRAPHY

Hyunjung Cho is born in Seoul, Korea as the last daughter of her parents, Ban-Seok Cho and Young-Ae Cho. Hyunjung had first an interest in the apparel design and textiles during her undergraduate study. For her master program, she majored in textile science. Her research interests were focused on fabric hand and clothing comfort. For pursuing more study through doctoral program in US, Hyunjung came to Raleigh, North Carolina and began to study in Fiber and Polymer Science program in College of Textiles, North Carolina State University. Then, she transferred to Textile Technology and Management program. Now, she has an interest for developing a Cotton quality index and new US cotton pricing structure by using statistical and econometrical modeling.

ACKNOWLEGEMENTS

I would like to express my deep gratitude to Dr. Moon W. Suh, Chairman of my Advisory Committee, for the great advice, support, and insight on this research.

I wish to appreciate Dr. Pamela Banks-Lee for her helpful comments and encouragement during this research. And I would like to acknowledge Dr. Michelle Jones for her kind advice and interests. Special thanks are also to Dr. John Monahan, Department of Statistics, for his guidance and advice in developing statistical models.

I appreciate Mr. Gus Shield in Cotton Incorporated for supporting the software program and database for this study.

I also would like to express my appreciation to other faculties and staffs of the College of Textiles, to my fellow graduate students in US and to my friends in Korea.

Finally, my special thanks are to my parents who always love me and my brother, Young-Seok, and sister, Hyun-Jin for their love and support. Without their love and encouragement, I would not complete my study. I would like to say that I love them sincerely.

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1 INTRODUCTION

U.S. cotton plays a key role in international textile and apparel trades as a basic raw material for almost all commodities. Embarkation of free-trade era under WTO in 2005 and the volatility of crude oil prices mandate cotton to be a reliable agricultural commodity for the global fiber markets. While U.S. price support policies have had significant effects on cotton price, the measured and perceived qualities of cotton are considered to be the better predictors of the price in practice.

U.S. cotton industry has been influenced by three key factors - fiber production, textile manufacturing, and marketing of fibers. As a middle process, cotton marketing bridges fiber producers to textile manufacturers in a profound way. Information on mill demand of fiber and fiber supply from cotton growers is channeled through the market through price signals. Knowledge of the pricing structures associated with fiber attributes at both ends of the market is important because the quality of final textile products depends on quality attributes of the fibers [Chen and Ethridge, 1996].

The market price of cotton is determined from two major components: 1) the "base price" determined by quantitative factors and 2) "implicit price" determined by the quality characteristics of cotton [Chiou, Chen and Capps, 1993]. The base price is determined by supply and demand, basic production costs and price support among others. In U.S. the implicit price, while not directly estimable from the selling price, is often determined by the premium and discount scheme, whether the system is scientifically based or not. How the implicit price could best be determined has been the focal point of discussions in the U.S. cotton industry.

Once cotton is ginned and baled, a sample taken from each bale is sent to a classing office to be given an official grade based on the quality of the cotton fibers in each bale. The Cotton Division of Agricultural Marketing Service (AMS), United States Department of Agriculture (USDA) performs the measurement of cotton characteristics. Since the inception of cotton classing, classification methods have become more sophisticated over time, evolving from a few subjective measurements to a more accurate and objective system with the introduction of High Volume Instrument (HVI) grading technology [Suh, 1996]. Suh amplified the economic and technological significance of applying HVI for cotton classing and global trades.

The USDA recognizes eight official quality attributes: fiber length, fiber strength, fiber length uniformity, micronaire, leaf content, color grade, extraneous matter content, and preparation [USDA, 1985]. Because of this grading system, the cotton buyer is able to select cotton that contains attributes necessary to maintain the quality of the specific end product. Cotton producers, then, attempt to supply cotton that contains these characteristics. This interaction between producer and buyers determines the values for each of these quality attributes.

The base price of cotton represents the typical price for cotton containing base qualities. The implicit price of cotton which reflects the actual demand and utility of the cotton quality apart from the base quality is reported as an array of quality premiums and discounts. They indicate how much more or less the cotton is worth as a given quality characteristic may deviate from the base value. However, the implicit price is not directly observable from the market price. Therefore, it is very essential to find an appropriate method for quantifying the hidden values of cotton from the selling price.

Currently, there are two sources of price information widely available to the cotton industry. The Daily Spot Cotton Quotations (DSCQ), published daily for seven designated market regions by the USDA - AMS is one source (U.S. Dept. of Ag., Daily Issues). The other is the Commodity Credit Corporation’s (CCC) loan schedule. The CCC loan schedule is formulated by averaging DCSQ for the first seven months of the current marketing year with CCC loan schedule of the preceding year. In the many empirical researches for cotton pricing structure, however, the DSCQ has not been a good indicator of the producer market prices, premiums, and discounts in cotton markets, and there is increasing evidence that they do not represent prices supported at the mill-level. Because of the formulation of the CCC loan schedule, errors in the DSCQ affect the loan schedule as well. Furthermore, the price estimates by DSCQ are not objective and cannot be reproduced or tested for statistical reliability [Hudson, Ethridge and Brown, 1994].

As an alternative price reporting system, referred to as the Daily Price Estimation System (DPES), has been developed to complement the HVI grading system and has been tested for use in the Texas-Oklahoma cotton marketing region [Brown and Ethridge, 1995]. This method measures daily market prices with a hedonic price approach.

Under classical price theory, for a homogeneous product, the intersection of supply and demand schedules determines the price of the product. However, for a non-homogeneous product such as cotton that contains various quality attributes, a hedonic price approach is shown to be more appropriate than the classical price approach [Hoelscher, 2001]. The premise of hedonic price analysis is that a commodity is valued by the amount of utility-bearing characteristics associated with that commodity [Rosen, 1974]. Under this assumption, Rosen [1974] proposed use of a two-stage hedonic framework.

In developing a hedonic price model for cotton, marginal implicit price of each quality attribute of cotton measured by HVI can be determined by applying a ***First-Stage Hedonic Model***. However, this marginal implicit price often fails to reflect the market conditions formed by the supply and demand situations associated with each cotton quality attribute, weather conditions and other market factors. There are two groups of market factors that are known to affect the price of cotton. The supply factors include weather variables, the inventory level of cotton fiber in the previous year and the cotton plant variety, whereas the demand factors includes quantity of cotton fibers consumed in a given year, international trade patterns of cotton and world cotton consumption.

For this reason, a Second-Stage Hedonic Model can be constructed by employing both the supply factors and demand factors.

2 CURRENT COTTON PRICE STRUCTURE IN U.S.

2.1. Base Price Structure of Cotton Quality

The base price of cotton is determined by a set of base fiber quality attributes. Color attributes are incorporated into the grade expressed as a two-digit numerical code. The degree of greyness is indicated by the first digit of grade code ranging from 1 to 8 with a base quality at 4, while the degree of yellowness is shown by the second digit of the grade code ranging from 0 to 5, with a base quality at 1. For both color grades, quality is better with grade codes less than base figures. The color of cotton usually deteriorates due to environmental conditions. The deterioration of color affects the ability of fibers to absorb and hold dyes and finishes.

Staple is the measurement of fiber length and is measured in increment of 1/32 inches, with a base value at 34, a higher quality with a longer fiber length. Fiber length can be influenced by several factors including variety, weather, water stress, nutrient deficiencies, and ginning practices. Fiber length is important to the textile mills for several reasons. Longer fibers produce stronger yarns and fabrics and enhanced fabric appearances. These longer fibers are also necessary for textile mills to maintain and enhance yarn processing efficiencies [USDA et al., 2002]. As air jet spinning became popular for its productivity and spinning efficiency, short fiber contents became detrimental to the operation.

Uniformity is related to fiber length in that the uniformity index is the ratio between the mean length and the upper one-half mean length of the fiber sample [USDA, 2001]. This measurement is reported via HVI analysis as a percentage. Thus, if all the fibers in a sample are the same length, the uniformity index is 100. A wide range of fiber lengths in the sample will result in a lower the uniformity index. The Uniformity Index generally ranges from 77 to 85. Uniformity is important to the textile industry because it is an indirect indicator of short fiber content, which ultimately affects yarn evenness, strength, and the efficiency of the spinning process. It is important to note the difference between short staple and short fibers. Short staple cotton is that which has an average staple length (upper ½ mean length) of less than 34. Short fibers refer to individual fibers that are less than 0.5 inches in length [Jost, 2005]. The base range for uniformity is 80 to 82, with uniformity indices greater than 82 eligible for premiums and those lower than 80 receiving discounts [USDA, 2004]. On a purely monetary basis, the discounts for uniformity are not as severe as those for staple. However, uniformity is an indirect measurement of short fiber content (fibers less than 0.5 inches). This appears to be one of the parameters for which mills are increasing scrutiny.

Micronaire is a measure of fiber fineness and maturity. Fiber maturity means different things to cotton processors, physiologists, and producers. To a physiologist and a cotton producer, cotton maturity indicates a measure of time elapsed between flowering and harvest. To a textile manufacturer, maturity indicates fiber wall thickness [Bradow and Davidonis, 2000]. Immature fibers contain thinner walls than more mature fibers of the same variety. While a finer mature fiber results in more fibers per unit area and thus a higher luster dyed fabric [Ramey, 1982], a fine but immature fiber will stretch and tangle, causing problems in the spinning process. In addition, dye uptake will also be inconsistent with immature fibers [Bradow and Davidonis, 2000]. Micronaire is different compared to other fiber parameters in that there is a base range, and deductions are assessed to bales possessing micronaire values above and below this range [USDA, 2001]. There is also a premium range. The base range is from 3.5 to 4.9 with premiums assigned to micronaire readings ranging from 3.7 to 4.2. In most states, micronaire problems are associated more often with high micronaire readings than low readings.

Fiber strength is the break resistance of the fibers and is measured by grams per tex. The breaking strength of the individual cotton fibers is considered to be the most important factor in determining the strength of the yarn spun from those fibers [Munro, 1987; Patil and Singh, 1995; Moore, 1996]. Shifts in spinning technology have placed a premium on individual fiber strength, as these new technologies produce yarns of lower strength [Patil and Singh, 1995]. The base range for fiber strength is 25.5 to 29.5 with higher values for higher quality, and lower values for lower quality.

The amount of non-lint materials in a cotton sample is considered trash [USDA, 2001]. These materials may include leaf and bark from the cotton plant or weeds. HVI analysis determines trash content by scanning the surface of the cotton sample and calculating the percentage occupied by non-lint material. Leaf grade is a visual human estimate of the amount of plant leaf particles in the cotton sample made manually by a cotton classer [USDA, 2001]. There are eight leaf grades, 1 through 8. Although trash and leaf grade are not the same, there is a correlation between the two. The term "leaf" includes dried, broken plant foliage, bark and stem. These particles can also be classified into two general categories, large leaf and pin or pepper trash [Munro, 1987].

The general level of base price will affect the values of specific fiber characteristics. Higher prices should cause the premium of desired characteristics to rise. The reason for this lies in the dispersion of prices that occurs when prices rise and fall.

2.2. Daily Cotton Price Information

2.2.1. DSCQ (Daily Spot Cotton Quotations)

The official price reporting system for cotton is administered by the USDA-AMS, cotton division. As required by law, the Daily Spot Cotton Quotations (DSCQ), published by the AMS on a daily basis, supplies estimated prices on all cotton qualities in the form of a base price and premiums/discounts for all other applicable quality combinations. These prices are intended to represent all pricing points in the marketing chain. They are taken from producer sales, merchant to merchant sales, merchant to textile manufacturer sales, etc. All of these types of sales are used in the quotations of the DSCQ, which is published for seven designated market regions-Southeast, North Delta, South Delta, East Texas-Oklahoma, West Texas, Desert Southwest, and the San Joaquin Valley [Hudson et al., 1994].

To formulate the daily estimated prices, AMS market news reporters gather market information by observing market operations and conducting personal interviews, primarily with merchants and marketing associations. The market reporter uses observed sales and market assessments collected from merchants to compile a set of price estimates for a set of quality combinations. These price/quality combinations are then inserted into a pre-programmed spread sheet which generates a set of prices for all quality combinations. The market reporter may make adjustments to the estimated prices based on comparisons of prices generated versus those from personal interviews. After the market news reporter makes the final premium/discount estimates, they are sent to AMS for publication. It should be noted that there are no documented procedures that the market reporter follows to estimate prices. Therefore, the estimates cannot be reproduced or tested for statistical reliability.

The primary point concerning the process of estimating the DSCQ is that it is subjective – it depends on human perception, opinion, and belief. The fact that the process is subjective does not necessarily mean that it is biased and inaccurate. However, it is also possible that the process is biased by the subjectivity in the procedure. Table 1 below is an example of DSCQ for composite HVI cotton quality.

Table 1. Daily Spot Cotton Quotations Table for Composite Quality

PREMIUMS AND DISCOUNTS FOR GRADE, STAPLE LENGTH, AND LEAF CONTENT OF 1990 CROP AMERICAN UPLAND COTTON

		Staple 1/	26-29	30	31	32	33	34	35	36	37+
Color 2/		Leaf 3/	<----	----	----	Points per pound	----	----	----	---->	
	SM &	Leaf 1-2	630	435	310	215	65	130	200	205	210
	better	3	640	440	315	220	70	125	195	200	200
	11 & 21	4	690	485	365	260	130	50	115	120	125
		5	750	540	435	405	225	170	120	120	115
		6	-870	-715	-620	-620	-470	-470	-470	-470	-470
		7	-965	-885	-875	-875	-725	-725	-725	-725	-725
W	MID	Leaf 1-2	-645	-450	-320	-210	-85	120	190	195	195
	31	3	-650	-455	-325	-245	-35	120	135	195	195
H		4	-690	-500	-370	-300	-145	45	105	110	110
		5	-765	-560	-455	-410	-260	-175	-130	-125	-125
I		6	880	720	625	625	475	475	475	475	475
		7	985	890	880	880	730	730	730	730	730
T	SLM	Leaf 1-2	715	505	400	390	170	5	60	65	65
	41	3	715	505	400	335	170	5	60	65	65
E		4	-715	-540	-430	-350	-180	Base	55	60	60
		5	-825	-650	-540	-505	-300	-310	-205	-205	-205
		6	-825	-770	-700	-695	-615	-615	-615	-615	-615
		7	-1075	-1005	-990	-990	-840	-840	-840	-840	-840
	LM	Leaf 1-2	-830	-660	-560	-560	-410	-365	-325	-325	-320
	51	3	-830	-660	-560	-560	-410	-365	-325	-325	-325
		4	860	685	585	585	435	385	345	345	345
		5	885	710	655	650	500	470	430	430	430
		6	1005	925	865	865	735	735	735	735	735
		7	1130	1085	1085	1085	935	935	935	935	935
	SGO	Leaf 1-2	-1000	-885	-865	-865	-730	-730	-730	-730	-730
	61	3	-1060	-885	-865	-890	-710	-710	-710	-710	-710
		4	-1060	-885	-865	-855	-760	-760	-760	-760	-760
		5	-1065	-1000	-900	-900	-830	-830	-830	-830	-830
		6	-1065	-1015	-1000	-1000	-850	-850	-850	-850	-850
		7	1245	1195	1175	1175	1025	1025	1025	1025	1025

2.2.2. DPES (Daily Price Estimation System)

An alternative method to measuring daily market prices is DPES (Daily Price Estimation System) rooted on a hedonic price approach. The hedonic analysis approach assigns the implicit values of the quality attributes by regressing the price of a mixed lot against the average qualities of the lot. This process yields the values of the individual qualities, which in turn facilitates the calculation of premiums and discounts. Such an approach, called DPES, has been developed and tested for the Texas-Oklahoma market regions. The econometric system separates the price from each observed sale into the components of price as affected by trash, color, staple, micronaire, uniformity, and strength in a manner that is objective, and results are reproducible. Because separate quality premiums and discounts are not directly observable in the market, they must be derived from observations of market prices and the results of price estimates are reproducible. The hedonic model parameters are reestimated daily, using only actual sales transactions that occur during the day being estimated. The price estimates are produced overnight so that the results of price measurements can be distributed each day. The DPES is limited to Texas and Oklahoma regions now. [Hudson et al., 1996]

2.3. Analysis and Evaluation of Existing Cotton Pricing Scheme

To examine if the current cotton pricing system is appropriate and relevant for the observed demand, the relationships between the actual cotton prices from DSCQ and the actual cotton quality attributes from USDA-AMS were analyzed only for California and Texas with 2004/2005 data. However, the performance of the new Hedonic pricing System will be evaluated with other states as well in Chapter 8. This is an attempt on my part to justify a further study to enhance the cotton pricing system.

2.3.1. Description of the Data and Analysis Procedure

The states chosen for this preliminary analysis were Texas and California during 2004/2005 crop year. Texas produces 29% of US cotton production. The overall qualities of cotton fiber yielded in California are superior to that of other states since genetically superior Acala varieties are grown in the Mediterranean-like environment of California.

The total number of bales produced and ginned in California and Texas for 2004/2005 was 1,761,712 and 7,497,295, respectively. HVI Quality measures used in this analysis are fiber strength, micronaire and fiber length uniformity. From USDA-AMS website, the cotton HVI quality data and the matching cotton price discounts/premiums information for California and Texas were obtained. Using EFS®-USCROP™ software program, the descriptive statistics for cotton qualities was produced. Then, the base price and each quality adjusted price for three HVI measures were calculated. To analyze the relationships between the cotton prices from DSCQ and the actual cotton quality measures, *Price-Quality Indices (PQIs)* for three quality measures of cotton were developed. These indices measure the ratio of the average weekly price of a cotton quality attribute obtained from the prevailing Discount/Premium scheme vs. the yearly average, relative to the corresponding ratio of the specific cotton quality attribute measured by HVI. This index should be one if the price adjustment based on the discount/premium scheme is perfect.

$$P\text{-}Q\ Index = \left(\frac{P_{ji} / P_{aj}}{Q_{ji} / Q_{aj}} \right) \quad (2.1)$$

Where;

P_{ji} = the average [base price + discount/premium] for quality j (j; fiber length, strength and uniformity) at week (i).

P_{aj} = the average [base price + discount/premium] for quality j for the entire 2004/2005 crop year.

Q_{ji} = the average quality (j) at week (i).

Q_{aj} = the average value for the entire 2004/2005 crop year.

2.3.2. Results and Discussion

Figures 1 through 18 show 1) changes in the cotton quality, 2) prices with discounts/premiums and 3) Price-Quality relationships for each of the three quality attributes (strength, micronaire and length uniformity) for the two states. For both California and Texas, it was clearly shown that there are significant departure in ***Price-Quality indices (PQIs)*** from one (1.0) for strength and micronaire, whereas the departure was relatively small for length uniformity. As an illustration, Figures 1 and 2 represent the changes in HVI strength and the price adjusted for the HVI strength discount/premium, respectively, for

California. It is shown that the trends look almost the same. However, a more exact analysis can be made in Figure 3 by observing the magnitudes of the departure in the Price-Quality Index from the expected standard (1.0). As shown in Figure 3, the PQI values are under 1 from October 7 to January 20 of the following year. This result indicates that significant biases exist in the discount/premium scheme in the strength. Namely, the discount/premium prices for the strength was underestimated for the period, and overestimated during February through the last week of 2004/2005 crop year. In case of Texas, as illustrated in Figure 6, a similar trend was clearly exhibited although the patterns were somewhat different between the two states.

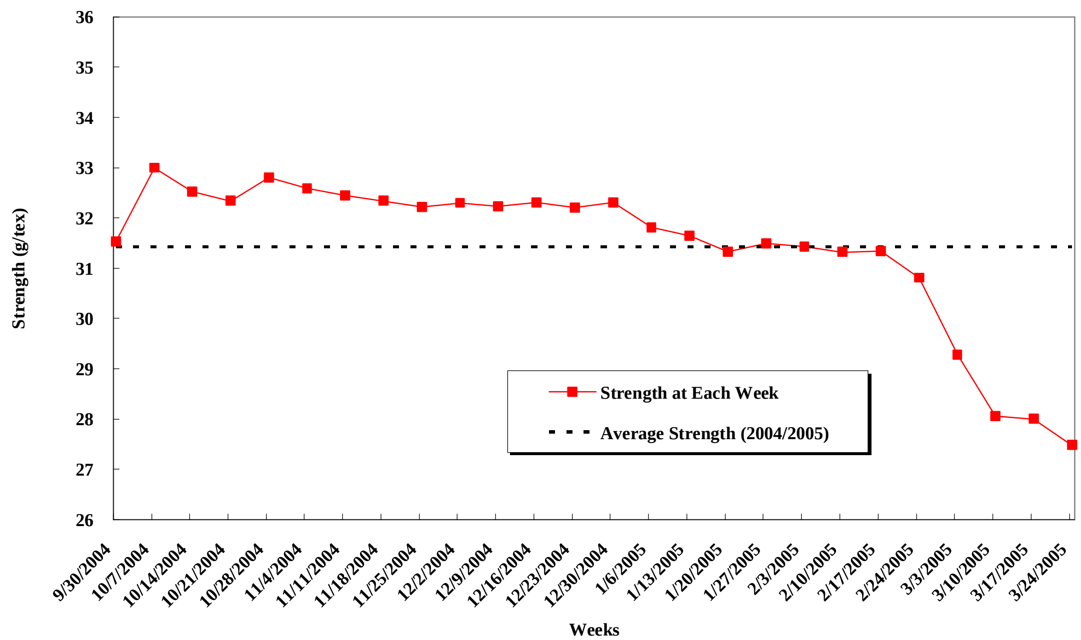

Figure 1. Weekly Average HVI Strength for CA Cotton during 2004/2005 Crop Year

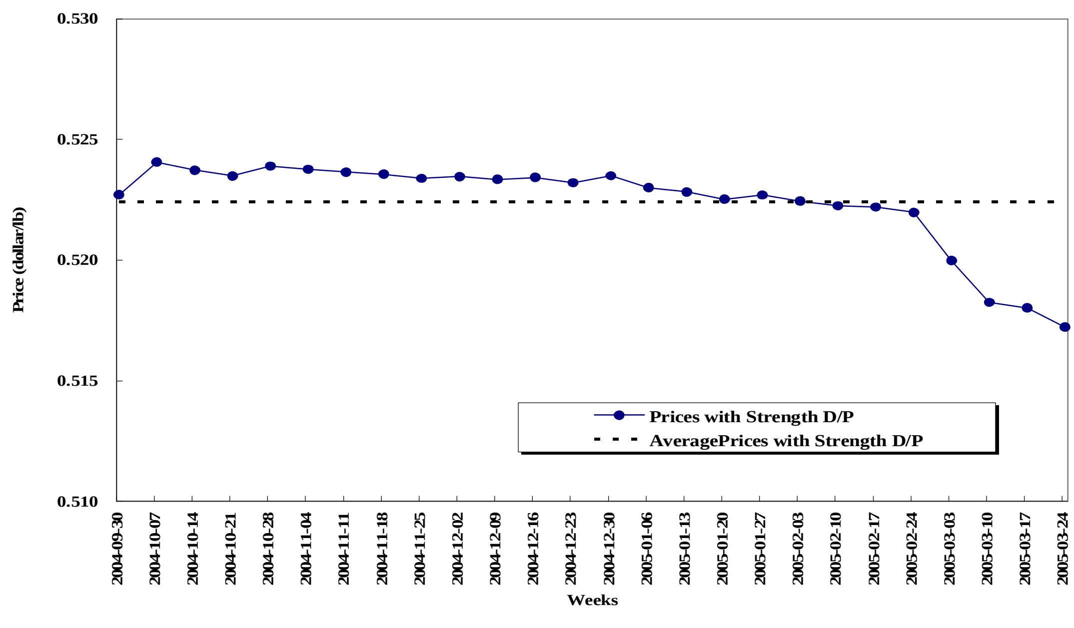

Figure 2. Weekly Average Base Prices plus Discounts/Premiums due to Strength for CA Cotton during 2004/2005 Crop Year

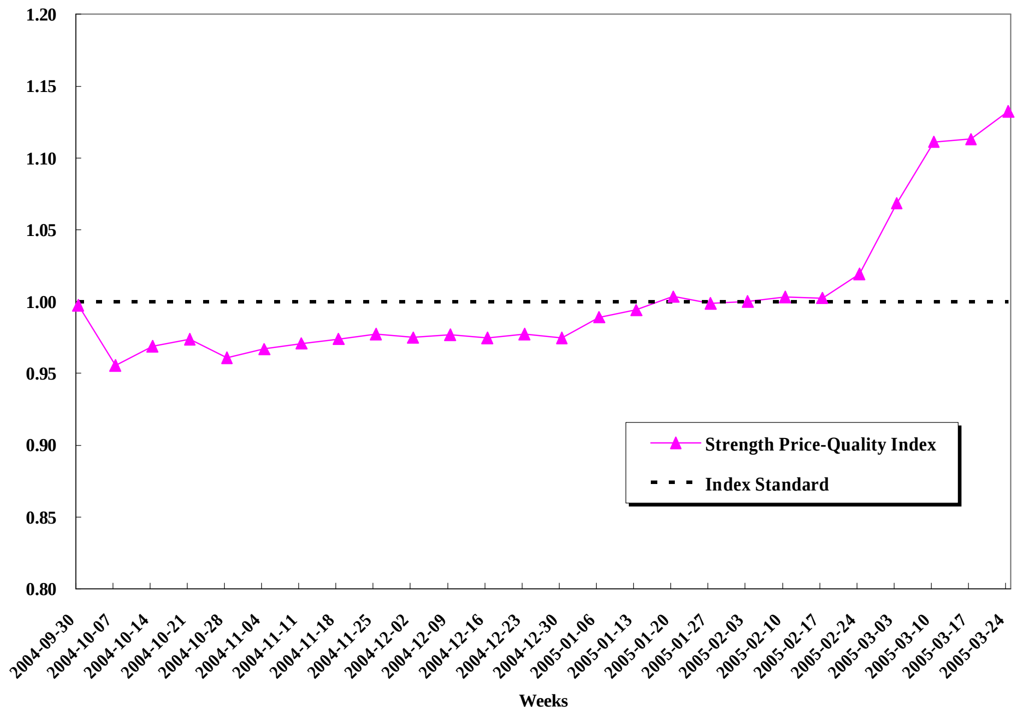

Figure 3. P-Q Index for HVI Strength for CA Cotton during 2004/2005 Crop Year

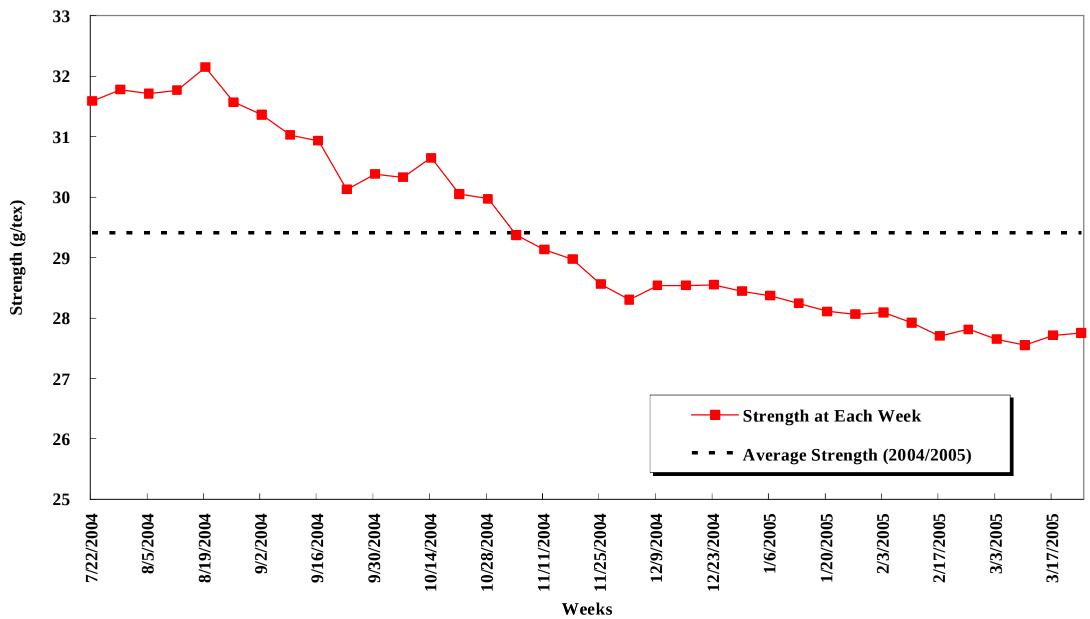

Figure 4. Weekly Average HVI Strength for TX Cotton during 2004/2005 Crop Year

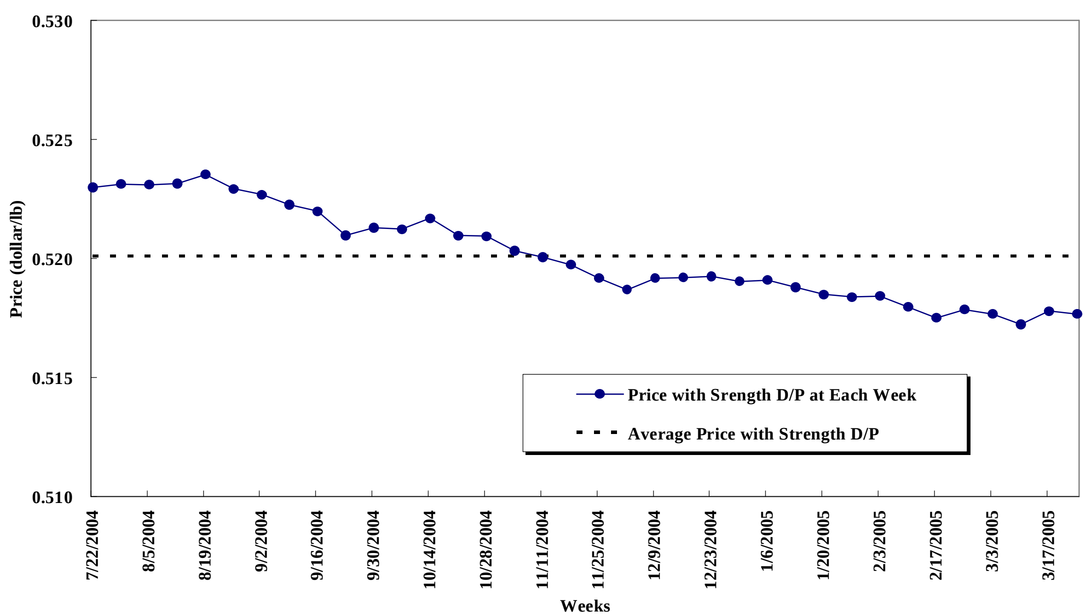

Figure 5. Weekly Average Base Prices plus Discounts/Premiums due to Strength for TX Cotton during 2004/2005 Crop Year

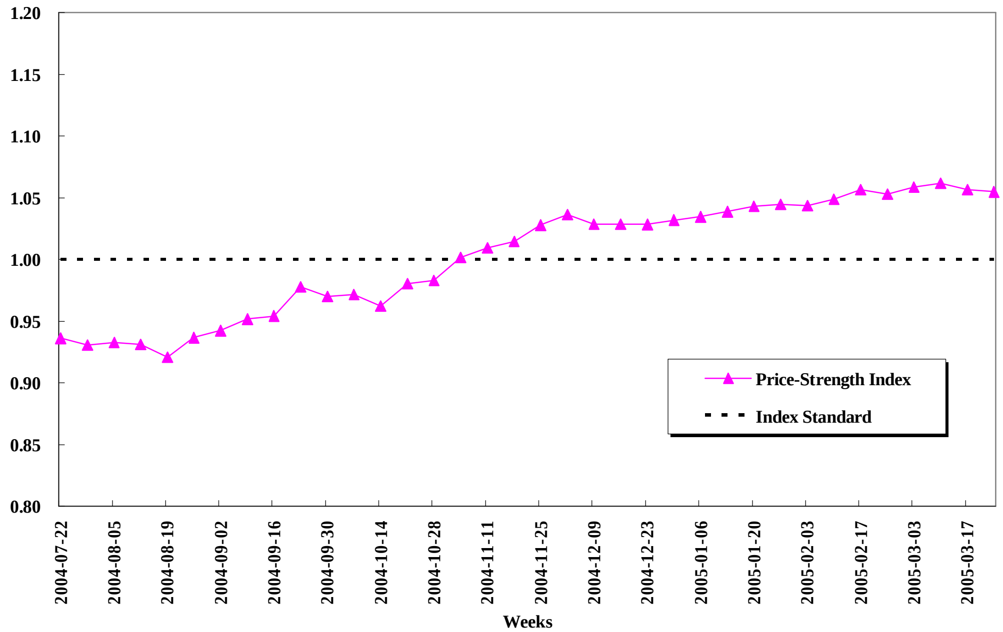

Figure 6. P-Q Index for HVI Strength for TX Cotton during 2004/2005 Crop Year

Figures 9 and 12 show the changes in PQIs of micronaire for California and Texas. For California, the overall trend of PQI shows slight under pricing by the discount/premium scheme as the PQI is somewhat below 1.0.before February, 2005, followed by a overpricing later on. For Texas, the change in PQIs is more severe than that of California. From July 22 to November 4, the PQIs for micronaire ranged from 0.88 to 0.97. Especially, for a 10 – week period, PQIs were below 0.90, followed by large jump to 1.05~1.08 range from the middle of the crop year. These results reveal significant biases in the discount/premium pricing structure of cotton.

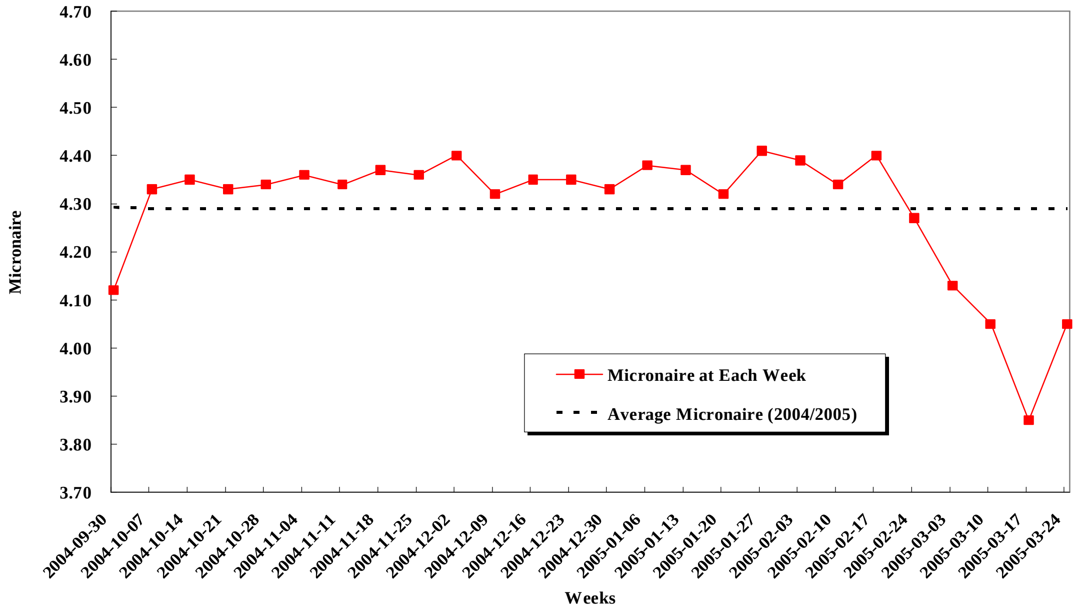

Figure 7. Weekly Average HVI Micronaire for CA Cotton during 2004/2005 Crop Year

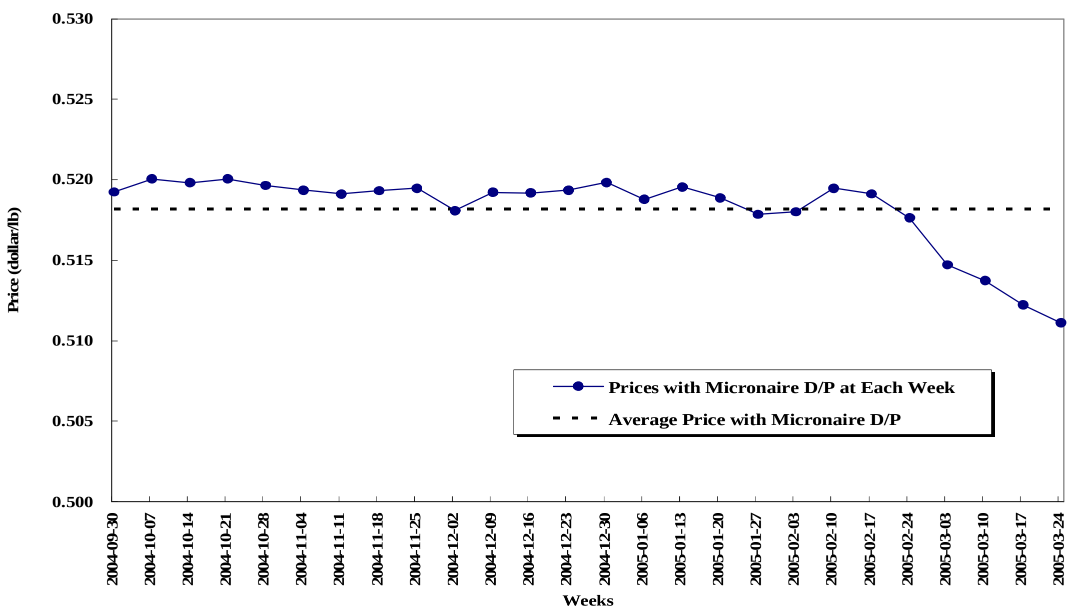

Figure 8. Weekly Average Base Prices plus Discounts/Premiums due to Micronaire for CA Cotton during 2004/2005 Crop Year

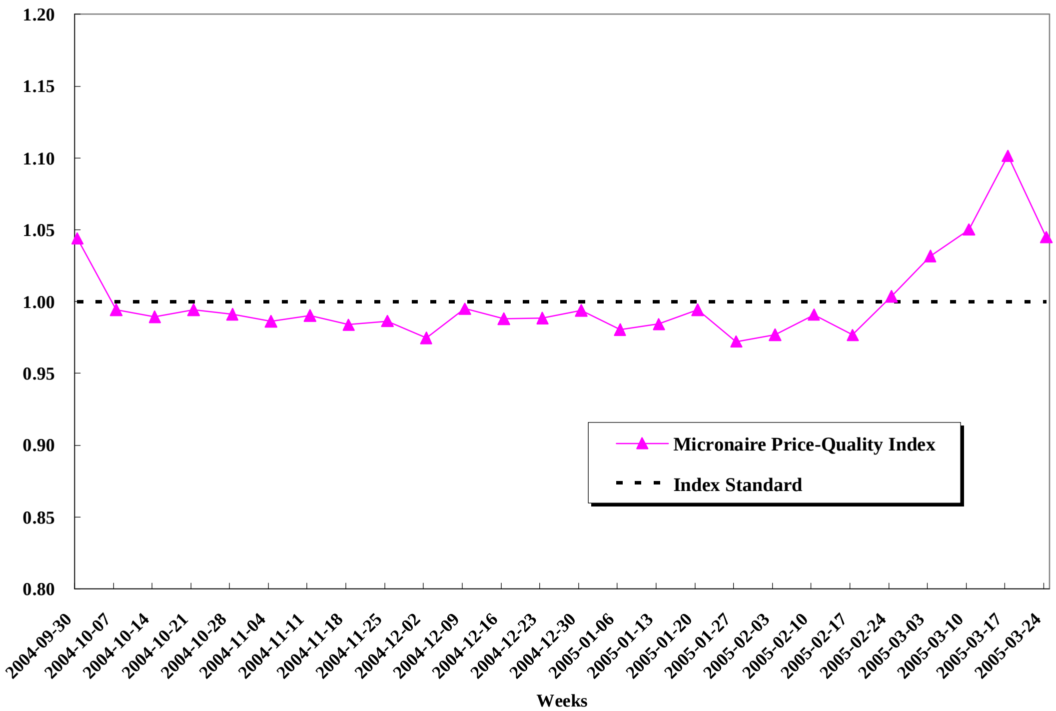

Figure 9. P-Q Index for HVI Micronaire for CA Cotton during 2004/2005 Crop Year

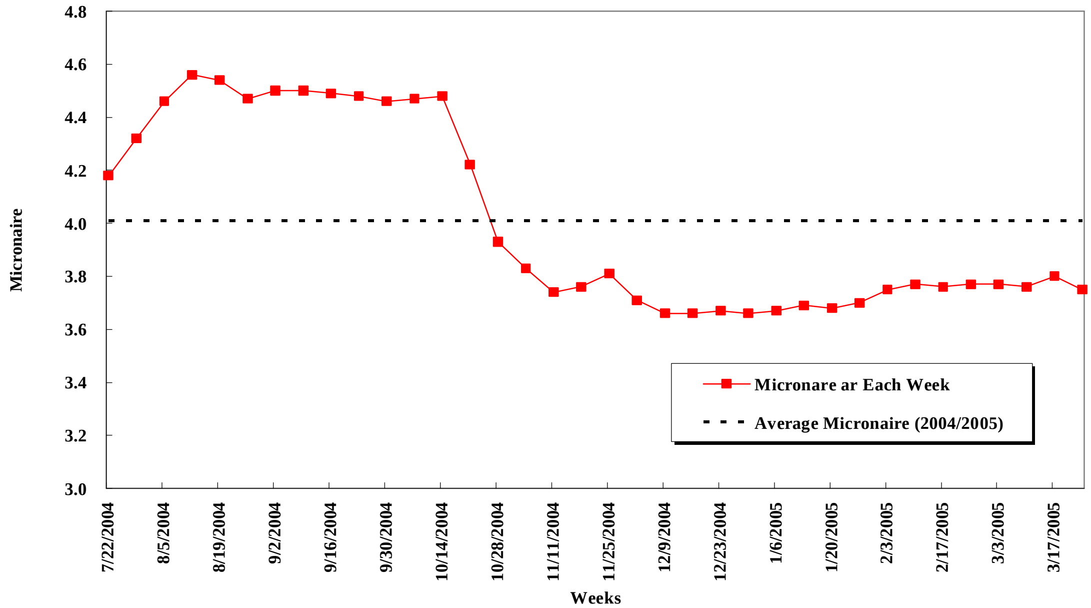

Figure 10. Weekly Average HVI Micronaire for TX Cotton during 2004/2005 Crop Year

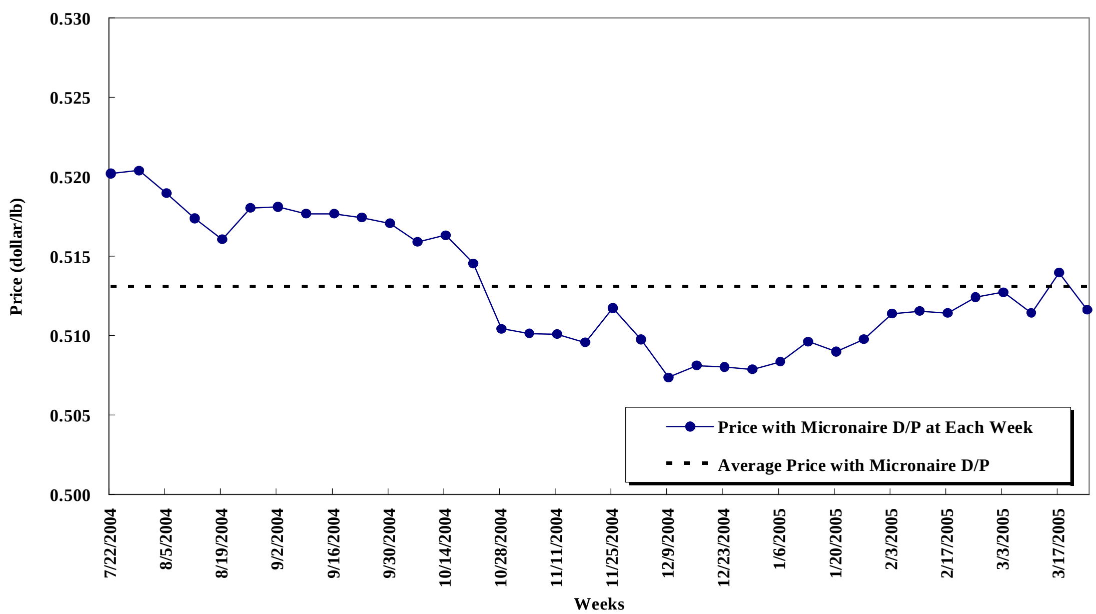

Figure 11. Weekly Average Base Prices plus Discounts/Premiums due to Micronaire for TX Cotton during 2004/2005 Crop Year

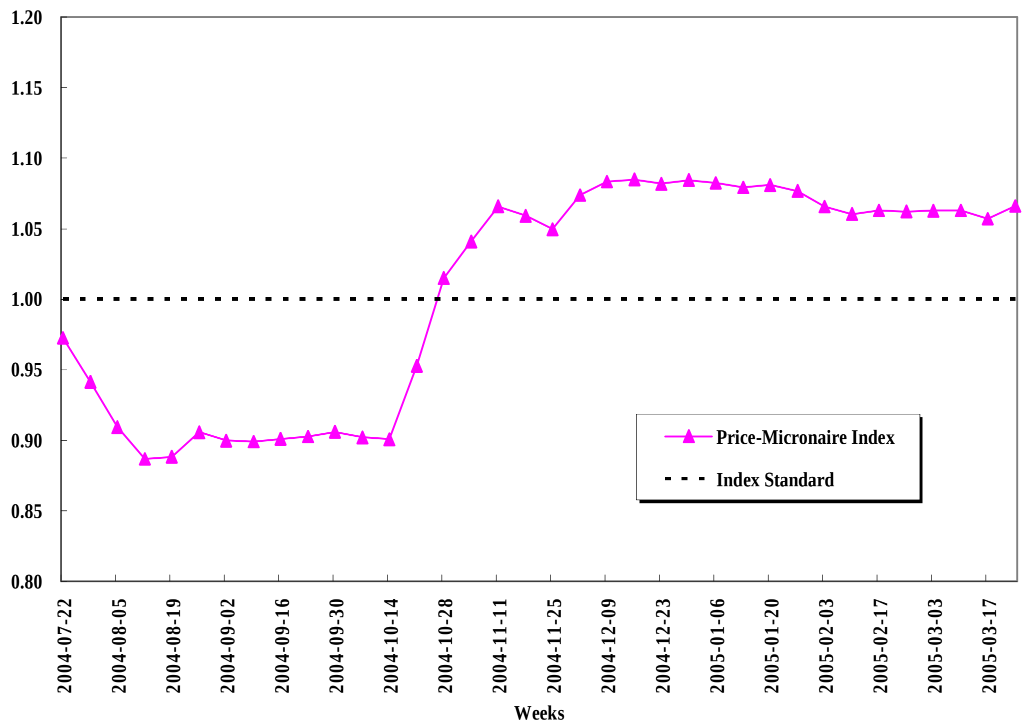

Figure 12. P-Q Index for HVI Micronaire for TX Cotton during 2004/2005 Crop Year

On the other hand, the results for the relationship between price and length uniformity (Figures 15 and 18) were quite different from that for strength and micronaire. The biases based on the differences between PQIs and 1.0 were not large as most of PQI values hovered around 1.0 for both states.

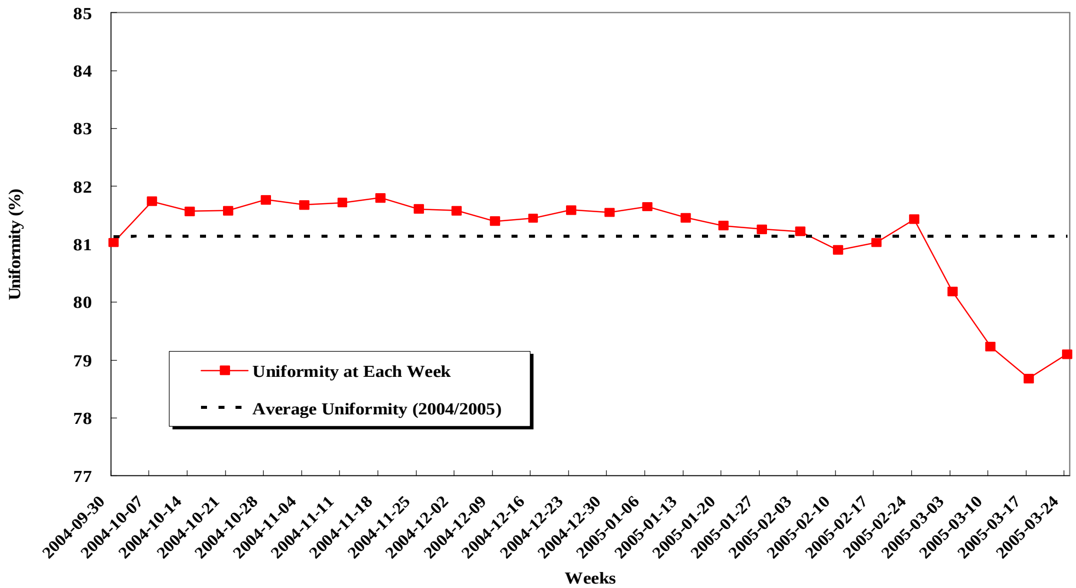

Figure 13. Weekly Average HVI Uniformity for CA Cotton during 2004/2005 Crop Year

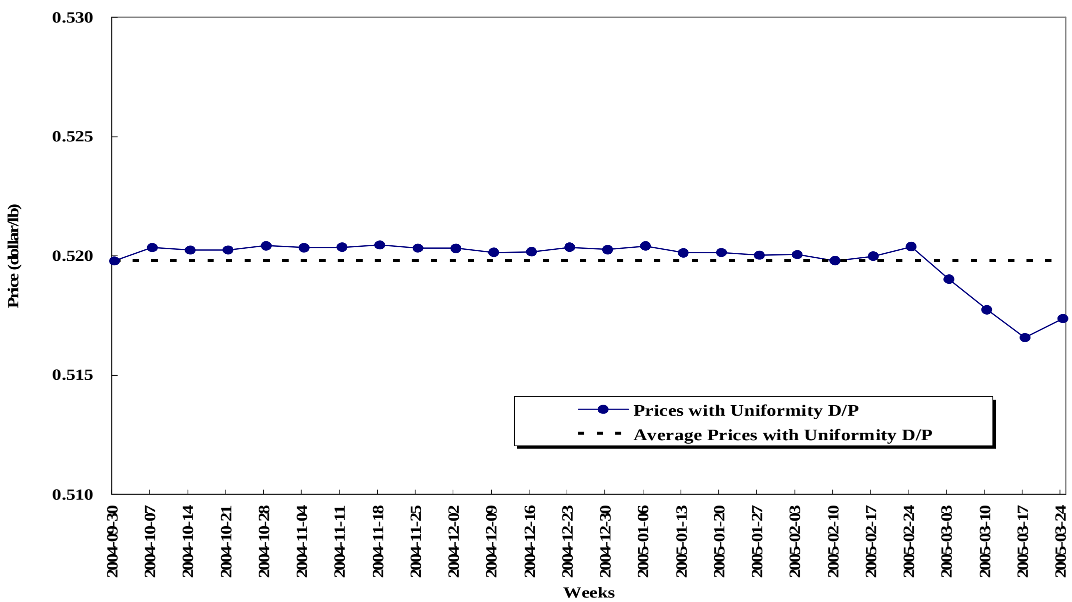

Figure 14. Weekly Average Base Prices plus Discounts/Premiums due to Uniformity for CA Cotton during 2004/2005 Crop Year

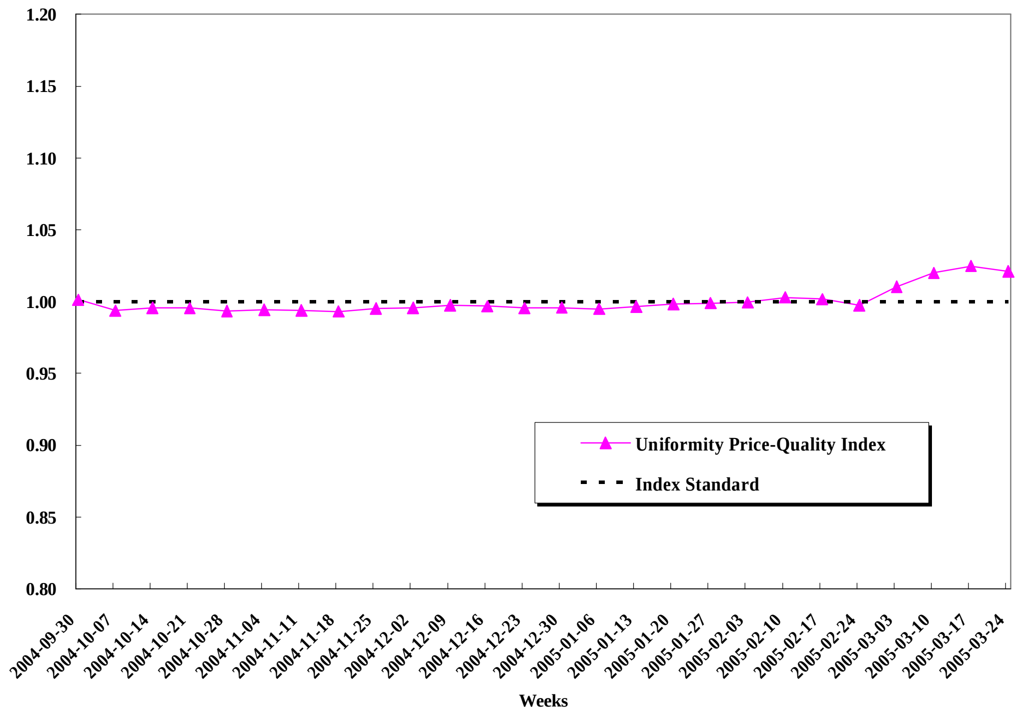

Figure 15. P-Q Index for HVI Uniformity for CA Cotton during 2004/2005 Crop Year

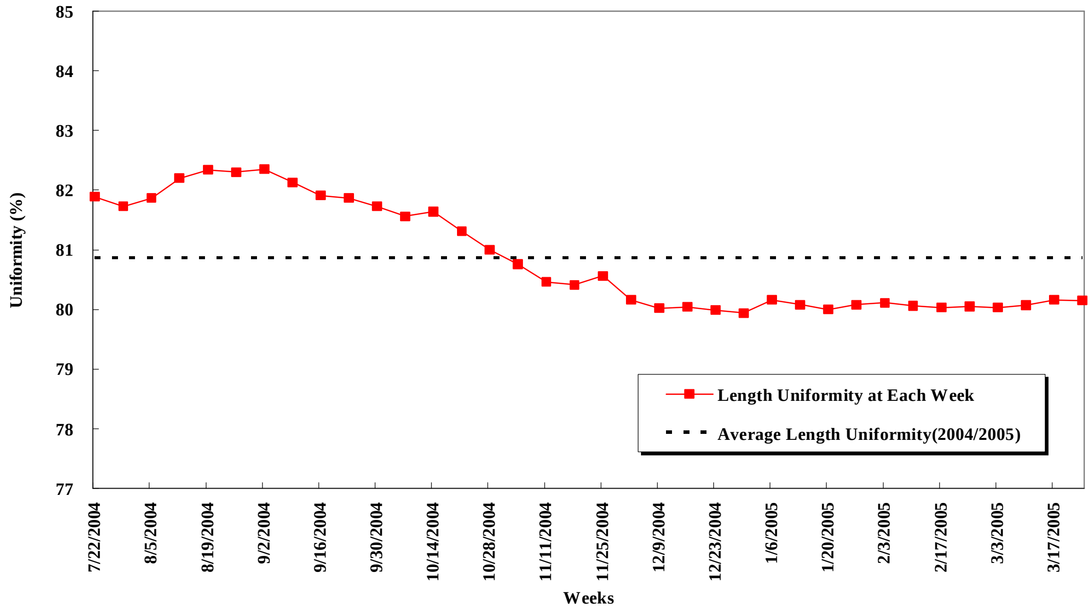

Figure 16. Weekly Average HVI Uniformity for TX Cotton during 2004/2005 Crop Year

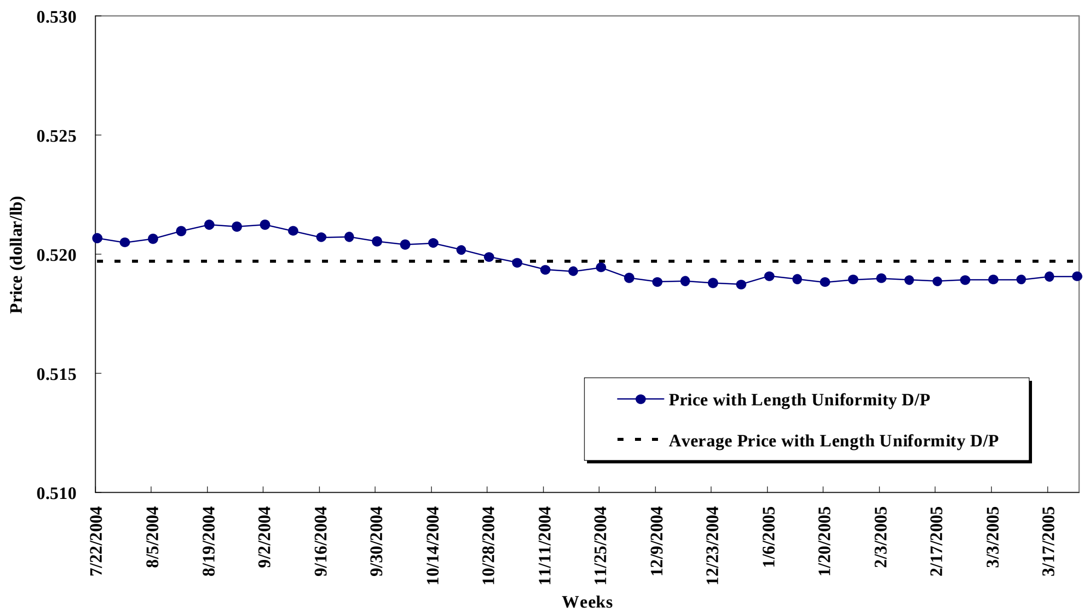

Figure 17. Weekly Average Base Prices plus Discounts/Premiums due to Uniformity for TX Cotton during 2004/2005 Crop Year

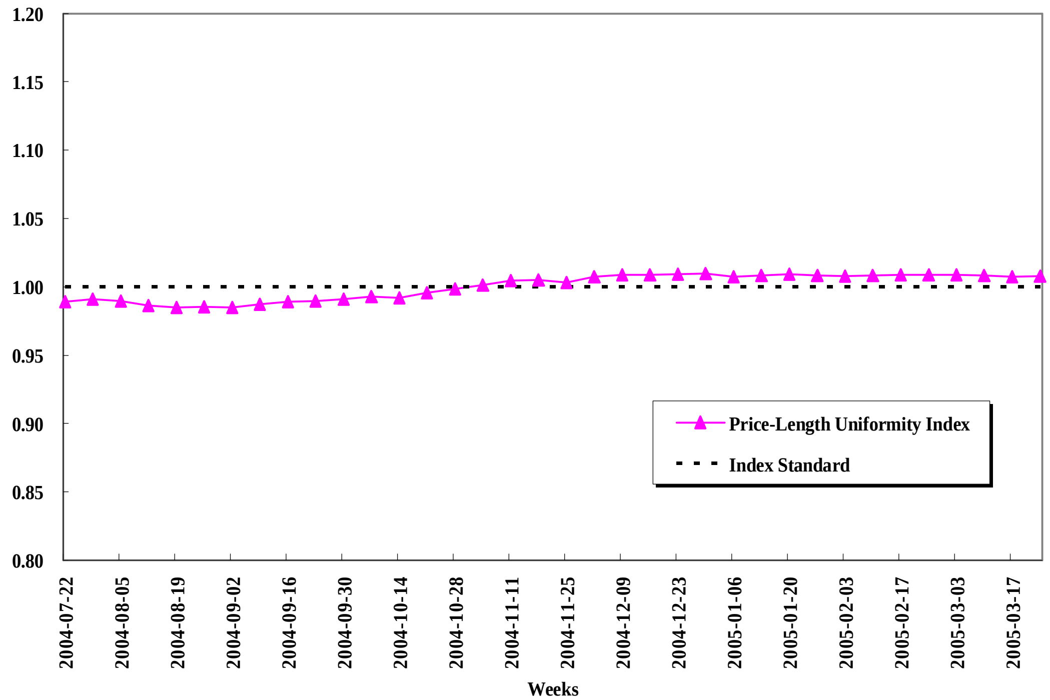

Figure 18. P-Q Index for HVI Uniformity for TX Cotton during 2004/2005 Crop Year

These results reveal that the current cotton discounts/premiums scheme is quite inconsistent and biased, suggesting that there are other factors that affect the pricing scheme. Therefore, the development of the alternative approach for cotton price estimation which can replace the DSCQ is needed.

3 OVERVIEW OF COTTON MARKET, POLICIES AND ISSUES

3.1. The Market Setting of Cotton

Cotton is the single most important textile fiber in the world, accounting for 40% of all fibers produced [USDA, 2001]. The U.S. and China each accounts for approximately 20 percent of global cotton production, followed by India (12 percent), Pakistan (8 percent), and Uzbekistan (5 percent). Approximately, one-third of cotton produced is traded internationally. The four dominant exporters-United States, Uzbekistan, Francophone Africa, and Australia- account for more than two-thirds of global exports. Four major producers, China, India, Pakistan, and Turkey are generally net importers of cotton to supply their textile industries [Baffes, 2004].

Real cotton prices have declined considerably during last half century; they are currently one fifth of their 1950 levels. In particular, cotton prices followed a steadily declining pattern. A structural break in cotton prices appears to have taken place in 1985 when the United States changed the nature of its support policies from stockholding to price support.

The long term decline in cotton prices has been aided by technological improvement such as an improved varieties, fertilizers, chemicals, irrigation, and mechanical harvesting. Most recent developments in technology such as genetically modified seeds and precision farming are likely to further reduce the costs of producing cotton. The United

States allocates more than 70 percent of its cotton area to genetically modified cotton, followed by Australia (40 percent), China (20 percent) and more recently by India.

The cotton market has been significantly affected by the rapid expansion of chemical fiber, mainly polyester. Chemical fibers account currently for almost 60 percent of global fiber consumption, up from 33 percent in 1960.

Figure 19 illustrates world per capita fiber consumption during the last four decades. As shown in this figure, the solid line with round markers represents world per capita cotton consumption and another solid line with square markers shows world per capita non-cotton fiber consumption. Cotton consumption between 1960 and 2000 grew by an annual average of 1.8 percent, approximately at the same rate as the population growth, implying zero per capita growth. Consumption of chemical fibers, on the other hand, has grown by 3 percent per capita [MacDonald, 2002].

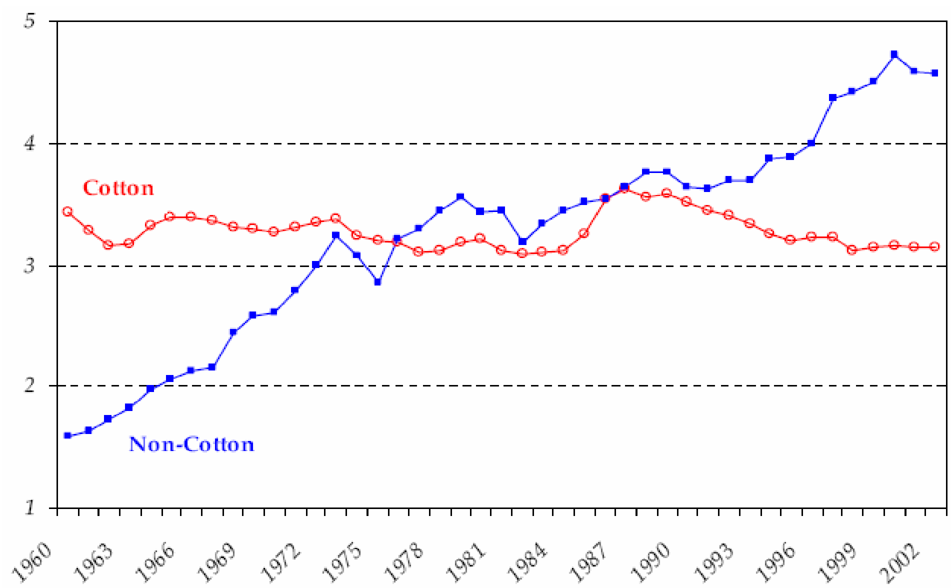

Figure 19. World Per Capita Fiber Consumption (Unit=Kilograms)

[Source: USDA]

The consumption pattern of cotton is primarily determined by the size of the textile industries of the dominant cotton consumers. China, the leading textile producer, absorbed more than one quarter of global cotton output during the 1990s [Kalsas, 2004]
Other major textile producers are India, the United States, and Turkey, which together (including China) account for three-quarter of global cotton consumption. A number of East Asian countries have emerged recently as important cotton consumers. For example, Indonesia, Thailand, Korea, and Taiwan consumed only 130 thousand tons in 1960 (1.2 percent of global consumption) while they consumed 1.5 million tons in 2003 (7.2 percent of global consumption) [Baffes, 2004].

3.2. Supply and Demand Factors Affecting Changes in U.S. Cotton Price

3.2.1. Supply Factors

3.2.1.1. Inventory Level, Production and Imports

Beginning stock is the first item to consider when estimating supply. Beginning stock for the current year are the ending stocks from the previous year.

The next supply item is production. Production depends on three items: planted acres, harvested acres, and yield per harvest acre. Figure 20 below represents the total supply of cotton in U.S. from 1965 to 2005. During the past decade, cotton production has varied from a record 22.5 million bales (1 bale = 480 pounds) in 2004 to only 13.9 million in 1998. However, cotton production in the United States rose only moderately after 1998, averaging about 19 million bales. In 2004/2005 crop year, the United States produced about 22.5 million bales of cotton, the most in the last four decades. Key producing States and their percent of U.S. cotton production for last five years include: Texas (29%), Mississippi (11%), Arkansas and Georgia (10 percent each), California (9%) and North Carolina (7%).

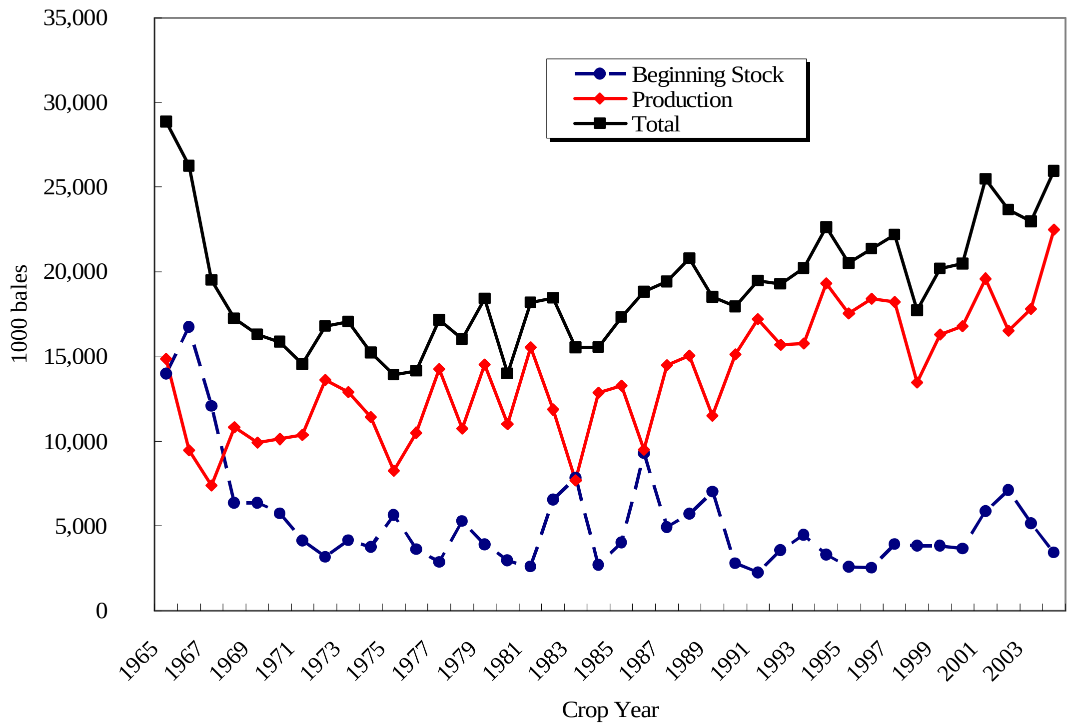

Figure 20. Total Supply for Cotton in United States (From 1965 to 2005)

Bio technology has also become an important factor in cotton production. Since their introduction in 1996, biotech cotton varieties (Bt and herbicide-tolerant crops) have been adopted rapidly by U.S. farmers seeking to reduce pest management costs. In 2005, adoption of biotech cotton increased to 75 percent of the acreage planted for cotton, up from 61 percent in 2000 [USDA, 2005].

Imports represent the smallest percentage of total supply, averaging less than 1 percent of total production. However, imports have ranged from 75 thousand bales to over 400 thousand bales. The largest variation is due to a government program known as “Step 3”. In August and September, most of the current year’s crop has not yet been harvested. Mills and exporters normally use cotton stocks from the previous year. If the demand for cotton is strong compared to supply, the price rises. When the United States/Northern European price quotation stays above the Northern European price by more than 1.25 cents for four consecutive weeks, the President may authorize additional imports of upland cotton according to Step 3 regulations. The increased imports will lower the price of United States cotton, allowing United States mills to stay competitive in the world market. By the time the current year’s cotton production is harvested and ginned, Step 3 imports are usually reduced or eliminated [Kenyon, 2001].

3.2.1.2. Weather Factors

Cotton is cultivated as an annual in the temperate and even sub-tropical zones and develops in an orderly, predictable pattern. The seasonal development of cotton is shown in Figure 21. Plant development in cotton proceeds through five growth stages; germination and emergence, seedling establishment, leaf-area-canopy development, flowering and boll development, and boll and fiber maturation.

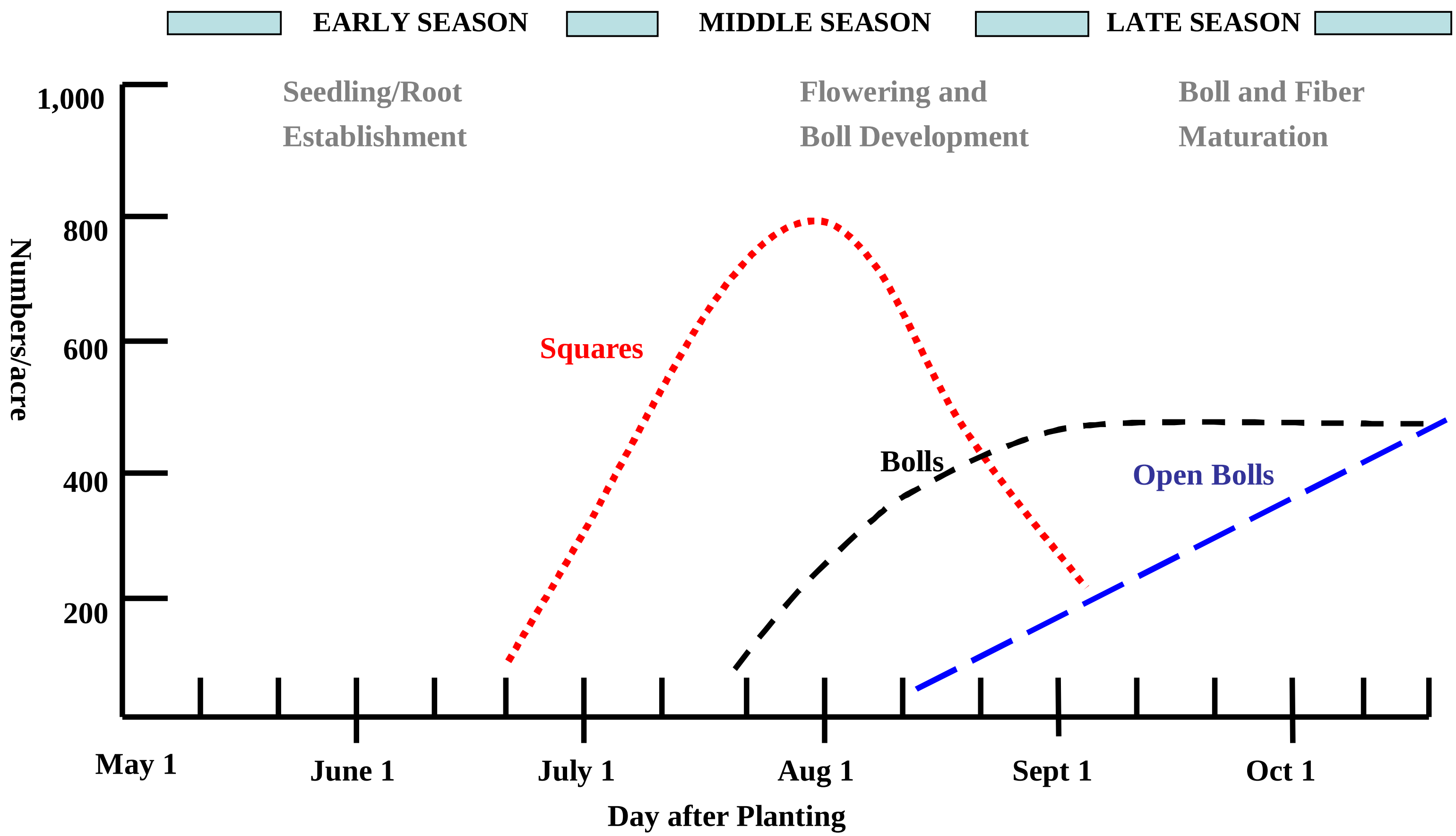

Figure 21. The Seasonal Development of Cotton, Showing the Production Pattern of Squares, Bolls and Open Bolls [Oosterhuis, 1990]

Cotton requires a minimum daily air temperature of 60°F for germination, 70-80°F for vegetative growth, and 80-90°F during the fruiting period [Freeland et al, 2006]. Mauney [1986] stated that all processes leading to square, boll initiation and maturation are temperature-dependent. Especially, the weather of harvest season is the most important factor for the quality of cotton. In the study for the cotton produced in Arizona, Silvertooth [2001] found that while variety and location influence micronaire, excessive heat units in the field late in the season clearly give a high probability of micronaire. There exist many papers dealing with the effects of the weather of harvest season on cotton quality.

3.2.2. Demand Factors

Cotton demand fluctuates annually and depends heavily on the strength of world economic conditions. Over the past decade, domestic mill use accounted for 60 percent of the total disappearance of U.S. cotton, while exports accounted for the remainder. However, exports are becoming more important as the U.S. textile industry continues to restructure with lower trade barriers and the labor costs decline outside the United States, thus reducing the mill consumption. Figure 22 shows the total consumption of cotton in the Unites States during the last four decades.

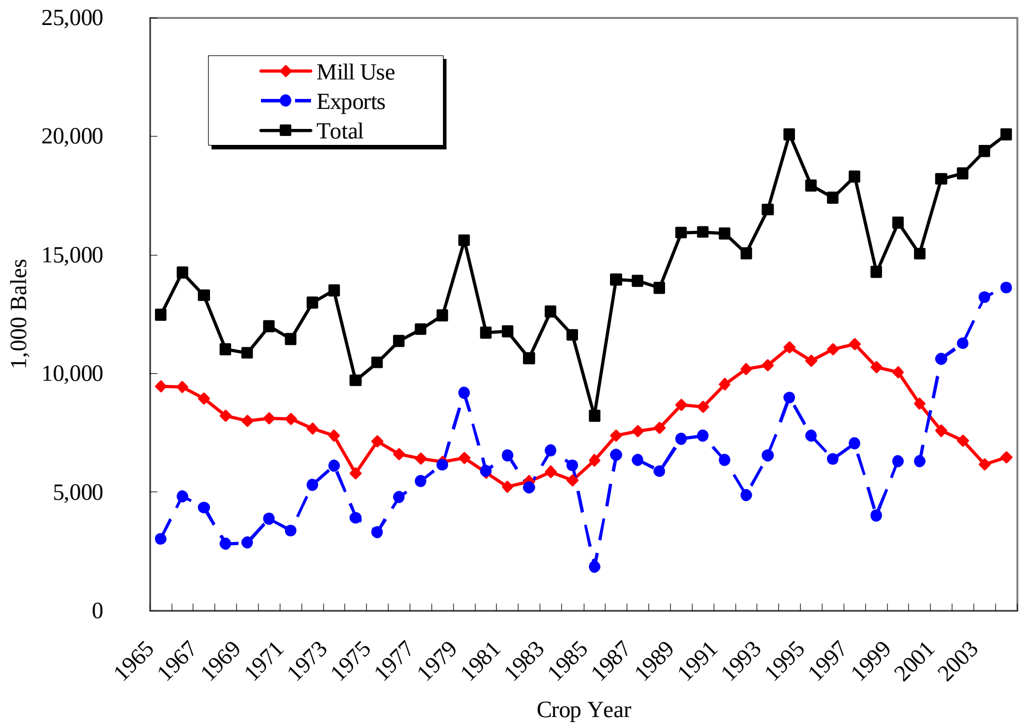

Figure 22. Demand for Cotton (From 1965 to 2005)

U.S. mill use climbed steadily throughout much of the 1990s as consumer demand increased for natural fiber clothing, like denim. U.S. mill use peaked in 1997/98 at a near-record 11.3 million bales. However, from 1998 to 2005 mill use continued to decrease. The change in trend is caused by competition from less expensive apparel imports, exacerbated by recent trade agreements, and a strong dollar, forcing some industry participants to limit output, relocate, or close operations. As the textile industry continues to relocate abroad, the mill use of cotton is expected to decline, while exports of raw cotton will rise. Production in the United States and other countries, exchange rates, government programs in the United States and other countries, and politics determine the United States' exports.

With the continued liberalization of world textile and apparel trade, the U.S. cotton textile trade deficit continues to expand. The North American Free Trade Agreement (NAFTA) – which became effective in 1994 – along with the Caribbean Basin initiative (CBI) accelerated the growth of U.S. cotton textile and apparel imports, which have seen significant gains over the last decade.

3.2.3. Other Factors Affecting Cotton Price

There are some other factors affecting cotton price as well as supply and demand factors above mentioned.

One of them is the European market as the price for cotton in Europe helps determine not only world cotton prices but is also used in calculating the payments for United States cotton support program. The price of European market is referred to as the A-index. The A-index is the average of the five cheapest cottons available in the European market. It is an important determinant of the US cotton price because in the past Europe was the largest importer of cotton in the world market. The A-index prices are also usually found in Cotton and Wool Outlook.

Today, China's sheer size and the volatility of cotton production in China affect price of cotton throughout the world. China, world's largest producer and consumer of cotton, is believed to hold 30% of world stocks and is the largest exporter of garments in the world. China has been at the borderline of being a net importer and net exporter. This constant shifting has produced volatility in the world cotton market in recent years. Figure 23 shows the correlation between China's import and the world cotton price. When China's cotton exports exceed imports, the world cotton prices are shown to have declined. Therefore, China factors must be considered in forecasting the changes in U.S. cotton prices.

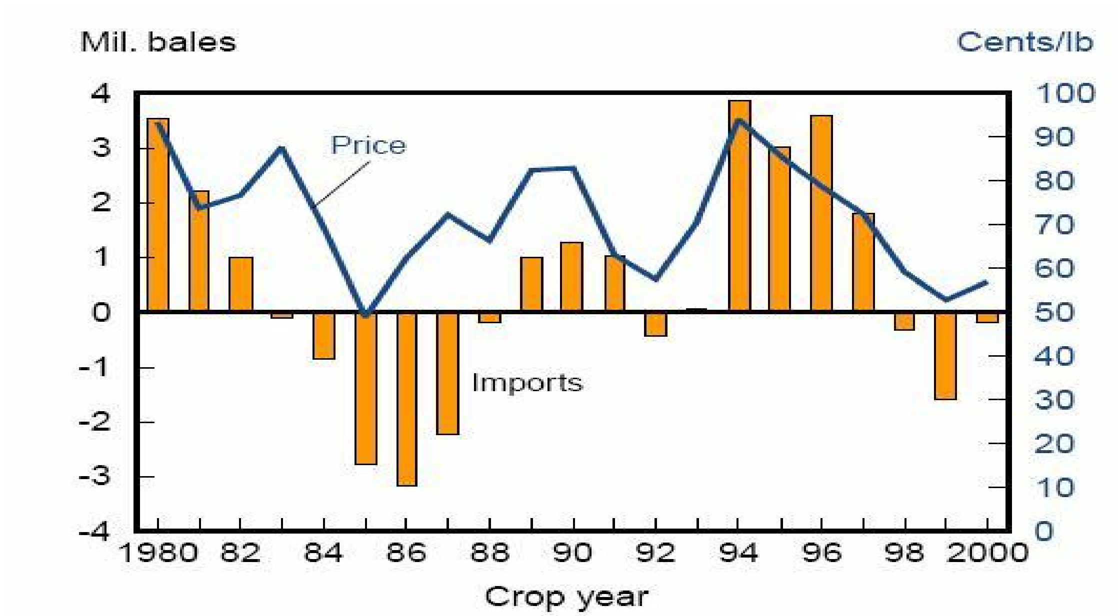

Figure 23. China's Import and Cotton Price

[Source : USDA-ERS]

4 THEORETICAL BACKGROUND

4.1. Hedonic Price Theory

4.1.1. Historical Review

Hedonic studies date back as early as the 1920s, when, in one of the first such studies, Waugh [1928] analyzed the relationship between characteristics of fresh vegetables and wholesale vegetable prices in the Boston wholesale market. Although Waugh was one of the earliest to study product characteristics, the term "hedonic" was not applied until Court [1939] attempted to improve the consumer price index related to the automobile sector as it was reported by the Bureau of Labor Statistics. Subsequent development of hedonic theory was done in later studies by Houthakker [1952] and Theil [1952], but the first major advancement in hedonic price theory was made by Lancaster [1966].

Lancaster proposed that a good was essentially a collection of characteristics. Consumer purchases a good in the market because of the characteristics it possesses, and derives utility from the utility-bearing characteristics embodied in that good. Lancaster explains how this theory helps to explain market issues with which traditional economic theory is not equipped to deal, such as the determination of which goods (or characteristics) would make acceptable substitutes for other goods. For example, traditional economic theory would allow completely unrelated products, such as wood and a loaf of bread, to substitute for one another, while hedonic theory recognizes that these two products would not be substitutes to each other because the characteristics embodied in a loaf of bread are entirely different than those embodied in wood. This study laid the groundwork for modern hedonic price theory by establishing the concept of utility for individual characteristic [Hoelscher, 2001]. However, Lancaster's model of consumer theory allowed only for discovery of characteristic values, but did not give insight into the formation of these values. Building upon Lancaster's work, Rosen [1974] expanded upon these theories and introduced the concepts of supply and demand of characteristics into the hedonic price framework.

Departing somewhat from Lancaster, Rosen described a good as an invisible package of characteristics that can be bought or sold in the market. The goal of his model was to maximize the utilities associated with each characteristic for the consumer subject to budget constraints. Each characteristic inherent in a product, therefore, has a unique supply and demand function that determines the equilibrium price and the quantity demanded of that characteristic. Rosen developed a two stage hedonic framework to estimate these functions. In the first stage, the market prices of a commodity are regressed against the quality attributes of the good. By differentiating the function with respect to each attribute, the implicit marginal value of each attribute is derived. In the second stage, the marginal implicit prices derived in the first stage are used as endogenous variables in a system of simultaneous equations. These equations contain vectors of characteristics and exogenous supply and demand shifters.

4.1.2. Hedonic Price Theory - The Concept

Hedonic price theory is to provide a detailed quantitative explanation of the market for heterogeneous commodities which traditional economic theories cannot explain. The purpose of a hedonic model is to disaggregate the price of a good so that a marginal implicit price can be derived for each of the utility-bearing characteristics that comprise the good.

Cotton is recognized in the industry as being a differentiated good. Before cotton is offered for sale in the market, each bale is classed and given an official measurement for each of its inherent characteristics: color, leaf grade, trash content, fiber length, fiber strength, micronaire, and fiber length uniformity, and etc. Following hedonic price theory, cotton can be reviewed as a bundle of characteristics as follows:

$$C = (CG, LG, TR, MIC, LEN, STR, UNI) \qquad (4.1)$$

Where cotton(C) is comprised of a vector of coordinates measuring the amount of each quality characteristic of cotton (CG = Color grade, LG = Leaf grade, TR= Trash Content, Mic= Micronaire, Len= Fiber length, STR = Fiber Strength and UNI = Fiber length uniformity)

The price of cotton can then be represented as :

$$P(C) = P\,(CG, LG, TR, MIC, LEN, STR, UNI) \qquad (4.2)$$

Where price is a function of the price of each individual quality attribute.

The value of cotton can be expressed as a function of the implicit prices of each of the characteristics embodied in the good. Each of these implicit prices is determined in the market by the interaction of the supply of and demand for each quality characteristic embodied in cotton. Figure 23 gives an example of how the equilibrium price for a characteristic (in this case fiber length) is determined by the market. Assume that cotton is composed of only two characteristics, fiber length and micronaire. In Figure 23, LEN represents the level of fiber length for lot of cotton and P the price of the lot, and ϕ the cotton producer's supply function. The horizontal axis represents fiber length at a fixed micronaire value. Holding the level of micronaire constant, all points along the supply curve represent all of the prices at which the producer is willing to sell a lot of cotton with varying levels of fiber length. The θ is the buyer's demand function, representing all prices which the buyer is willing to pay for varying levels if fiber length with a given level of micronaire. Points A and B, the points at which the supply and demand curves are tangent to each other, represents the equilibrium prices for fiber length at levels LEN_1 and LEN_2. Following this logic, the line, P (LEN), can be drawn representing the locus of all points at which the bid and offer functions are tangent to each other for each level of fiber length.

The example above assumes that the fiber length is a desirable attribute, and hence the P (LEN) curve has a positive slope. Not all characteristics embodied in a product, however, are always desirable.

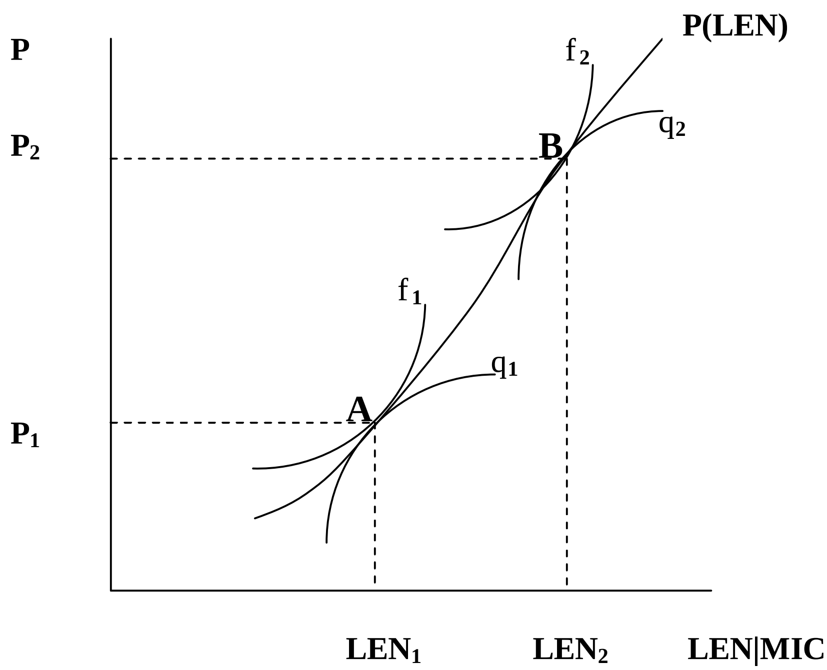

Figure 24. Determination of an Equilibrium Price for Fiber Length
[Hoelscher, 2001]

For example, the leaf grade is considered in the cotton industry to be an undesirable quality characteristic as it can increase production costs for textile mills, making the slope negative. That is, a cotton lot with lower trash content is worth more to a textile mill than one with higher trash content. Holding all other characteristics constant, an increase in the level of leaf content would cause a decrease in the price of the lot. Thus, the price relationship depicted in Figure 24 would be downward sloping for leaf content. Therefore, the implicit value of a characteristic can take on a positive or negative value, so that a lower price for a good could be due not only to a smaller amount of a desirable characteristic, but also to a large amount of an undesirable characteristic. Continuing with the original example, let us assume that fiber length and micronaire have implicit prices of P_{LEN} and P_{MIC}, respectively. The price of the cotton lot then would be the sum of each characteristic possessed by the cotton multiplied by its implicit price.

This relationship could be expressed as:

$$P(C) = (LEN*P_{LEN}) + (MIC*P_{MIC}) \qquad (4.3)$$

From Equations (4.2) and (4.3), it follows that if the price relationship of cotton, P(C), is differentiated with respect to an individual characteristic, for example, Fiber length (LEN), then the market equilibrium price function for LEN, may be derived. This derivation gives the equilibrium value of a characteristic at a point in time. However, as the value of a lot of cotton with a fixed set of attributes varies over time, so do the values of the attributes contained in that lot. As in any other market, prices are subject to fluctuations due to shifts in supply and demand. A heterogeneous commodity is also subject to the same fluctuations, not only due to general market fluctuations, but also as a result of the changes in the supply or demand functions for each attribute in order to accurately reveal the variation of implicit prices over time [Hoelscher, 2001].

4.2. Empirical Studies in Hedonic Pricing Analysis

4.2.1. First –Stage Hedonic Models

Ethridge and Davis [1982] published the first formal application of hedonic theory to the cotton market in 1982. The authors proposed that cotton producer price was a function of cotton fiber attributes. The purpose of their study was to determine the impact of four quality attributes (trash content, color, staple, and micronaire) on the price of cotton lint received by producers. They used a generalized least squares (GLS) procedure to address the problem of autocorrelation for the time-series and cross-sectional data.

The results of the estimation indicated that the producer prices were significantly affected by the staple length, micronaire, and trash content while the market value of the fiber properties varied year to year. The study concluded that while other factors may influence the price of cotton, the characteristics of the cotton itself always play a significant role in determining the price. Ethridge and Davis also suggested that the market values of cotton quality characteristics could provide market participants with valuable information. Producers could use this information to choose planting varieties, while policymakers could use it to make recommendation for generic research or educational programs.

Hembree et al. [1986] analyzed the effects of cotton fiber properties on cotton prices at Southeastern U.S. textile mills. The data was provided by the USDA for staple length, length uniformity, micronaire, strength, whiteness, yellowness, and trash content for the marketing years 1977/78 through 1983/84. The mill price of the cotton was regressed against the cotton fiber characteristics and dummy variables representing time. They found that all fiber properties were statistically significant in explaining the textile mill prices. Fiber properties having the greatest impact on price were fiber strength, staple length, and micronaire, followed by uniformity, yellowness, whiteness, and trash content. Hembree et al. also found that when market conditions were not allowed to fluctuate, fiber attributes explained 85% of the variation in prices. However, when market forces were allowed to vary, fiber attributes explained only 18% of the variation in mill prices. This suggested that, while quality characteristics do play a role in the determination of prices at the mill level, other market forces such as supply or demand shifters play a dominant important role.

Bowman and Ethridge [1987] conducted a followup study by extending the data through 1985/86 marketing year. The results were proven to be similar to that of Hembree et al. They concluded that the dummy variables indicating marketing year accounted for the effect of general market supply and demand forces. In addition, the ranking of the explanatory of the attributes changed slightly. Fiber properties having the greatest impact on price were micronaire, strength, yellowness, trash content, length, length uniformity, and whiteness, in descending order of explanatory power.

Ethridge and Neeper [1987] estimated the implicit prices of cotton fiber characteristics in Texas and Oklahoma for 1983/84 and 1984/85 market years. The focus of the study was fiber strength and length uniformity. They used a seemingly unrelated regression (SUR) procedure to estimate the correlations among cotton fiber attributes. They hypothesized that the farm price of cotton lint could be separated into two components - the loan price and premiums over the loan. Their study was the first one using a hedonic price model of cotton by employing a multi-equation approach for quality attributes. Ethridge and Neeper concluded that fiber strength and length uniformity significantly affected producer prices. Producer prices were most responsive to fiber length and micronaire and least responsive to variations in color and strength. In addition, strength premiums and uniformity discounts were much smaller at the producer level than those paid at the textile mill level. Based upon the results of this study, they suggested that the significant impact of strength and uniformity on cotton prices justified their inclusion in the USDA's cotton pricing reporting.

Chen and Ethridge [1996] examined the price determination of cotton in the textile market and then identified the patterns of premiums and discounts across different production regions. Their objectives were to use primary data from actual textile mill market transactions to estimate the premiums/discounts across regions, to determine patterns of similarities/differences for the regional pricing structures, and to investigate the cause of these patterns. Their results indicated that textile mills differentiate attribute premiums and discounts by production region. They concluded that knowledge of the end-use pricing structure is important in deriving prices at other pricing points when the market generates information effectively. Chen et al. [1997] later concluded that in addition to quality attributes, the non-quality factors also determined cotton prices in the end-use market.

The Ethridge and Davis and Ethridge and Neeper studies, along with Bowman and Ethridge, served as a prelude to the development of the Daily Price Estimation System (DPES) for cotton. Introduced by Ethridge et al. and Brown et al., this system represents the first attempt to implement cotton price estimation using a hedonic framework for the purpose of daily price reporting.

Brown et al [1995] and Ethridge et al [1992] provide a description of the DPES as a computerized, automated, econometric system developed for the purpose of estimating and reporting daily cotton prices, premiums, and discounts based on hedonic price analysis. The implementation of HVI grading standards made it possible to collect quality attribute information on cotton sales. This system receives spot market transactions from two Texas-Oklahoma regions where the market price of cotton reported each night and uses a series of computer programs to regress the cotton prices against the quality attributes of each sale and then generates a set of tables containing premiums and discounts based upon that day's market activity. These tables are then distributed via electronic mail. Brown et al. [1995] and Ethridge et al. [1992] also suggested that changes in the grading system (particularly with regard to the introduction of HVI) have impacted many aspects of the cotton marketing system, especially price reporting activities. They suggested that this econometric approach provides price estimates for more quality attributes than the current price reporting system (DSCQ) and constituted a reproducible and analytically rigorous means of providing timely and accurate market information.

4.2.2. Second-Stage Hedonic Models

Only two studies were found that have used Rosen's two-stage hedonic framework to develop characteristic bid function and characteristic offer function as presented in this section.

Bowman and Ethridge [1992] used Rosen's two-stage hedonic framework to develop a model to estimate the characteristic supply and demand functions for cotton fiber attributes in the U.S. producer market. The first-stage model determined the average annual implicit prices for each of the quality attributes (staple length, strength, trash content, color grade, low and high micronaire) in each region (Southeast, Mid south, Southwest, and West) for each year of the study. Producer prices were regressed against the cotton characteristics using a linear difference model in which a dummy variable was used to represent the regional differences.

The second-stage models (characteristic supply and demand models) were determined separately using their respective supply and demand shifters. The annual demand models were established by equating the implicit price of the attribute to a function of all attributes, the base price of cotton, and the change in the proportion of rotor to ring spindles in U.S. textile mills. The base price was included to capture the effects of general price movements in the market. The annual supply models estimated the levels of each quality attribute as a function of seasonal weather variables and a trend variable to approximate the effect of variety improvements over time. They then combined the derived supply and demand functions and derived equation systems for each of the four cotton marketing regions.

Bowman and Ethridge found that all factors analyzed had a significant impact on fiber attribute demand, to some extent while the environmental factors varied largely across regions with respect to attribute supply. They also projected values of fiber characteristics for the two years following the study period. These results indicated that the supply equations generally predicted the changes in the level of characteristics well for most cases. However, the demand equations proved to be less effective, exhibiting consistent bias when compared with the actual values observed over the two-year period. Bowman and Ethridge suggest that the failure to predict the prices of the quality characteristics may be associated with trends in the prices or inadequate empirical data. The concern on inadequacy of the data (primarily with regard to using DSCQ pricing information) raises a question on how the results might change had the accurate for reflecting the market activities. Consequently, the development of the DPES provides an alternative source of data for this study and a strong incentive for developing an enhanced model.

4.3. Price-Quality Relationships of U.S. Cotton [Brown, 1993]

The theory of cotton pricing through quality attributes is complex because of the number of attributes that play a role in price determination. This part presents the nature of the relationships between the price of cotton and quality attributes.

Brown [1993] developed the optimal price model for the Texas and Oklahoma cotton markets for 1993/94 seasons. The functional model in his study stems from the concept of hedonic pricing. He recognized that the quality characteristics in cotton have implicit prices. These implicit prices were referred to in his study as the price-quality (P-Q) relationships. Brown made several functional models and tested the appropriateness of these models using a partial regression analysis and a residual analysis. He chose a following functional model.

$$P = b_0 e^{b_1 CTR^2} Rd^{b_2} e^{b_3(+b)+b_4 STA+b_5 STA^2} STR^{b_6} U^{b_7} e^{b_8 M+b_9 M^2+b_{10}R+b_{11}LB+b_{12}HB+b_{13}HB} e \qquad (4.4)$$

Where

P = average price of cotton

CTR = average trash content

Rd = average percentage of reflectance

+b = average of the yellowness readings

STA = average staple length

STR = average fiber strength

U = average fiber length uniformity

M = average micronaire

R = regional dummy variables

LB = average percentage of level 1 bark

HB = average percentage of level 2 bark

The price-quality relationship is the relation between the price of cotton or the implicit prices of an attribute and the level (quantity) of the attribute holding all other attributes constant. As the quantity of the quality attribute increases, the efficiency or marginal productivity of the attribute increases, leading to a price increase. This is based on the assumption that the attribute is a desirable one. The opposite holds when the attributes is an undesirable one. Thus, the general shape of the P-Q relationship of each attribute is determined by the marginal product of the quantity of each attribute in the production of yarn.

The values of trash and the first digit of the grade code, in cotton in the making of yarn are thought to take on an inverse shape on the yarn production. This evaluation evolves from the fact that a low trash level will be more desirable and valued at the highest price because of the ease of cleaning and spinning in the processing. The productivity will only decrease slightly from there because moderately low trash designations only present a small problem in the production process. The highest trash levels will be most detrimental in cotton processing. Therefore, the price of cotton containing high trash levels will be exceptionally low. As supported by Brown's [1995] functional model, the trash attribute is expected to have a P-Q curve that was negative and concave to the origin (see Figure 25(a)).

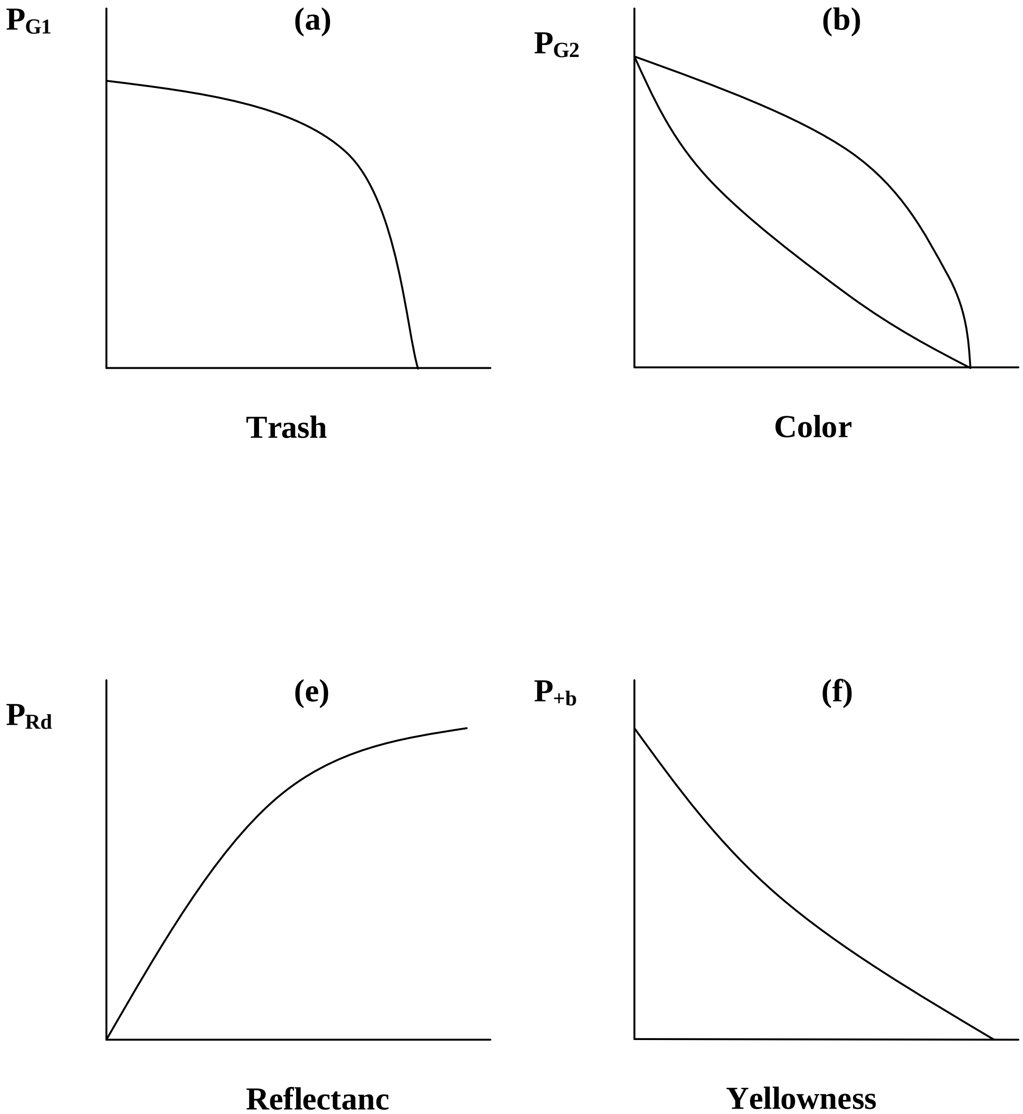

Figure 25. Price –Quality Relationship for the Cotton Quality Attributes of (a) trash, (b) color, (c) reflectance, and (d) yellowness

[Brown, 1993]

The color attribute in cotton has the potential to affect the use-value of cotton in processing. The color of cotton indicates that the cotton is damaged or strained, which can mean the fibers will not be as strong and problems can occur during dyeing of the yarn. The more color, that being yellowness and grayness of the cotton, the higher the color designation. Thus, a low color level will receive a higher price. The results of color, the second digit of the grade code were that its P-Q relationship could be convex, concave, or log-linear for any given sales day in his study (see Figure 25(b)).

The color grades can be divided into its two component parts, that being reflectance (Rd) and yellowness (+b). Both are the more objective measurements than the color code. Reflectance refers to the percentage of light that the cotton will reflect. If cotton is gray, there will be little reflectance, and when the cotton is white, there will be a great deal of reflectance. Therefore, as the percentage reflectance increase in the cotton, the price of cotton will increase. This P-Q relationship is shown in Figure 25(c).

The degree of yellowness in cotton is determined by a calculation known as Hunter's +b. The degree of yellowness in relation to the price of cotton is negative. As the units of yellowness increase, the price of cotton is expected to decrease, because the cotton is not as pure and white as the manufacturer would prefer. Brown's model indicated that the price-yellowness relationship was decreasing but log-linear or only slightly convex (see Figure 25(d)).

Fiber length (staple length) in the production process, while it is still important, became less critical because of the advances in spinning technology. The cotton industry is moving more toward the use of rotor spinning that do not require fibers as long as the older ring spindles. Yet, as far as the P-Q relationship is concerned, the advances in technology only affect the magnitude or position of the relationship and not the general shape. For each additional length of cotton fiber, the price of cotton or the implicit price of fiber length is expected to increase at a declining rate. In model (4.4), the double-log model result indicates that it does not allow the P-Q curve for fiber length to bend sharp enough. Thus, a quadratic transformation was determined to be a correct form, as shown in Figure 26(a).

The marginal product of micronaire in the production of yarn is believed to have a quadratic shape. It increase at a decreasing rate at low micronaire levels, reaches a maximum (this has believed to have been between micronaire readings of 3.5 to 4.9), and then decreases at an accelerated rate at high micronaire levels. Therefore, low and high micronarie cotton is expected to bring a lower price than the preferred micronaire readings, ceterus paribus. This hypothesis was correct in that a quadratic P-Q relationship does exist for this attribute (see Figure 26(b)) [Brown, 1993].

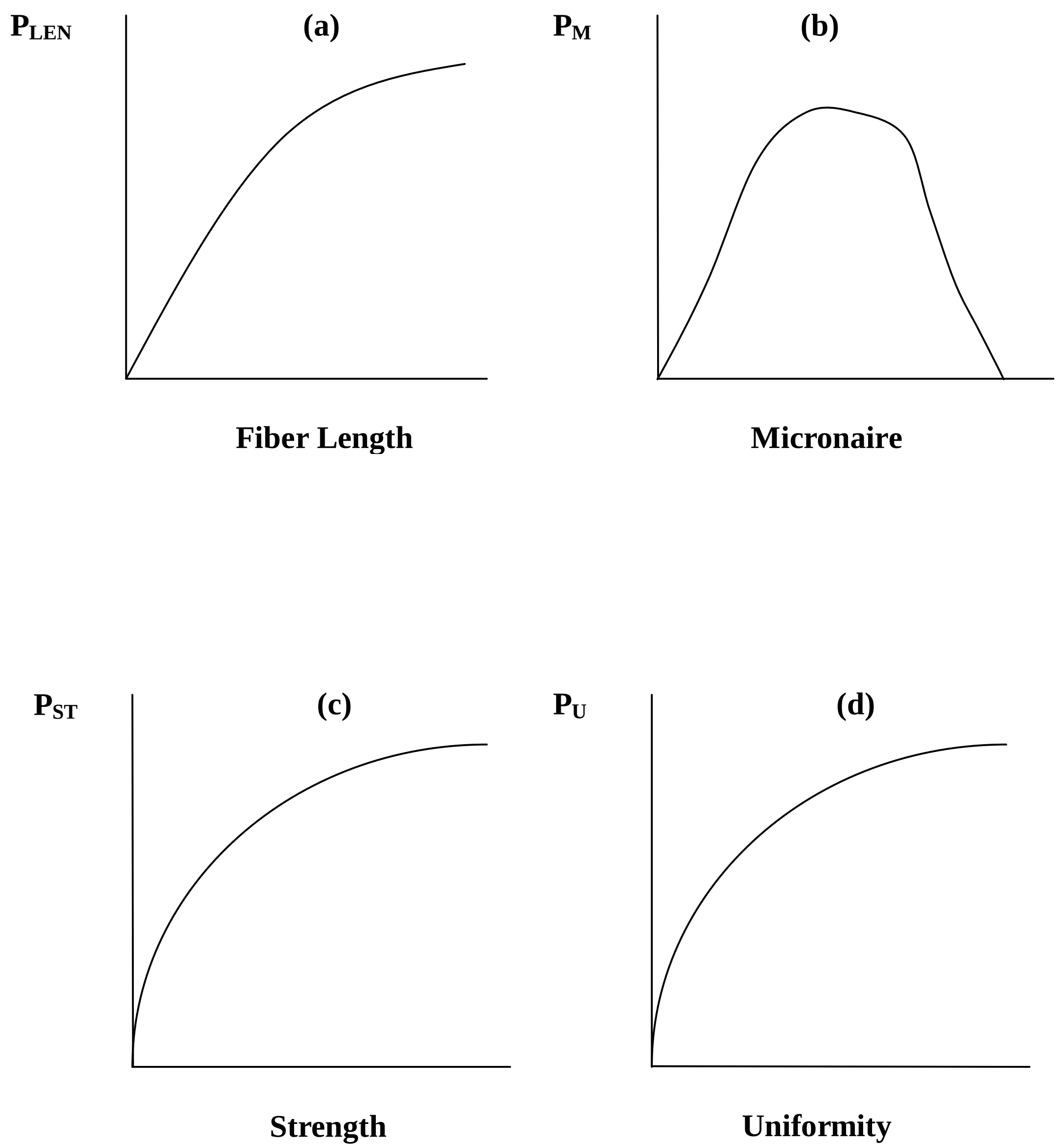

Figure 26. Price–Quality Relationship for the Cotton Quality Attributes of (a) fiber length, (b) micronaire, (c) strength, and (d) uniformity. [Brown, 1993]

The strength of cotton fiber has consistently been an important factor in the production process. Strength adds efficiency to all stages processing, including ginning and cleaning, carding, and spinning for the textile mill. The marginal product of strength is expected to be increasing at a decreasing rate from low strength (very weak fiber) to high strength (very strong fiber) in Figure 26(c).

The marginal productivity of length uniformity in the production of yarn should exhibit a shape that increases at a decreasing rate as uniformity increases. Uniformity of fibers is needed to some degree so the fibers will spin and intertwine together. Thus, the price of cotton with non-uniform fibers is believed to be low and exhibits diminishing marginal returns, and vise versa. This assumed relationship for length uniformity was found to be acceptable for model (4.4). This can be seen in Figure 26(d). In previous studies, Neeper [1985] reported the opposite result of P-Q relationship for uniformity. He found that length uniformity had negative slope in the price-quality relationship [Brown, 1993].

5 RESEARCH OBJECTIVES AND SCOPE

The main objectives of this research are to establish a "Hedonic Cotton Pricing System" based on HVI cotton quality characteristics aimed at improving the current cotton pricing methods driven by the controversial "premium and discount" schemes. The task will be carried out by: 1) creation of marginal implicit price for each quality attribute measured by HVI and 2) development of Composite Cotton Quality Indices (CCQI) as functions of more than one HVI quality measures.

In order to justify a study for the objectives, a comprehensive preliminary analysis was performed on the performance of the current cotton pricing system based on the premiums and discounts applied to each cotton characteristic measure by HVI. For enhancing and reconstructing the current cotton pricing structure, Rosen's first stage hedonic model will be employed. By applying the estimates obtained from the first stage hedonic model, the marginal implicit price of each HVI cotton quality characteristic will be derived. In addition, as an attempt to simplify and improve the current cotton pricing and bale management systems, a set of Composite Cotton Quality Indices (CCQIs) will be created by studying the covariance structure of the cotton properties measured by HVI and their statistical correlation with cotton prices. Then, an innovative ***First Stage Hedonic Model*** will be developed by applying the CCQIs developed. Finally, a ***Second Stage Hedonic Model*** will be developed by combining the marginal implicit prices derived from the First Stage Hedonic Model and the supply factors of cotton that reflect the weather and market effects.

6 FIRST STAGE HEDONIC MODEL – MODELING AND ANALSYS

In order to examine the effect of market forces on the value of cotton HVI quality attributes, analyses were performed on the relationship between cotton HVI quality characteristics and cotton price. In this part, the First Stage Hedonic Model will be developed. From the model developed, the marginal implicit price will be derived for each cotton HVI quality characteristic.

6.1. First Stage Hedonic Model I with Eight HVI Quality Characteristics

In this part, conceptual and empirical forms of the First Stage Hedonic Model will be described.

6.1.1. Conceptual Model

Cotton is represented by a vector of *n* inherent quality attributes which are inherently contained within it.

$$C = (C_1, C_2, C_3, \cdots, C_n) \qquad (6.1)$$

The price of cotton P(C) is expressed as a function of the quality attributes C_i, i=1, 2,⋯, n.

$$P(C) = f(C_1, C_2, C_3, \cdots, C_n) \qquad (6.2)$$

For this study, C is composed of eight HVI quality measures for two digit color grade, micronaire, length, length uniformity, strength, leaf grade and trash contents.

$$P_i(C) = \partial f(C) / \partial C_i \qquad (6.3)$$

The partial derivative of P(C) in Equation (6.2) with respect to the i^{th} attribute C_i gives the marginal implicit price for that quality characteristic as given by Equation 6.3.

6.1.2. Empirical Model

The empirical form of First Stage Hedonic Model can be expressed by

$$P_i = f(FC_i, SC_i, MIC_i, LEN_i, UNI_i, STR_i, LG_i, TR_i) \qquad (6.4)$$

Where:

P_i = average price (cents/lb) of cotton in week ***i***
FC_i = average first digit of the color grade in week ***i***
SC_i = average second digit of the color grade in week ***i***
MIC_i = average micronaire reading in week ***i***
LEN_i = average fiber length (inches) in week ***i***
UNI_i = average fiber length uniformity (%) in week ***i***
STR_i = average strength (g/tex) in week ***i***
LG_i = average leaf grade in week ***i***
TR_i = average trash content in week ***i***

This model is called *First-Stage Hedonic Model I* in this study.

6.1.3. Description of the Data and Analysis Procedure

Cotton HVI quality measures and the matching cotton prices based on CCC loan schedule were obtained by state from the USDA-AMS website and EFS®-USCROP™ software programs for five consecutive crop years (2000/2001 - 2004/2005). The dataset consisted of 1086 covering ten states: Alabama, Arkansas, Arizona, California, Georgia, Louisiana, Mississippi, North Carolina, Tennessee and Texas.

Alabama, Georgia and North Carolina belong to the South East region. Tennessee, Mississippi, Louisiana and Arkansas compose the Mid-South region, while Texas represents the South Western region. The Western region contains California and Arizona.

SAS statistical analysis system was used for estimating the relationship among eight HVI measures and the matching cotton prices. The first-stage models in Equation [6.4] were estimated by applying OLS (Ordinary Least Square) procedure. These hedonic models were also evaluated using the usual statistical tests including R^2, F-tests, t-tests, Durbin-Watson tests for auto correlation, residual tests and White's test for heteroscedasticity. These results are listed in Appendices 12.A and B.

In the preliminary analyses, Rd and +b were initially included in the model but were dropped from the final model due to multicollinearity between FC and Rd, and SC and +b (Appendices 12.C). In addition, the correlation between micronaire and micronaire squared was found to be rather high. In spite of high correlation between micronaire and micronaire squared variables, many researchers [Brown (1995), Chen et al (1996) and Hoelscher (2001)] developed their hedonic price models including both variables. In the preliminary analyses, these two variable were initially included in the model, however, micronaire squared was removed from the final model, as well as Rd and +b. Finally, in this part, the first-stage hedonic models, including eight HVI quality measures and the matching cotton price, were developed.

Figures 27-33, following, illustrate the total production quantities and the average cotton quality measures including the analysis by state for 2000-2004. Descriptive statistics of other cotton quality measures not shown in following figures are listed in Appendices 12.D. Figure 27 indicates Texas produced the largest amount of Upland cotton in the US for several years followed by Mississippi, Arkansas, California and Georgia. As shown in the figures, all HVI cotton qualities produced in California were superior to that in other states. This is due to Acala variety grown in California.

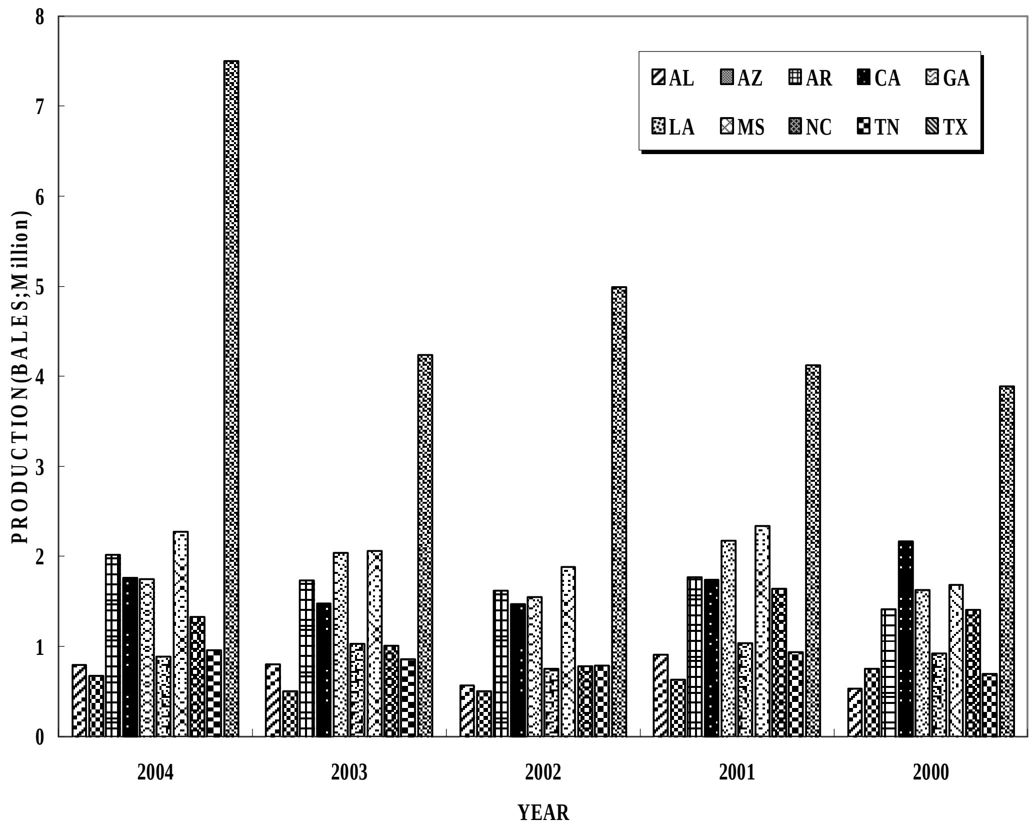

Figure 27. Total Production Quantities of US Upland Cotton by State for 2000-2004

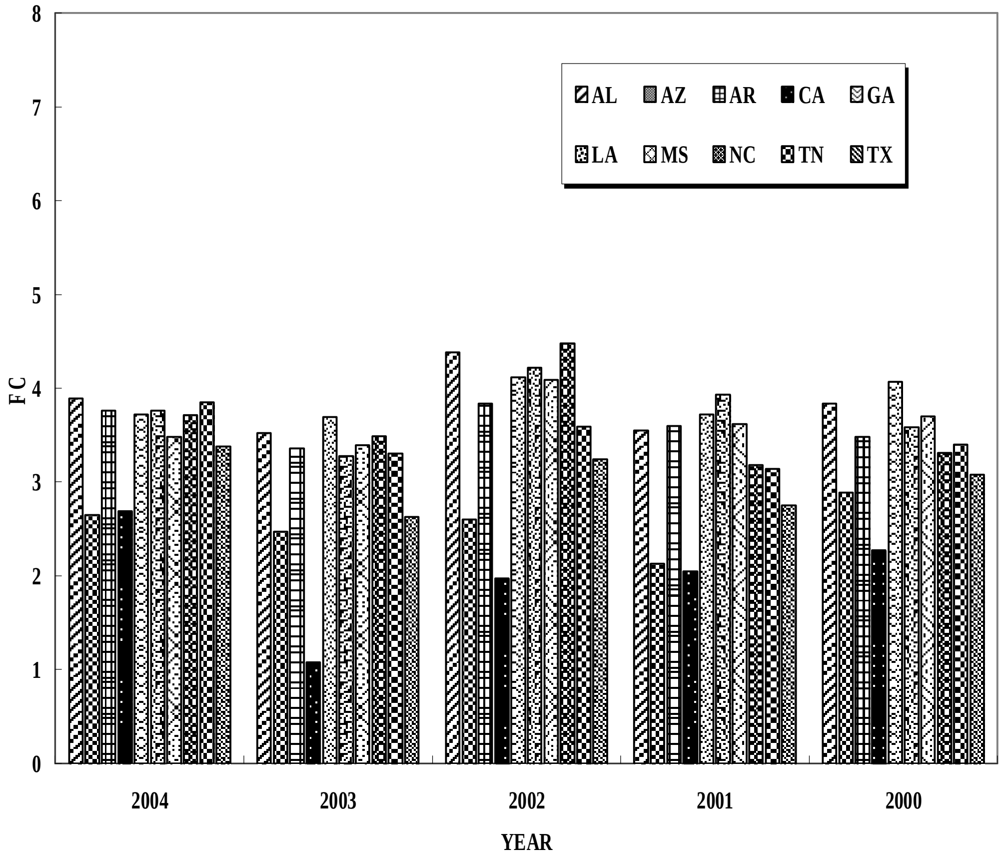

Figure 28. Average First Digit Color Code of US Upland Cotton by State for 2000-2004

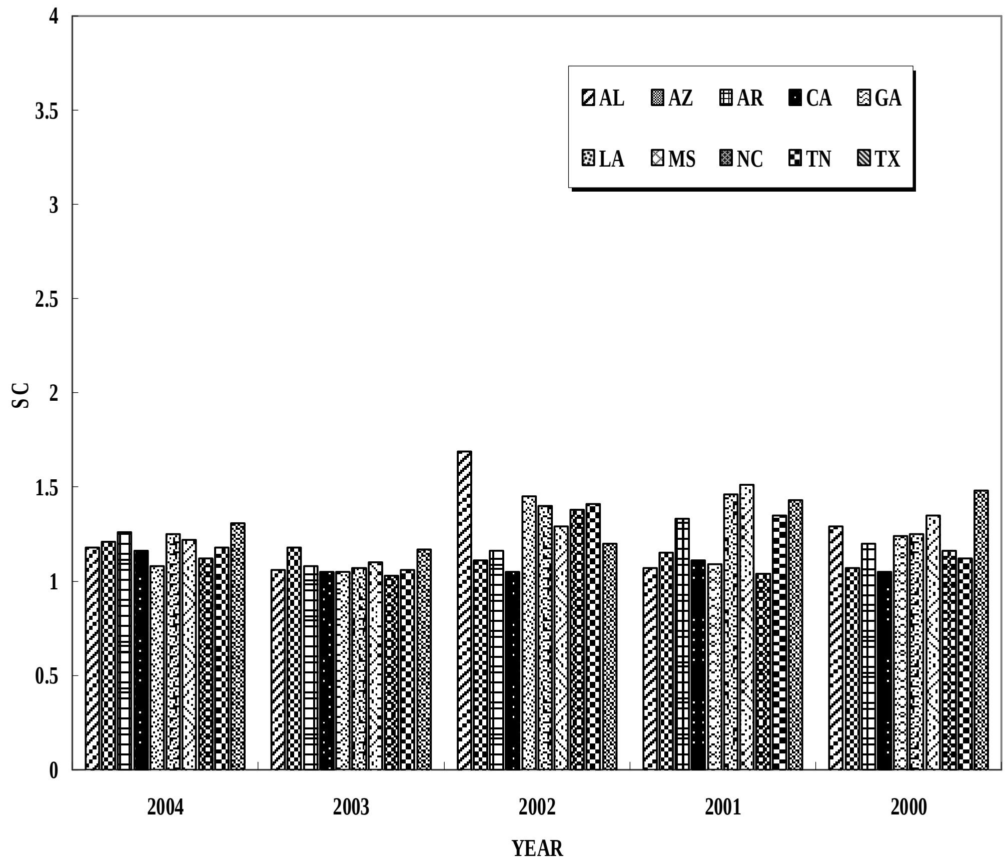

Figure 29. Average Second Digit Color Code of US Upland Cotton by State for 2000-2004

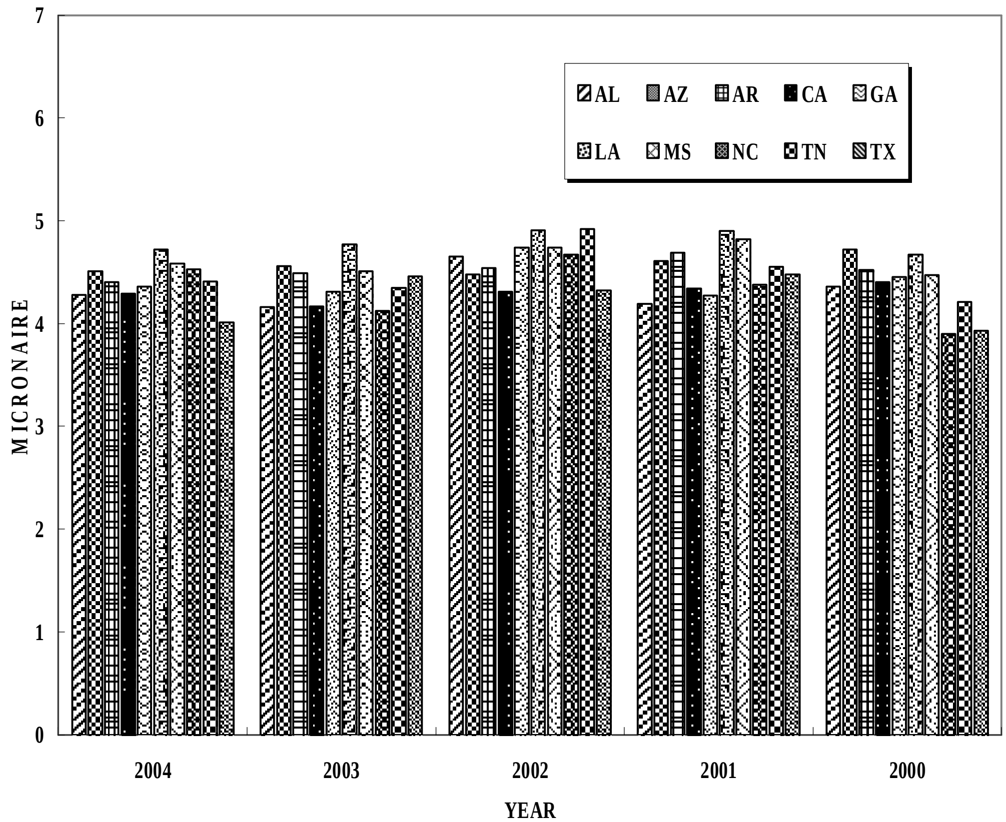

Figure 30. Average Micronaire of US Upland Cotton by State for 2000-2004

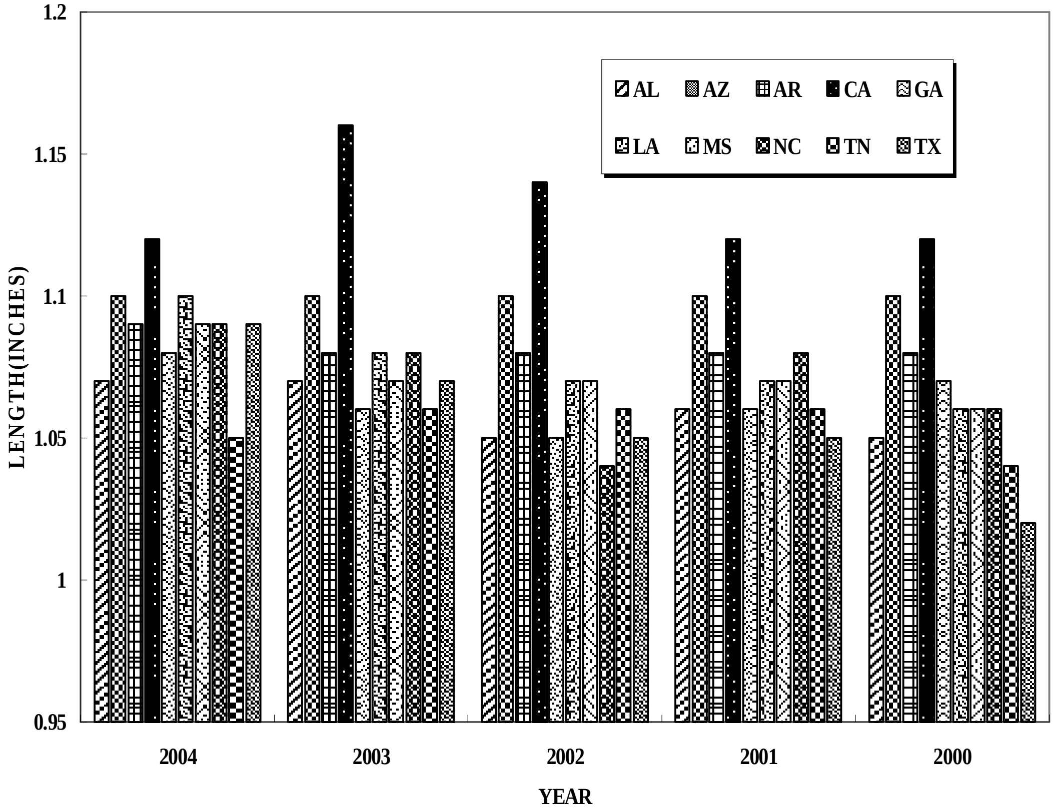

Figure 31. Average Fiber Length of US Upland Cotton by State for 2000-2004

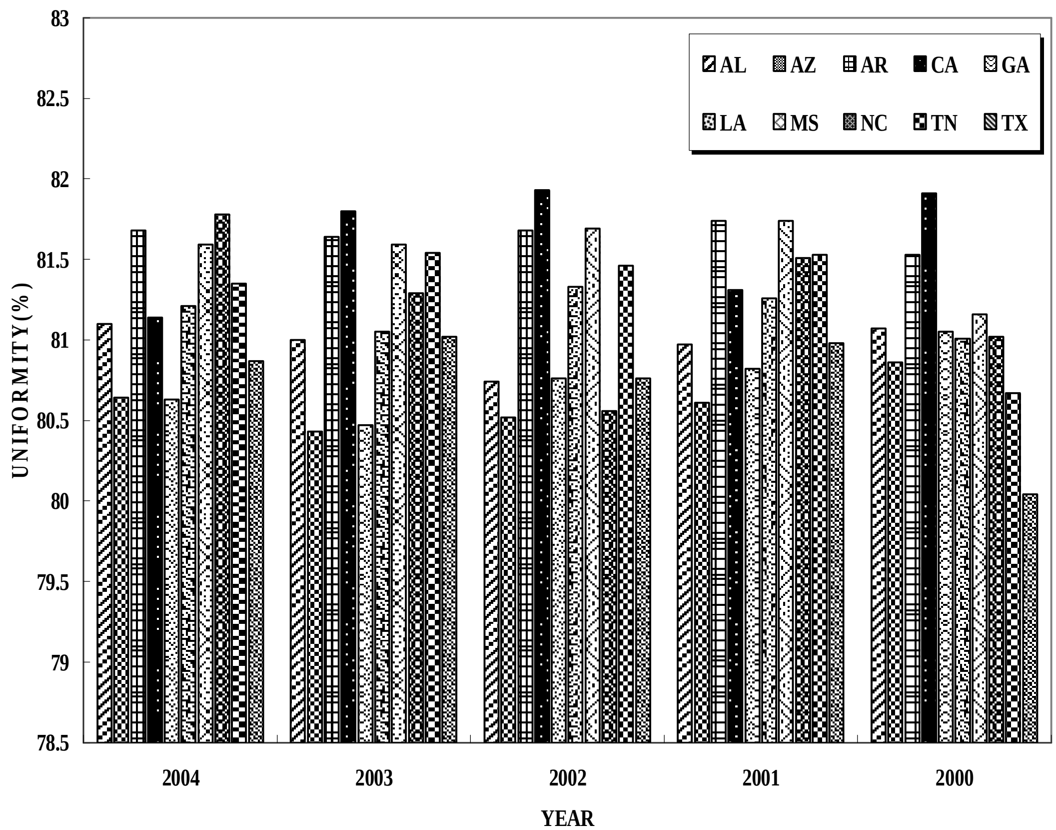

Figure 32. Average Length uniformity of US Upland Cotton by State for 2000-2004

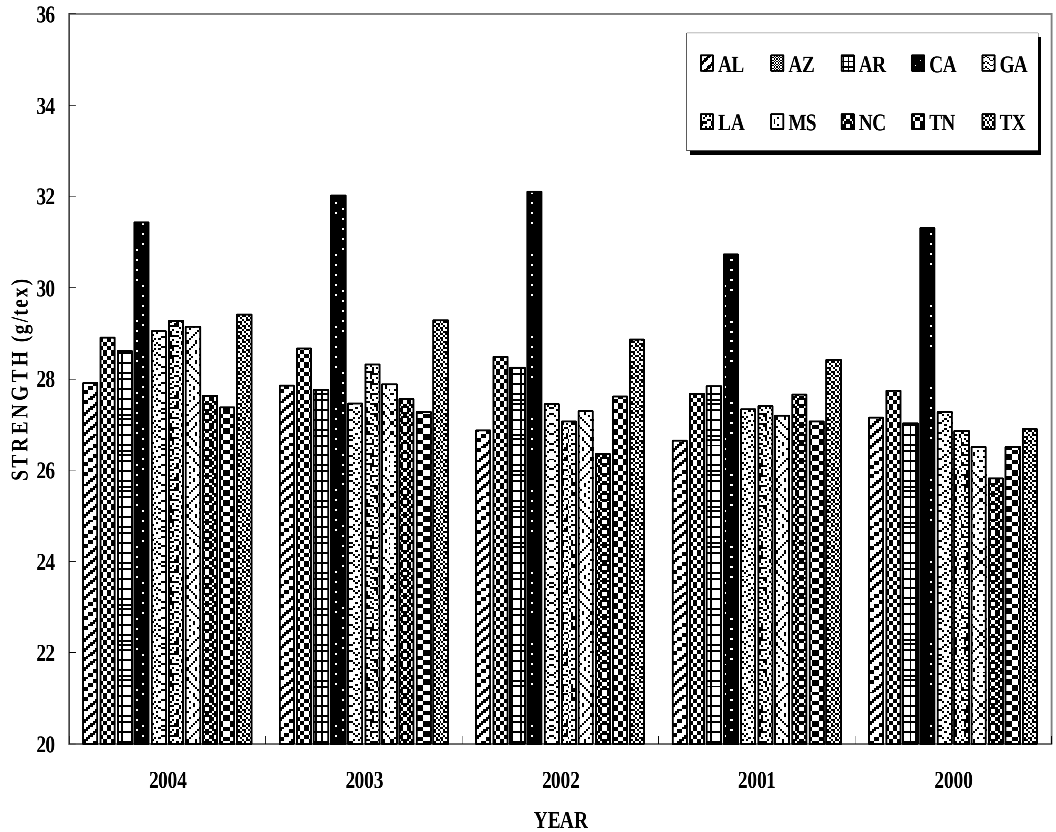

Figure 33. Average Strength of US Upland Cotton by State for 2000-2004

6.1.4. Results and Discussion

What follows (Tables 2-12) are the summaries of the First- Stage Hedonic Model I of cotton price by state for 2000-2004 crop years. Each table presents the specific empirical form of the general first-stage model with parameter estimates, corresponding t-values for significance tests and the standardized estimates.

The main results are summarized as follows.

All estimated equations showed high R-squared values ranging between 0.8662 (TN) and 0.9720 (LA) and all variables selected were shown to be highly significant at a 10% error level. In all models, the coefficients of color grades were negative, indicating that price decreases as the color grades increase. There results were consistent with the normal expectations.

Coefficients for strength and fiber length were expected to be positive as the price is expected to rise when the strength and length increase. In all cases except Louisiana, the estimated parameters for strength were positive, although they were not statistically significant in some states (AZ, AK, LA, MS and TX). In each model, the estimated coefficients for fiber length were found to be positive as expected.

Micronaire is an indirect measurement of cotton's fineness and maturity. Low micronaire readings indicate either fine or immature fibers. Fine fibers are desirable, but immature fibers often produce neps and reduce the value of the resulting goods. The discount/premium scheme for micronaire is different compared to other fiber parameters of cotton. Since there is the base range not a base value for micronaire, it becomes difficult to identify the relationships between micronaire and cotton price. Micronaire levels are considered beneficial in certain ranges, but the values above and below these ranges are known to lower the processing efficiency and product qualities. Among ten states, Alabama, Georgia and Texas showed positive coefficients for micronaire whereas they were found to be negative in models for Arizona, Arkansas, California, Louisiana, Mississippi, North Carolina and Tennessee.

High length uniformity is considered good for the qualities of the resulting product quality and thus increase price of cotton. However, the estimates of coefficients for length uniformity showed negative signs in the most models (Alabama, Arizona, California, Georgia, Louisiana, North Carolina and Texas).

In most models, the parameter estimates for leaf grade and trash content were shown to be insignificant and inconsistent sign state to state.

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Table 2. First Stage Estimates for Ten Combined States (AL,AZ,AR,CA,GA,LA,MS, NC,TN and TX)

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.38913	-6.85*	0
FC	-0.00933	-10.99*	-0.23973
SC	-0.06627	-34.55*	-0.45187
MIC	0.00823	5.73*	0.07610
LEN	0.46982	19.96*	0.41852
UNI	0.00557	6.84*	0.10101
STR	0.00028698	0.71	0.01398
LG	-0.00097271	-0.48	-0.01454
TR	0.01185	1.61	0.04404
R-Square = 0.8676			
Total Number of Observations (Weeks) = 1086			

Where:

FC = first digit of the color grade

SC = second digit of the color grade

MIC = micronaire reading

LEN = fiber length (inches)

UNI = fiber length uniformity (%)

STR = strength (g/tex)

LG = leaf grade

TR = trash content

Note; * the coefficient is significant with $p < 0.05$.

Table 3. First Stage Estimates for Alabama

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.50526	2.54*	0
FC	-0.02638	-13.77*	-0.58919
SC	-0.02934	-6.25*	-0.27007
MIC	0.01238	3.39*	0.11404
LEN	0.57338	4.40*	0.25351
UNI	-0.01062	-3.25*	-0.15677
STR	0.00983	6.47*	0.25903
LG	0.01675	2.44*	0.12652
TR	-0.00227	0.11	-0.00528
R-Square = 0.9565			
Total Number of Observations (Weeks) = 108			

Table 4. First Stage Estimates for Arizona

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.32652	2.13*	0
FC	-0.00582	-4.07*	-0.21567
SC	-0.00690	-1.56	-0.05506
MIC	-0.01507	-3.82*	-0.12932
LEN	0.27242	3.13*	0.12797
UNI	-0.00249	-1.10	-0.04459
STR	0.00816	8.69*	0.22990
LG	-0.00770	-2.95*	-0.19317
TR	-0.08653	-8.20*	-0.54774
R-Square = 0.9515			
Total Number of Observations (Weeks) = 133			

Table 5. First Stage Estimates for Arkansas

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.09455	0.33	0
FC	-0.01286	-5.83*	-0.39623
SC	-0.05002	-11.49*	-0.50666
MIC	-0.00346	-0.74	-0.03527
LEN	0.71496	6.54*	0.39749
UNI	-0.00286	-0.72	-0.03936
STR	0.00086	0.47	0.03260
LG	-0.00378	-0.68	-0.05447
TR	-0.02964	-1.04	-0.10328

R-Square = 0.9008

Total Number of Observations (Weeks) = 89

Table 6. First Stage Estimates for California

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.39324	3.64*	0
FC	-0.00441	-2.78*	-0.13774
SC	-0.02788	-3.70*	-0.17081
MIC	-0.00983	-2.22*	-0.08518
LEN	0.21394	4.66*	0.31077
UNI	-0.00145	-0.89	-0.05245
STR	0.00370	4.99*	0.29275
LG	0.00818	2.83*	0.14155
TR	-0.11202	-6.72*	-0.42461

R-Square = 0.9177

Total Number of Observations (Weeks) = 117

Table 7. First Stage Estimates for Georgia

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.66242	3.82*	0
FC	-0.02579	-11.08*	-0.45242
SC	-0.04235	-7.30*	-0.34980
MIC	0.00580	1.86*	0.05837
LEN	0.57472	6.89*	0.36368
UNI	-0.00973	-3.61*	-0.13559
STR	0.00464	4.34*	0.17521
LG	-0.00077	-0.15	-0.00724
TR	0.02091	1.09	0.05451
R-Square = 0.9406			
Total Number of Observations (Weeks) = 114			

Table 8. First Stage Estimates for Louisiana

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.67425	3.75*	0
FC	-0.02214	-9.98*	-0.53212
SC	-0.04524	-10.35*	-0.39766
MIC	-0.03570	-4.22*	-0.15453
LEN	0.69665	7.94*	0.41341
UNI	-0.00721	-2.85*	-0.07652
STR	-0.00193	-1.18	-0.07839
LG	0.00611	0.97	0.06709
TR	0.00919	0.46	0.02641
R-Square = 0.9729			
Total Number of Observations (Weeks) = 75			

Table 9. First Stage Estimates for Mississippi

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.67059	-3.13*	0
FC	-0.00839	-5.11*	-0.21246
SC	-0.06043	-14.64*	-0.57797
MIC	-0.01358	-3.63*	-0.13169
LEN	0.70304	7.44*	0.44070
UNI	0.00740	2.60*	0.13200
STR	0.00152	0.94	0.06723
LG	-0.01579	-2.78*	-0.14012
TR	-0.01525	-0.85	-0.04553

R-Square = 0.9283

Total Number of Observations (Weeks) = 101

Table 10. First Stage Estimates for North Carolina

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.67153	1.98*	0
FC	-0.00310	-0.83	-0.05171
SC	-0.03360	-5.41*	-0.22746
MIC	-0.00214	-0.34	-0.02363
LEN	1.02384	7.96*	0.67170
UNI	-0.01705	-3.20*	-0.27490
STR	0.00972	5.40*	0.31305
LG	-0.00973	-1.39	-0.06932
TR	-0.08795	-4.30*	-0.22144

R-Square = 0.9242

Total Number of Observations (Weeks) = 105

Table 11. First Stage Estimates for Tennessee

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.89707	-3.38*	0
FC	0.00530	1.84*	0.14243
SC	-0.04634	-7.98*	-0.42290
MIC	-0.03397	-5.79*	-0.56960
LEN	0.92672	7.96*	0.58434
UNI	0.00511	1.32*	0.11081
STR	0.00960	4.34*	0.42075
LG	-0.00968	-1.84*	-0.12630
TR	-0.10874	-3.80*	-0.31608
R-Square = 0.8662			
Total Number of Observations (Weeks) = 93			

Table 12. First Stage Estimates for Texas

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.58444	2.49*	0
FC	-0.01036	-3.13*	-0.16528
SC	-0.06458	-11.08*	-0.37518
MIC	0.02190	3.95*	0.16754
LEN	0.85098	12.90*	0.63232
UNI	-0.01203	-3.30*	-0.19088
STR	0.00044439	0.26	0.01380
LG	0.00130	0.31	0.01501
TR	-0.06310	-3.10*	-0.18093
R-Square = 0.9536			
Total Number of Observations (Weeks) = 155			

6.2. Creation of Composite Cotton Quality Indices (CCQIs)

In many studies concerning hedonic pricing model for cotton [Brown, Bowman, Ethridge et al], cotton pricing structures are shown to be too complex and difficult to understand due to the large number of quality variables. In this study, the HVI quality measures included as independent variables of the first-stage hedonic regression model includes the first-digit color code (FC), the second-digit color code (SC), micronaire, fiber length, strength, length uniformity, leaf grade and trash content. These variables can be divided by two major components: 1) the color factor determined by the color and appearance of cotton and measured by two digits of color grade, leaf grade and trash content and 2) the physical factor determined by the physical properties of cotton and measured by strength, fiber length, length uniformity and micronaire.

In this section, we consider a new concept for creating Composite Cotton Quality Index (CCQI) based on the needs for 1) improved cotton selection, 2) improved pricing, 3) simplified and more economical bale storage/retrieval, laydown formation and 4) higher product qualities. While bales are priced individually, they are processed by forming laydowns with 20~60 bales reflected by the HVI quality measures in such a way that the laydown averages are uniform with respect strength and micronaire, fiber length and other HVI measures. The enormous complexity in the combinatorial algorithm and physical requirements for storage and retrieval have been well documented [Robin, 1993 and Lee, 1995]

In this part, two Composite Cotton Quality Indices (CCQIs) representing the color factor and the physical factor each will be developed in order to simplify, economize and improve these processes. The CCQIs are particularly attractive for the development of a hedonic cotton pricing system.

6.2.1. Correlation Analysis of HVI Quality Characteristics and Cotton Price

As the initial analysis for developing Composite Cotton Quality Indices (CCQIs), a correlation analysis was performed for the HVI measures.

6.2.1.1. Description of the Data and Analysis Procedure

The set described above for CCQIs were also used for first-stage hedonic model. Using 'SAS PROC CORR' procedure, the correlations among ten HVI measures and the matching cotton prices were analyzed by state.

6.2.1.2. Result and Discussion

Pearson correlation coefficients among ten HVI measures and the matching cotton prices are given in Tables 13 through 23.

Table 13 provides the results of the correlation for ten combined states. Examining the results, it can be seen that fiber length has the highest positive correlation with the cotton price, followed by reflectance, strength and length uniformity. The correlation coefficient between fiber length and cotton price was 0.77. For the analyses by state (Tables 14-23), high positive correlations were also found between fiber length and cotton price. These findings are consistent with our expectation and the results from Brown's model [1995]. In addition, it was found that the cotton prices were negatively correlated with the first-digit color code (FC), the second-digit color code (SC), leaf grade, and trash content. They were all statistically significant. The two-digit color codes (FC and SC), leaf grade and trash content are factors that make up the color property of cotton. The analysis indicates that the pure white cotton with fewer impurities is expected to be paid more.

The first-digit color code and reflectance were found to be highly correlated with each other. Even though the correlation coefficient was not high, there was significant positive correlation between the second digit of color grade and +b. These results indicate that Reflectance and +b are good objective measurements for the color property of cotton. In addition, there were high positive correlations between the first-digit color code, leaf grade and trash content. These results mean that the color grade increases as increase of impurities in cotton.

Fiber strength was significantly correlated with fiber length (R=0.52) and length uniformity (R=0.39). These results are consistent with the usual expectation and belief. This is based on the expectation and established fact that cotton with longer fibers will produce a stronger yarn because of increased contact area between fibers [Deussen, 1984]. Ethridge and Hembrey [1982] also found similar results. They found a strong positive correlation between micronaire and length uniformity, and a negative correlation between micronaire and length. They also found a strong positive correlation between strength and length, and a general pattern of intercorrelations among micronaire, strength, length and length uniformity.

There were no studies about the relationship between the color factors of cotton such as the color code and leaf grade and the physical factors of cotton such as fiber strength and length. The results for each state showed that strength, length and length uniformity have negative correlation with both digits of color code, leaf grade and trash content. This indicates that the pure white cotton with few impurities also comes with good physical properties.

In most results by state, there were low negative correlation between micronaire and trash content and micronaire and leaf grade. These results indicate that the impurities in cotton increase when cotton fiber is immature. While the overall results showed there was no correlation between micronaire and strength, or fiber length, the relationships were found to be inconsistent. In Arizona and Texas (Table 15 and 23), a strong positive correlation was found between micronaire and fiber length, whereas in Arkansas, California and Louisiana (Table 16, 17 and 19) correlation was negative between these two variables. The relationship between strength and micronaire were similar to above. Although the correlation coefficients were not high, it was found that there were positive correlations between length uniformity and micronaire for all states, especially in Mississippi and Texas (Table 20 and 23).

As expected, there were positive correlations between leaf grade, the first digit of color grade and between trash content and the same.

Table 13. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Ten States - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 1086 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.67	-0.74	0.66	0.77	0.50	0.09	0.76	-0.12	-0.55	-0.56
FC		1.00	0.46	-0.56	-0.52	-0.22	0.05	-0.88	-0.40	0.79	0.75
SC			1.00	-0.35	-0.39	-0.25	0.08	-0.70	0.53	0.36	0.39
STR				1.00	0.78	0.39	0.02	0.52	0.14	-0.40	-0.45
LEN					1.00	0.51	0.09	0.51	0.04	-0.48	-0.47
UNI						1.00	0.35	0.22	0.08	-0.11	-0.20
MIC							1.00	-0.11	0.11	-0.12	-0.21
RD								1.00	0.04	-0.66	-0.64
+b									1.00	-0.31	-0.26
LG										1.00	0.89
TR											1.00

Where:

PR = price of cotton
FC = first digit of the color grade
SC = second digit of the color grade
MIC = micronaire reading
LEN = fiber length (inches)
UNI = fiber length uniformity (%)
STR = strength (g/tex)
RD = reflectance
+b = degree of yellowness
LG = leaf grade
TR = trash content

Table 14. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Alabama State - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 108 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.84	-0.72	0.73	0.79	0.63	-0.08	0.85	-0.14	-0.13	-0.01
FC		1.00	0.71	-0.43	-0.50	-0.57	0.17	-0.94	0.04	0.49	0.36
SC			1.00	-0.29	-0.43	-0.26	0.55	-0.89	0.68	0.35	0.14
STR				1.00	0.82	0.71	0.24	0.40	0.11	0.21	0.29
LEN					1.00	0.81	0.14	0.52	-0.06	0.19	0.22
UNI						1.00	0.38	0.47	0.26	-0.02	0.01
MIC							1.00	-0.38	0.68	0.18	0.05
RD								1.00	-0.38	-0.42	-0.27
+b									1.00	0.01	-0.11
LG										1.00	0.86
TR											1.00

Table 15. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Arizona State - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 133 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.80	-0.63	0.32	0.68	0.71	0.47	0.91	0.32	-0.89	-0.92
FC		1.00	0.34	0.10	-0.42	-0.65	-0.27	-0.90	-0.72	0.87	0.79
SC			1.00	-0.21	-0.37	-0.42	-0.55	-0.67	0.33	0.53	0.71
STR				1.00	0.46	0.09	0.14	0.04	-0.26	-0.04	-0.09
LEN					1.00	0.75	0.63	0.53	0.04	-0.60	-0.62
UNI						1.00	0.63	0.69	0.25	-0.76	-0.75
MIC							1.00	0.46	-0.17	-0.56	-0.59
RD								1.00	0.37	-0.80	-0.94
+b									1.00	-0.45	-0.24
LG										1.00	0.91
TR											1.00

Table 16. **Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Arkansas State - 2000~2004 Crop Year**

Pearson Correlation Coefficients, N = 89 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.70	-0.79	0.47	0.44	0.45	-0.16	0.83	-0.34	-0.23	-0.30
FC		1.00	0.48	-0.17	0.05	-0.45	-0.11	-0.94	-0.22	0.56	0.65
SC			1.00	-0.32	-0.20	-0.31	0.11	-0.72	0.67	0.02	0.16
STR				1.00	0.72	0.48	-0.13	0.23	-0.28	0.37	0.42
LEN					1.00	0.34	-0.34	0.05	-0.36	0.31	0.42
UNI						1.00	0.38	0.46	0.04	-0.16	-0.15
MIC							1.00	0.05	0.32	-0.26	-0.27
RD								1.00	-0.09	-0.41	-0.55
+b									1.00	-0.44	-0.35
LG										1.00	0.88
TR											1.00

Table 17. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for California State - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 117 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.58	-0.76	0.81	0.83	0.78	0.04	0.68	0.15	-0.35	-0.72
FC		1.00	0.64	-0.21	0.33	-0.45	-0.26	-0.90	-0.52	0.70	0.75
SC			1.00	-0.55	-0.53	-0.66	-0.21	-0.83	0.15	0.47	0.69
STR				1.00	0.85	0.76	-0.10	0.33	-0.06	-0.03	-0.39
LEN					1.00	0.80	-0.19	0.42	0.16	-0.09	-0.42
UNI						1.00	0.14	0.56	0.05	-0.16	-0.52
MIC							1.00	0.21	0.07	-0.27	-0.42
RD								1.00	0.20	-0.66	-0.77
+b									1.00	-0.32	-0.23
LG										1.00	0.74
TR											1.00

Table 18. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Georgia State - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 114 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.75	-0.78	0.71	0.61	0.00	-0.10	0.89	-0.34	-0.46	-0.37
FC		1.00	0.50	-0.58	-0.11	0.10	0.01	-0.88	-0.11	0.52	0.51
SC			1.00	-0.31	-0.52	0.07	0.38	-0.81	0.74	0.50	0.44
STR				1.00	0.47	0.02	0.18	0.52	0.10	-0.23	-0.18
LEN					1.00	0.49	-0.01	0.34	-0.45	-0.20	-0.06
UNI						1.00	0.33	-0.10	0.00	-0.11	0.13
MIC							1.00	-0.26	0.53	0.18	-0.01
RD								1.00	-0.37	-0.54	-0.53
+b									1.00	0.16	0.15
LG										1.00	0.82
TR											1.00

Table 19. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Louisiana State - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 75 (weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.78	-0.87	0.73	0.45	-0.01	-0.64	0.88	-0.68	-0.18	-0.17
FC		1.00	0.73	-0.47	0.04	-0.10	0.41	-0.97	0.30	0.48	0.41
SC			1.00	-0.45	-0.14	0.13	0.56	-0.84	0.76	0.36	0.39
STR				1.00	0.76	0.27	-0.32	0.55	-0.47	0.36	0.39
LEN					1.00	0.30	-0.17	0.08	-0.42	0.59	0.50
UNI						1.00	0.36	0.04	0.26	0.25	0.15
MIC							1.00	-0.47	0.37	0.42	0.26
RD								1.00	-0.50	-0.39	-0.35
+b									1.00	-0.09	0.04
LG										1.00	0.89
TR											1.00

Table 20. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Mississippi State - 2000~2004 Crop Year

	Pearson Correlation Coefficients, N = 101 (Weeks)										
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.64	-0.77	0.72	0.57	0.19	-0.20	0.58	-0.41	-0.00	-0.03
FC		1.00	0.45	-0.40	-0.13	-0.22	0.00	-0.69	-0.18	0.31	0.32
SC			1.00	-0.41	-0.13	-0.08	0.20	-0.43	0.73	-0.05	0.07
STR				1.00	0.82	0.42	0.08	0.35	-0.27	0.31	0.38
LEN					1.00	0.39	0.00	0.18	-0.17	0.39	0.43
UNI						1.00	0.51	0.16	0.19	0.23	0.19
MIC							1.00	-0.13	0.27	0.06	-0.01
RD								1.00	0.00	-0.15	-0.13
+b									1.00	-0.33	-0.24
LG										1.00	0.80
TR											1.00

Table 21. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for North Carolina State - 2000~2004 Crop Year

	Pearson Correlation Coefficients, N = 105 (Weeks)										
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.60	-0.70	0.78	0.80	0.71	0.01	0.72	-0.38	-0.66	-0.45
FC		1.00	0.50	-0.28	-0.62	-0.53	0.58	-0.92	0.09	0.64	0.11
SC			1.00	-0.42	-0.45	-0.48	-0.02	-0.75	0.79	0.47	0.51
STR				1.00	0.68	0.70	0.39	0.35	-0.17	-0.42	-0.33
LEN					1.00	0.90	-0.11	0.62	-0.06	-0.49	0.03
UNI						1.00	0.10	0.54	-0.09	-0.42	0.00
MIC							1.00	-0.48	-0.09	0.31	-0.28
RD								1.00	-0.46	-0.69	-0.29
+b									1.00	0.26	0.55
LG										1.00	
TR											1.00

Table 22. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Tennessee State - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 93 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.56	-0.57	0.56	0.60	0.47	-0.03	0.71	-0.20	-0.18	-0.08
FC		1.00	0.25	-0.45	-0.38	-0.44	-0.17	-0.92	-0.40	0.58	0.51
SC			1.00	-0.21	0.10	-0.01	0.16	-0.56	0.70	0.19	-0.10
STR				1.00	0.56	0.80	0.65	0.47	0.19	-0.19	-0.14
LEN					1.00	0.65	0.20	0.36	0.26	0.22	0.17
UNI						1.00	0.61	0.41	0.32	-0.13	-0.08
MIC							1.00	0.07	0.41	-0.23	-0.47
RD								1.00	0.04	-0.48	-0.39
+b									1.00	-0.34	-0.37
LG										1.00	0.68
TR											1.00

Table 23. Pearson Correlation Coefficients among Cotton Price and Ten HVI Properties for Texas State - 2000~2004 Crop Year

Pearson Correlation Coefficients, N = 156 (Weeks)											
	PR	**FC**	**SC**	**STR**	**LEN**	**UNI**	**MIC**	**RD**	**+b**	**LG**	**TR**
PR	1.00	-0.63	-0.82	0.81	0.79	0.83	0.54	0.81	-0.36	-0.49	-0.57
FC		1.00	0.57	-0.26	-0.20	-0.48	-0.39	-0.90	-0.19	0.87	0.85
SC			1.00	-0.69	-0.52	-0.59	-0.30	-0.85	0.62	0.39	0.47
STR				1.00	0.85	0.83	0.47	0.53	-0.54	-0.06	-0.18
LEN					1.00	0.81	0.33	0.41	-0.36	-0.10	-0.10
UNI						1.00	0.69	0.60	-0.18	-0.30	-0.45
MIC							1.00	0.42	0.04	-0.33	-0.64
RD								1.00	-0.23	-0.72	-0.77
+b									1.00	-0.27	-0.20
LG										1.00	0.84
TR											1.00

6.2.2. Variable Selection Methods for Creating Composite Cotton Quality Indices (CCQIs)

In order to choose the best variables for generating the Composite Cotton Quality Indices (CCQIs), SAS R-Square selection method and Mallow's C_p statistics analysis were applied. These indices will be used for obtaining the first-stage hedonic model by state.

6.2.2.1. Application of R-SQUARE Selection Method

Analyses were performed by using all-possible variable combinations procedure (R-SQUARE selection in PROC REG of the SAS System). Four best models were selected for each subset size (n=1 to 4).

The results provided the four best (highest R-Square) models in the order of decreasing fit, for each subset size (numbers in model). For each model, the R-square values and the selected independent variables were listed. As an illustration, for 10 combined states, the best model with one independent variable was with fiber length (LEN) with an R-square value of 0.5982 (Table 24). In the same table, the best two-variable model used fiber length and the second-digit color code (SC) with an R-square value of 0.8217.

Examining the R-square values, it can be seen that the value increases rapidly as the number of independent variables increases from one to three variables, but only slightly by adding a fourth variable. Adding more did not improve the model fit. Therefore, from these results, we conclude that a four-variable model is the best for creating CCQIs.

6.2.2.2. Application of Mallow's C_p Statistics

In addition to the R-square values, Mallow's C_p values were examined in each of Tables 24 ~ 34 in finalizing the hedonic model.

The C_p statistic, proposed by Mallows (1973), is a measure of total squared error for a subset model containing p independent variables,

The C_p statistic is computed as;

$$C_p = (SSE(p)/MSE) - (n-2p) \qquad (6.5)$$

Where :

MSE : the error mean square for the full model

SSE(p) : the error sum of squares for the subset model containing

p independent variables

n: the sample size.

6.2.2.3. Result and Discussion

From the correlation analyses in Chapter 6.2.1, it was found that there were significant correlations among two digit-color grade and leaf grade, and trash content. In addition, there were also significant positive correlations among fiber length, strength, length uniformity and micronaire. Based on this observation, it was decided to generate two Composite Cotton Quality Indices (CCQIs); one by using color factors only and the other from physical factors only. The model obtained from these two CCQIs will be called *First-Stage Hedonic Model II*.

By applying the results given in Table 24-34, appropriate HVI quality variables representing the best color factors and the best physical factors of cotton were chosen.

For selecting a hedonic model for ten combined states, fiber length(LEN) and the second-digit color code (SC) were considered most important for obtaining a CCQI because these two are shown to impact on the cotton price most (see Table 24). Using only these two variables, the model explained cotton price most (R^2=0.8228). However, when four variables were considered as a model, the two-digit color codes (FC and SC), fiber length (LEN) and length uniformity (UNI) had to be selected, R square value increased slightly from that with two variables (SC and LEN). Therefore, it can be concluded that a composite index based on color qualities should be composed of two-digit color code, whereas the same based on physical properties should include fiber length and length uniformity.

The analyses and conclusions drawn for individual state differ somewhat from each other. For Alabama, Arizona, Arkansas and Georgia, with fiber length and strength variables were used in the model, the R-squared values were higher than that with fiber length and length uniformity. For Arizona, the model using FC and TR as a color factor together with MIC and STR as a physical factor was the best for explaining the cotton price variation. In most cases, the second-digit color code was shown to impact on the cotton price more. However, trash content substituted for the second-digit color code as the best model for Arizona. Similar results were shown in models for California and North Carolina. In case of Tennessee, unlike other states, the model is realized by selecting the second-digit color code and trash content as color factors, and micronaire and fiber length as physical factors with the highest R-square value.

Table 24. Evaluation of Model Performances –Ten Combined States

Number of X's in Model	C(p)	R-Square	Variables Selected
1	2125.871	0.5981	LEN
1	2585.090	0.5423	SC
1	3322.450	0.4503	FC
1	3426.773	0.4350	STR
2	343.6293	0.8228	SC, LEN
2	1115.324	0.7262	SC, STR
2	1341.801	0.6977	FC, LEN
2	1487.864	0.6808	FC, SC
3	126.2035	0.8507	FC, SC, LEN
3	254.5440	0.8347	SC, LEN, TR
3	255.6895	0.8343	SC, LEN, LG
3	270.7118	0.8327	SC, LEN, UNI
4	31.4830	0.8635	FC, SC, LEN, UNI
4	58.8491	0.8602	FC, SC, MIC, LEN
4	126.3967	0.8509	FC, SC, LEN, LG
4	128.0625	0.8327	FC, SC, LEN, STR

Table 25. Evaluation of Model Performances - Alabama

Number of X's in Model	C(p)	R-Square	Variables Selected
1	420.6731	0.7236	FC
1	571.3923	0.6236	LEN
1	728.1581	0.5423	STR
1	757.6395	0.5257	SC
2	99.0615	0.8983	FC, LEN
2	113.2510	0.8950	FC, STR
2	216.1128	0.8304	SC, STR
2	228.9374	0.8302	FC, LG
3	54.1721	0.9275	FC, SC, STR
3	67.2023	0.9189	FC, LEN, STR
3	71.9603	0.9136	FC, SC, TR
3	72.5970	0.9135	FC, SC,LEN
4	26.3851	0.9423	FC, SC, STR, LG
4	28.5400	0.9418	FC, SC, LEN, STR
4	40.8122	0.9345	FC, LEN, UNI, STR
4	44.0813	0.9333	FC, SC, STR, TR

Table 26. Evaluation of Model Performances - Arizona

Number of X's in Model	C(p)	R-Square	Variables in Model
1	251.0269	0.8515	TR
1	418.3228	0.7861	LG
1	777.3798	0.6458	FC
1	1123.501	0.5106	UNI
2	113.9503	0.9058	STR, TR
2	201.0263	0.8718	LEN, TR
2	216.4755	0.8658	FC, TR
2	216.5405	0.8658	LG, TR
3	21.9837	0.9426	FC, STR, TR
3	64.5863	0.9259	STR, LG, TR
3	83.6679	0.9185	MIC, STR, TR
3	95.6869	0.9137	SC, STR, TR
4	19.6734	0.9442	FC, MIC, STR, TR
4	21.0878	0.9437	FC, STR, LG, TR
4	21.8007	0.9434	FC, LEN, STR, TR
4	23.8343	0.9426	FC, UNI, STR, TR

Table 27. Evaluation of Model Performances -Arkansas

Number of X's in Model	C(p)	R-Square	Variables Selected
1	213.1371	0.6301	SC
1	325.4691	0.4907	FC
1	540.8142	0.2236	STR
1	554.5460	0.2066	UNI
2	106.8010	0.7645	FC, SC
2	146.4326	0.7154	FC, LEN
2	147.4335	0.7141	SC, LEN
2	172.5117	0.6830	SC, STR
3	7.4391	0.8903	FC, SC, LEN
3	53.4988	0.8331	SC, LEN, TR
3	67.9811	0.8152	SC, LEN, LG
3	69.2606	0.8136	FC, SC, STR
4	3.6923	0.8974	FC, SC, LEN, TR
4	4.3313	0.8966	FC, SC, LEN, LG
4	7.4188	0.8928	FC, SC, LEN, STR
4	7.8183	0.8923	FC, SC, LEN, UNI

Table 28. Evaluation of Model Performances - California

Number of X's in Model	C(p)	R-Square	Variables Selected
1	286.7531	0.6954	LEN
1	344.5466	0.6514	STR
1	405.5456	0.6049	UNI
1	444.2929	0.5754	SC
2	67.1003	0.8643	LEN, TR
2	89.4881	0.8473	STR, TR
2	107.1132	0.8338	SC, LEN
2	112.6620	0.8296	FC, STR
3	35.1518	0.8902	LEN, STR, TR
3	38.5091	0.8876	SC, LEN, TR
3	64.8079	0.8676	LEN, LG, TR
3	65.0562	0.8674	FC, STR, TR
4	17.8888	0.9048	SC, LEN, STR, TR
4	25.5411	0.8990	FC, LEN, STR, TR
4	32.4848	0.8937	MIC, LEN, STR, TR
4	34.4935	0.8922	SC, LEN, LG, TR

Table 29. Evaluation of Model Performances - Georgia

Number of X's in Model	C(p)	R-Square	Variables Selected
1	571.0671	0.6147	SC
1	650.1082	0.5699	FC
1	755.6269	0.5102	STR
1	1003.985	0.3697	LEN
2	136.5654	0.8616	SC, STR
2	154.9908	0.8512	FC, LEN
2	259.6139	0.7920	FC, SC
2	446.4030	0.6863	FC, STR
3	60.1406	0.9060	FC, LEN, UNI
3	72.3648	0.8991	FC, SC, LEN
3	72.5130	0.8990	FC, SC, STR
3	133.6761	0.8644	SC, MIC, STR
4	23.9027	0.9276	FC, SC, LEN, STR
4	29.7051	0.9244	FC, SC, LEN, UNI
4	58.8877	0.9078	FC, LEN, UNI, TR
4	59.5934	0.9074	FC, LEN, UNI, STR

Table 30. Evaluation of Model Performances - Louisiana

Number of X's in Model	C(p)	R-Square	Variables Selected
1	519.1173	0.7576	SC
1	875.6502	0.6112	FC
1	1066.683	0.5328	STR
1	1375.033	0.4061	MIC
2	172.5826	0.9008	SC, STR
2	260.1066	0.8648	SC, LEN
2	324.1400	0.8385	FC, LEN
2	406.9325	0.8045	FC, SC
3	56.9279	0.9491	FC, SC, LEN
3	121.4775	0.9226	SC, MIC, STR
3	132.7710	0.9180	FC, SC, STR
3	140.4472	0.9148	SC, STR, LG
4	15.4818	0.9669	FC, SC, MIC, LEN
4	23.9847	0.9635	FC, SC, LEN, UNI
4	56.3959	0.9501	FC, SC, LEN, LG
4	58.1148	0.9494	FC, SC, LEN, TR

Table 31. Evaluation of Model Performances - Mississippi

Number of X's in Model	C(p)	R-Square	Variables Selected
1	418.6035	0.5983	SC
1	520.7238	0.5188	STR
1	661.3742	0.4092	FC
1	775.8618	0.3200	LEN
2	140.2693	0.8167	SC, LEN
2	169.3793	0.7940	SC, STR
2	284.5707	0.7043	FC, SC
2	334.3938	0.6655	FC, STR
3	35.0183	0.9003	FC, SC, LEN
3	65.6294	0.8764	SC, LEN, LG
3	87.7862	0.8592	SC, LEN, TR
3	111.5926	0.8406	FC, SC, STR
4	15.4871	0.9170	FC, SC, LEN, LG
4	25.1347	0.9095	FC, SC, LEN, TR
4	27.8565	0.9074	FC, SC, MIC, LEN
4	36.4251	0.9007	FC, SC, LEN, STR

Table 32. Evaluation of Model Performances - North Carolina

Number of X's in Model	C(p)	R-Square	Variables Selected
1	349.3511	0.6445	LEN
1	397.3073	0.6066	STR
1	519.9787	0.5098	UNI
1	540.2998	0.4937	SC
2	65.5029	0.8701	LEN, TR
2	170.5810	0.7872	SC, LEN
2	179.1703	0.7804	SC, STR
2	197.6820	0.7658	FC, STR
3	47.8599	0.8856	SC, LEN, TR
3	53.5923	0.8811	LEN, STR, TR
3	62.3661	0.8742	FC, LEN, TR
3	62.6795	0.8739	LEN, LG, TR
4	29.5132	0.9017	SC, LEN, STR, TR
4	37.0279	0.8958	MIC, LEN, STR, TR
4	40.8270	0.8928	FC, LEN, STR, TR
4	43.1031	0.8910	SC, LEN, UNI, TR

Table 33. Evaluation of Model Performances – Tennessee

Number of X's in Model	C(p)	R-Square	Variables Selected
1	309.2929	0.3657	LEN
1	336.2063	0.3229	SC
1	338.9023	0.3186	STR
1	341.9801	0.3137	FC
2	59.8319	0.7662	SC, LEN
2	168.1150	0.5937	MIC, STR
2	205.1864	0.5347	SC, UNI
2	208.9579	0.5287	SC, STR
3	35.0660	0.8088	SC, LEN, LG
3	44.0537	0.7945	FC, SC, LEN
3	51.4549	0.7827	SC, LEN, TR
3	59.1726	0.7704	SC, LEN, STR
4	26.2431	0.8260	SC, MIC, LEN, LG
4	35.8106	0.8107	SC, LEN, UNI, LG
4	36.5881	0.8096	FC, SC, LEN, LG
4	36.9864	0.8089	SC, LEN, LG, TR

Table 34. Evaluation of Model Performances - Texas

Number of X's in Model	C(p)	R-Square	Variables Selected
1	728.6703	0.6834	UNI
1	741.0581	0.6801	SC
1	804.3554	0.6500	STR
1	835.2500	0.6261	LEN
2	221.8749	0.8681	LEN, TR
2	231.5617	0.8603	SC, LEN
2	260.6638	0.8578	SC, UNI
2	274.3417	0.8530	FC, LEN
3	16.5892	0.9469	SC, LEN, TR
3	81.3883	0.9474	FC, SC, LEN
3	84.9059	0.9474	SC, LEN, LG
3	121.6072	0.9091	SC, MIC, LEN
4	17.0783	0.9483	SC, MIC, LEN, TR
4	17.0984	0.9474	SC, LEN, STR, TR
4	17.5602	0.9474	FC, SC, LEN, TR
4	17.8636	0.9469	SC, LEN, UNI, TR

6.3. First Stage Hedonic Model II with CCQIs

6.3.1. Formation of CCQIs

Based on the results of correlation and variable selection analyses in Chapter 6.2, it was decided to generate two Composite Cotton Quality Indices (CCQIs). In correlation analysis, it was found that there were significant positive correlations between two digits of color code (FC and SC). For ten combined states (Table 24), two-digit color code (FC and SC) is considered to be representative variables for color factors because using only these two variables, the model explained the variation of cotton price well (R^2=0.6808). From these results, it was decided to form the CCQI for color factors as the product of FC and SC indicating the dimensions of two positively correlated variables. As the same procedure, the CCQI for physical factors is formulated as the product of LEN and UNI as there were also significant positive correlations between fiber length and length uniformity.

6.3.2. Conceptual Model

The price of cotton P(C) is now expressed as a function of Composite Cotton Quality Indices, X_i, i=1, 2.

$$P(C) = f(X_1, X_2,) \qquad (6.6)$$

As discussed previously, this study will employ CCQI X_1 representing color factors and CCQI X_2 representing physical factors.

6.3.3. Empirical Model

This best model using two CCQIs is of the form;

$$P_i = f(FC_i \times SC_i, LEN_i \times UNI_i) \qquad (6.7)$$

Where:

P_i = average price (cents/lb) of cotton in week ***i***

FC_i = average first digit of the color code in week ***i***

SC_i = average second digit of the color code in week ***i***

LEN_i = average fiber length (inches) in week ***i***

UNI_i = average fiber length uniformity (%) in week ***i***

This model will be called *First-Stage Hedonic Model II with Two CCQIs* in this study

6.3.3. Results and Discussion

From the results of Chapter 6.2, two CCQIs, one from color factors and the other physical factors, were created. The CCQI from the color factors (X_1) was made by the product of two-digit color code (FC×SC) and CCQI for the physical factor (X_2) was done by the product of fiber length and length uniformity (LEN×UNI). These product forms were selected by comparing the R-square values of several alternative functional forms. These product forms not only produced the highest R-square values but also were easily explainable in physical terms.

As already described in a previous section (6.2.2.3.), some other forms than X_1 and X_2 above were found to be superior in terms of R^2. In order to examine how X_1= FC×SC and X_2= LEN$\times$UNI might perform in each state, careful comparisons were made for the differences. The idea is to examine the feasibility of using the same CCQIs for all states in addition to the 10 combined states. For all 10 states combined, three different sets of X_1 and X_2 were examined and the results are summarized in Tables 35 (a), (b) and (c). All three sets showed high R^2 values ranging from 0.7690 to 0.8390. The CCQIs used in the best model were X_1 composed of FC and SC and X_2 composed of LEN and UNI. All parameter estimates were statistically significant at the α =0.05 level. This result indicates that the cotton price can be determined by the observation of two CCQIs made by only four HVI quality measures. The variable X_1 represents the color component of cotton. The parameter estimates of X_1 were characterized by a negative sign, indicating negative effects of the color components on cotton price. These results are consistent with those from the First-Stage Hedonic Model I (see Chapter 6.1.4). In all models, the estimates of coefficient for X_2, the component for physical properties of cotton, had a positive impact on cotton price, also consistent with the results of Hedonic Model I.

Table 35(a) First Stage Estimates Including CCQIs - Ten Combined States

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.02357	1.54	0
X1= FC*SC	-0.01142	-39.10*	-0.55089
X2= LEN*UNI	0.00603	35.92*	0.50607
R-Square = 0.8390			
Total Number of Observations (Weeks) = 1086			

Where,

FC : the average first digit of color grade

SC: the average second digit of color grade

LEN: the average fiber length

STR: the average strength

MIC: the average micronaire

LG: the average leaf grade

UNI: the average length uniformity

Note: * the coefficient is significant with $p \leq 0.05$

Table 35(b) First Stage Estimates Including CCQIs - Ten Combined States

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.38603	48.77*	0
X1= FC*SC	-0.01207	-33.63*	-0.58234
X2= LEN*STR	0.005551	23.88*	0.41360
R-Square = 0.7690			
Total Number of Observations (Weeks) = 1086			

Table 35(c) First Stage Estimates Including CCQIs - Ten Combined States

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.38665	51.92*	0
X1= FC*SC	-0.01189	-33.87*	-0.57403
X2= LEN*STR*UNI	0.00006735	25.34*	0.42941
R-Square = 0.7785			
Total Number of Observations (Weeks) = 1086			

For model selection, many different sets of CCQIs were tried among many to select the three best sets of X_1 and X_2 as shown. In the first two models (Tables 35(a) and (b)), the CCQIs included only two variables, LEN and UNI, and LEN and STR, respectively. In the last model (Table 35 (c)), CCQI consisted of three variables (LEN, STR, UNI) was included. Of the three, the best CCQI for representing the physical factors was LEN×UNI. By adding another variable, the fit became poorer (see Table 35 (c)).

For the case of Alabama, the last model (Table 36(c), with X_2 =(LEN×STR×UNI) had the highest R^2 value (0.9216), the gain (0.0014) in R^2 over CCQI with two variables (LEN× STR) was negligible. There were also small R^2 difference value (0.0349) between the First Stage Hedonic Model I and Hedonic Model II with CCQIs. In addition, the R^2 value of a model including representative CCQIs, X_1= FC×SC and X_2= LEN×UNI, was high (0.8870).

Table 36(a) First Stage Estimates Including CCQIs – Alabama

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.35025	-5.27*	0
X1= FC*SC	-0.00925	-15.72*	-0.58640
X2= LEN*UNI	0.01035	13.65*	0.50911
R-Square = 0.8870			
Total Number of Observations (Weeks) = 108			

Table 36(b) First Stage Estimates Including CCQIs – Alabama

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.13718	5.72*	0
X1= FC*SC	-0.00960	-20.10*	-0.60863
X2= LEN*STR	0.01391	17.54*	0.53116
R-Square = 0.9202			
Total Number of Observations (Weeks) = 108			

Table 36(c) First Stage Estimates Including CCQIs – Alabama

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.17195	7.90*	0
X1= FC*SC	-0.00949	-19.94*	-0.60162
X2= LEN*STR*UNI	0.00015668	17.75*	0.53540
R-Square = 0.9216			
Total Number of Observations (Weeks) = 108			

For Arizona, Tables 37 (a), (b) and (c) illustrate the performances of three models including the use of different CCQIs (X_2). For the variable selection (Table 26), CCQIs with the FC and TR representing color factors, and MIC and STR for physical factors were expected to form a best model. However, that was not the case because the fit using these CCQI (X_1=FC×TR and X_2= MIC×STR) was not better than other results. For Arizona, the best CCQI for the physical factor was the product of fiber length and length uniformity and this model is shown in Table 37(b).

Similar results were shown in models for California and North Carolina. Tables 39 (a), (b) and (c) show the results on the First Stage Hedonic Models for California. As was the case for Arizona, trash content was an important variable for the cotton price instead of the first-digit color code. So, a new X_1 that includes trash content was formulated as a CCQI and included in the Hedonic Model II for California. From Table 39(c), it can be seen that the model including a new X_1 with trash content, instead of the first-digit color code, produces the highest R^2 value (0.9044).

Table 37(a) First Stage Estimates Including CCQIs – Arizona

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.03094	0.46	0
X1= FC*SC	-0.01196	-17.58*	-0.70355
X2= LEN*UNI	0.00593	8.01*	0.32064
R-Square = 0.8645			
Total Number of Observations (Weeks) = 133			

Table 37(b) First Stage Estimates Including CCQIs – Arizona

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.28279	13.67*	0
X1= FC*SC	-0.01423	-32.78*	-0.83719
X2= LEN*STR	0.00900	13.73*	0.35051
R-Square = 0.9174			
Total Number of Observations (Weeks) = 133			

Table 37(c) First Stage Estimates Including CCQIs – Arizona

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.24414	9.22*	0
X1= FC*SC	-0.01436	-31.00*	-0.84513
X2= STR*UNI	0.00013978	12.17*	0.33175
R-Square = 0.9054			
Total Number of Observations (Weeks) = 133			

Table 38. First Stage Estimates Including CCQI – Arkansas

Dependent Variable : Price of Cotton			
Independent Variable	Parameter Estimate	t Value	Standardized Estimate
Intercept	-0.05195	-0.76	0
X1= FC*SC	-0.01214	-19.68*	-0.79106
X2= LEN*UNI	0.00697	9.08*	0.36506
R-Square =0.8658			
Total Number of Observations (Weeks) =89			

Table 39(a). First Stage Estimates Including CCQIs – California

Dependent Variable : Price of Cotton			
Independent Variable	Parameter Estimate	t Value	Standardized Estimate
Intercept	0.16750	6.04*	0
X1= FC*SC	-0.00810	-8.88*	-0.38890
X2= LEN*UNI	0.00432	14.98*	0.65583
R-Square =0.8358			
Total Number of Observations (Weeks) =117			

Table 39(b). First Stage Estimates Including CCQIs –California

Dependent Variable : Price of Cotton			
Independent Variable	Parameter Estimate	t Value	Standardized Estimate
Intercept	0.38516	36.70*	0
X1= FC*SC	-0.00946	-13.04*	-0.45440
X2= LEN*STR	0.00516	19.02*	0.66254
R-Square =0.8832			
Total Number of Observations (Weeks) =117			

Table 39(c). First Stage Estimates Including CCQIs -California

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.40074	40.44*	0
X1= SC*TR	-0.08255	-15.26*	-0.50450
X2= LEN*STR	0.00466	18.12*	0.59894
R-Square =0.9044			
Total Number of Observations (Weeks) =117			

Table 40(a). First Stage Estimates Including CCQI -Georgia

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.21764	3.59*	0
X1= FC*SC	-0.01657	-19.46*	-0.79920
X2= LEN*UNI	0.00417	6.04*	0.24807
R-Square =0.8341			
Total Number of Observations (Weeks) =114			

Table 40(b). First Stage Estimates Including CCQI -Georgia

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.31076	15.27*	0
X1= FC*SC	-0.01367	-20.60*	-0.65936
X2= LEN*STR	0.00853	13.51*	0.43249
R-Square =0.9167			
Total Number of Observations (Weeks) =114			

Tables 41(a), (b), and (c) provide the results of the First Stage Hedonic Model II for Louisiana. From Table 30 of the previous section, it was found that the four variables which have the biggest impact on the cotton price were two-digit color code, fiber length and micronaire. From correlation analysis for Louisiana (Table 19), it was found that there were low negative correlations between micronaire and fiber length (correlation coefficient = -0.17). Based on this and R-Square selection method, a new X_2 variable was formulated by X_2=LEN/MIC. The results are shown in Table 41(c). Comparing this Table 41 (b), the R^2 value did not improve at all, proving that the new X_2 involving MIC is not warranted.

In case of Mississippi, it was found that leaf grade and trash content were as important variables as two-digit color code (FC and SC). Following several analyses, however, it was concluded that a new CCQI, X_1 = SC×LG, the product of the leaf grade and the second-digit color code was the best choice representing color factors as shown in Table 42(c).

Tables 43(a) through (e) show the results for North Carolina. Since it was found that the trash content can substitute for either one of the two-digit color codes based on the results of R-Squared selection methods in Chapter 6.2.2.3, a new CCQI that includes trash content was tried. Table 43 (d) provides results that use of X_1 = SC×TR representing the color factor, and X_2 = LNE×UNI for the physical factor, is the best model for explaining the cotton price variation for North Carolina.

Table 41(a). First Stage Estimates Including CCQIs –Louisiana

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.05246	-0.98	0
X1= FC*SC	-0.01414	-27.14*	-0.87203
X2= LEN*UNI	0.00707	11.60*	0.37278
R-Square = 0.9258			
Total Number of Observations (Week) = 75			

Table 41(b). First Stage Estimates Including CCQIs -Louisiana

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.34307	18.16*	0
X1= FC*SC	-0.01188	-21.56*	-0.73282
X2= LEN*STR	0.00707	11.97*	0.40690
R-Square = 0.9288			
Total Number of Observations (Weeks) = 75			

Table 41(c). First Stage Estimates including CCQIs -Louisiana

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.19386	5.55*	0
X1= FC*SC	-0.01150	-18.87*	-0.70927
X2= LEN/MIC	1.59818	10.73*	0.40328
R-Square = 0.9181			
Total Number of Observations (Weeks) = 75			

Table 42(a). First Stage Estimates including CCQIs – Mississippi

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.10651	0.05628	0
X1= FC*SC	-0.01359	-20.47*	-0.76190
X2= LEN*UNI	0.00765	12.01*	0.44709
R-Square =0.8664			
Total Number of Observations (Weeks) =101			

Table 42(b). First Stage Estimates Including CCQIs - Mississippi

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.33505	15.59*	0
X1= FC*SC	-0.01150	-15.37*	-0.64453
X2= LEN*STR	0.00736	11.00*	0.46122
R-Square =0.8552			
Total Number of Observations (Weeks) =101			

Table 42(c). First Stage Estimates Including CCQIs – Mississippi

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.28501	-5.58*	0
X1= SC*LG	-0.02277	-22.55*	-0.77006
X2= LEN*UNI	0.01007	17.24*	0.58879
R-Square =0.8861			
Total Number of Observations (Weeks) =101			

Table 43(a).   First Stage Estimates Including CCQIs - North Carolina

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.14233	-1.65	0
X1= FC*SC	-0.01005	-6.13*	-0.39938
X2= LEN*UNI	0.00795	8.42*	0.54903
R-Square = 0.7311			
Total Number of Observations (Weeks) = 105			

Table 43(b).   First Stage Estimates Including CCQIs - North Carolina

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.16512	5.61*	0
X1= FC*SC	-0.01047	-9.34*	-0.41593
X2= LEN*STR	0.01331	14.35*	0.63902
R-Square = 0.8489			
Total Number of Observations (Weeks) = 105			

Table 43(c).   First Stage Estimates Including CCQIs - North Carolina

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.68486	-4.75*	0
X1= FC*SC	-0.01044	-6.66*	-0.41477
X2= LEN/UNI	93.82832	8.81*	0.54882
R-Square = 0.7410			
Total Number of Observations (Weeks) = 105			

Table 43(d). First Stage Estimates Including CCQIs - North Carolina

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.27790	-6.05*	0
X1= SC*TR	-0.08307	-14.35*	-0.51365
X2= LEN*UNI	0.00958	18.49*	0.66163
R-Square = 0.8781			
Total Number of Observations (Weeks) = 105			

Table 43(e). First Stage Estimates Including CCQIs - North Carolina

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.15506	5.66*	0
X1= FC*TR	-0.03202	-10.07*	-0.41026
X2= LEN*STR	0.01415	16.67*	0.67920
R-Square = 0.8594			
Total Number of Observations (Weeks) = 105			

In summary, the results for each state were different somewhat from that for all states combined. For Alabama, Arizona, Arkansas and Georgia, the R-square values were higher when fiber length and strength variables were used in the model than the model with fiber length and length uniformity as physical factors. In case of Arizona, the second-digit color code impacted the cotton price most. However, trash content was preferred over the second-digit color code for Arizona. Similar results were shown for California and North Carolina. For Tennessee, unlike other states, all four variables included in the 10 combined state cases were not chosen. The highest R-square value was obtained when the second-digit color code and trash content were selected as color factors, and micronaire and fiber length were selected as physical factors.

Table 44(a). First Stage Estimates Including CCQI – Tennessee

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.06222	-0.83	0
X1= FC*SC	-0.01154	-10.17*	-0.59416
X2= LEN*UNI	0.00703	8.20*	0.47909
R-Square = 0.7077			
Total Number of Observations (Weeks)= 93			

Table 44(b). First Stage Estimates Including CCQI – Tennessee

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.29821	-4.46*	0
X1= SC*LG	-0.01674	-11.54*	-0.61644
X2= LEN*UNI	0.00998	12.74*	0.68048
R-Square = 0.7467			
Total Number of Observations (Weeks) = 93			

Table 45(a). First Stage Estimates Including CCQI – Texas

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	-0.09193	-3.03*	0
X1= FC*SC	-0.01618	-22.56*	-0.56475
X2= LEN*UNI	0.00748	22.19*	0.55562
R-Square =0.9263			
Total Number of Observations (Weeks) =155			

Table 45(b). First Stage Estimates Including CCQI - Texas

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Standardized Estimate**
Intercept	0.23110	12.53*	0
X1= FC*SC	-0.01589	-19.47*	-0.55474
X2= LEN*STR	0.01037	19.09*	0.54390
R-Square =0.9080			
Total Number of Observations (Weeks) =155			

7. SECOND STAGE HEDONIC MODEL

7.1. Supply Factors of Cotton Fiber

The Second-Stage Hedonic Model is developed here by utilizing such supply factors as weather, the inventory level of cotton fiber from the previous year, harvested acreage and production quantity by state. Since climatic factors are known to be cause of the variation in physical and color qualities of cotton fiber, the temperature and rainfall during spring, fall and winter seasons have been evaluated. Hoelscher [2001] reported that spring temperature affected color grades, micronaire and fiber length significantly.

Information on the inventory level of cotton was obtained and utilized from information sources at USDA-AMS. Beginning stocks were obtained from the ending stocks of the previous crop year. The crop year for cotton usually begins on August 1 and ends July 31 of the following year.

The harvested acreages and the production quantity for 2000-2004 crop years are presented in Tables 46 and 47, respectively by state. Texas was the largest producer of US upland cotton in recent years, followed by Mississippi, Arkansas, Georgia and California.

Table 46. Upland cotton: Harvested acreage, by State, 2000/2001-2004/2005

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	530	950	278	770	1,350	695	1,280	925	565	4,400
2001	605	1,065	290	625	1,480	855	1,600	965	615	4,250
2002	540	920	213	477	1,360	495	1,150	920	530	4,500
2003	510	945	213	545	1,290	510	1,090	770	530	4,350
2004	540	900	238	557	1,280	490	1,100	725	525	5,350
AVG.	**540**	**900**	**238**	**557**	**1,280**	**490**	**1,100**	**725**	**525**	**5,350**

Table 47. Upland cotton: Production, by State, 2000/2001-2004/2005

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	543	1,425	791	2,210	1,663	911	1.711	1,429	710	3,940
2001	920	1,833	690	1,770	2,220	1034	2,396	1,673	978	4,260
2002	570	1,669	613	1,460	1,578	739	1,935	806	818	5,040
2003	820	1,804	550	1,495	2,110	1027	2,120	1,037	890	4,330
2004	814	2,089	723	1,790	1,797	885	2,346	1,360	984	7,740
AVG.	**733**	**1,764**	**673**	**1,745**	**1,874**	**919**	**1,760**	**1,261**	**876**	**5,062**

Based on the seasonal pattern mentioned in Chapter 3.2.2.2, the weather variables were divided into three parts; spring (April-March), summer (June-August) and Harvest season (September-October). Tables 48 through 53 represent average temperature and rainfall by season for 2000/2001-2004/2005 crop years. In this part, average temperature and rainfall of Spring, Summer and Harvest seasons were included in the Second Stage Hedonic Model as exogenous variables.

Table 48. Average Spring Temperature (April-May; Fahrenheit), by State

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	67.80	66.30	72.07	65.23	67.75	71.90	68.55	66.90	63.30	68.10
2001	68.20	68.98	71.72	64.45	67.75	72.45	70.05	67.00	66.25	62.93
2002	69.23	66.30	71.7	63.78	68.80	72.60	65.00	68.00	63.85	66.38
2003	68.40	67.38	70.32	63.15	68.50	72.60	65.45	66.20	64.20	64.98
2004	68.98	68.00	73.20	67.33	70.20	70.15	66.65	68.90	65.55	66.35
AVG	**68.52**	**67.39**	**71.80**	**64.79**	**68.60**	**71.94**	**67.14**	**67.40**	**64.63**	**65.75**

Table 49. Average Summer Temperature (June-August; Fahrenheit), by State

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	81.35	81.55	89.68	75.05	80.43	82.60	82.40	77.83	78.83	81.7
2001	78.65	81.65	89.55	75.05	79.10	80.23	79.77	78.97	77.33	81.43
2002	80.10	80.53	91.05	74.67	80.63	80.93	80.37	79.30	79.00	79.82
2003	78.85	79.97	91.1	76.12	80.27	81.47	80.00	79.33	76.50	78.75
2004	79.72	77.95	89.38	75.72	81.47	81.30	78.67	78.83	75.87	78.01
AVG	**79.73**	**80.33**	**90.15**	**75.32**	**80.38**	**81.31**	**80.24**	**78.85**	**77.51**	**79.94**

Table 50. Average Harvest Season Temperature (September-October; Fahrenheit), by State

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	70.28	70.83	82.20	68.83	68.35	72.50	71.10	68.05	67.55	78.80
2001	67.03	66.70	84.97	70.35	67.15	70.35	68.05	67.05	64.35	73.95
2002	73.45	68.70	83.02	69.63	72.65	75.75	73.30	72.10	68.20	73.02
2003	69.38	68.60	85.42	72.83	70.6	72.60	69.75	68.30	65.40	76.67
2004	73.55	71.25	81.95	69.83	72.6	77.00	74.05	70.25	68.30	74.60
AVG	**70.74**	**69.22**	**83.51**	**70.29**	**70.27**	**73.64**	**71.25**	**69.15**	**66.76**	**75.41**

Table 51. Average Spring Rainfall (April-May; Inches), by State

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	2.87	3.68	0.78	0.40	0.64	1.35	5.25	4.17	6.95	1.56
2001	5.06	4.10	0.64	0.53	4.52	0.69	3.22	1.99	3.98	1.26
2002	2.32	4.27	0.04	0.34	2.81	3.24	3.32	1.48	4.15	1.17
2003	8.22	3.03	0.23	0.77	5.03	1.82	8.23	6.96	7.71	0.62
2004	4.07	4.88	0.87	0.21	2.0	8.67	6.07	2.58	6.80	4.15
AVG.	**4.51**	**3.99**	**0.51**	**0.45**	**3.01**	**3.15**	**5.22**	**3.43**	**5.92**	**1.76**

Table 52. Average Summer Rainfall (June-August; Inches), by State

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	2.65	3.38	0.94	0.02	3.44	3.69	2.65	7.48	1.98	2.58
2001	4.69	1.91	0.58	0.01	4.61	10.11	6.89	5.68	3.77	2.22
2002	4.36	3.22	1.22	0.00	2.39	3.98	6.21	8.03	4.18	3.38
2003	6.23	3.06	1.04	0.01	7.54	5.15	4.41	5.48	4.61	2.77
2004	4.48	4.64	0.48	0.00	4.47	5.17	6.36	6.61	3.61	2.73
AVG.	**4.48**	**3.24**	**0.85**	**0.01**	**4.49**	**5.62**	**5.30**	**6.65**	**3.63**	**2.74**

Table 53. Average Harvest Season Rainfall (September-October; Inches), by State

	States									
Crop Year	**AL**	**AR**	**AZ**	**CA**	**GA**	**LA**	**MS**	**NC**	**TN**	**TX**
2000	2.80	2.49	1.74	0.54	5.80	2.06	2.48	4.08	1.08	2.16
2001	3.22	3.70	0.39	0.05	3.36	6.30	4.05	1.75	3.20	3.88
2002	5.45	2.28	0.94	0.18	4.06	7.75	8.40	3.65	5.39	4.08
2003	2.10	2.59	0.93	0.28	1.78	3.05	2.87	7.66	5.25	3.53
2004	5.65	4.05	0.58	3.26	7.16	5.25	3.11	5.92	4.73	3.83
AVG.	**3.84**	**3.02**	**0.91**	**0.86**	**4.43**	**4.88**	**4.18**	**4.61**	**3.93**	**3.50**

7.2. Marginal Implicit Price Derived From the First Stage Hedonic Model

The marginal implicit price (MIP) for each cotton quality characteristic was derived by taking the partial derivative of each first-stage model with respect to each quality characteristic for each year by state. The marginal implicit price represents an equilibrium price due to each quality characteristic.

All MIPs derived for various quality characteristics by state are presented in Appendices 12.E. Table 54 lists the summary statistics for variables used in the second-stage estimations. The average values for color codes, micronaire, length uniformity, leaf grade and trash content were negative. Based on actual practice, length uniformity is expected to add premium by increasing its value. However, the results show a negative impact on cotton price. Increases in color codes, leaf grade and trash content decreased the value of cotton as expected. Most importantly, an increase in fiber length or strength added a premium to the value of cotton while an increase in the micronaire level discounted the value of cotton. The average MIP of fiber length was large compared to that of other quality attributes. This, however, is due to the differences in the measurement units. In this analysis, the unit for fiber length was inches but the differences in average fiber length among different cottons are very small fractions of an inch.

Table 54. Summary Statistics for Variables used in the Estimation of Characteristic Supply Function

Variable Definition	Mean	Standard Deviation	Minimum	Maximum
FC_MIP Average marginal implicit price of the first-digit color code (dollar/lb)	-0.00856	0.009923	0.01009	-0.00335
SC_MIP Average marginal implicit price of the second-digit color code (dollra/lb)	-0.03482	0.03392	0.06076	-0.14188
MIC_MIP Average marginal implicit price of micronaire (dollar/lb)	-0.00783	0.02888	0.06876	-0.07179
LEN_MIP Average marginal implicit price of fiber length (dollar/lb)	0.55213	0.43591	1.60454	-0.51183
UNI_MIP Average marginal implicit price of fiber length uniformity (dollar/lb)	-0.00147	0.01477	0.03746	-0.05660
STR_MIP Average marginal implicit price of strength (dollar/lb)	0.00356	0.00782	0.02836	-0.01526
LG_MIP Average marginal implicit price of leaf grade (dollar/lb)	-0.00314	0.01802	0.05089	-0.04640
TR_MIP Average marginal implicit price of trash content (dollar/lb)	-0.04383	0.06004	0.10094	-0.21243

7.3. Model and Estimation Method

From the results of Hedonic Model I (6.2), the marginal implicit price (MIP) of each cotton quality attribute was obtained by partial differentiation on that quality characteristic. When a quality characteristic is expressed as a linear function of cotton price, the coefficient attached to that parameter is its marginal implicit price. In addition, the supply factors of cotton as explained in Chapter 7.1, are included in the *Second-Stage Hedonic Model* as supply shifters.

Using each MIP, the supply function for each quality attribute can be modeled as follows:

$$C_i = g_i\,[P\,(C_1),\, P\,(C_2), \cdots, P\,(C_n),\, S\,] \qquad (7.1)$$

$$(\, i=1,\, 2, \cdots,\, n.)$$

For this study, C is composed of HVI quality characteristics for two-digit color code, micronaire, length, length uniformity, strength, leaf grade and trash contents. Here, P (C_i), i=1, 2,⋯, n., represents MIP of i^{th} HVI quality characteristic and S the supply factors of cotton.

The following is an empirical model to be used as the Second Stage Hedonic Model.

Here, FC_MIP = P(C_1), in Equation (7.1) and so on.

$$C_i = f\,(FC\_MIP,\, SC\_MIP,\, MIC\_MIP,\, LEN\_MIP,\, STR\_MIP,\, LG\_MIP,\, TR\_MIP$$
$$HA,\, PROD,\, B\_STOCK\,,\, SP\_TEMP\,,\, SM\_TEMP,\, HA\_TEMP,$$
$$SP\_RAIN,\, SM\_RAIN,\, HA\_RAIN\,) \qquad (7.2)$$

Where:

C_i = each average quality characteristic by state in a given year, (i=1~8)
FC_MIP = marginal implicit price of FC by state in a given year
SC_MIP = marginal implicit price of SC by state in a given year
MIC_MIPs = marginal implicit price of MIC by state in a given year
LEN_MIPs = marginal implicit price of LEN by state in a given year
STR_MIPs = marginal implicit price of STR by state in a given year
UNI_MIPs = marginal implicit price of FC by state in a given year
LG_MIPs = marginal implicit price of FC by state in a given year
TR_MIPs = marginal implicit price of FC by state in a given year
HA = harvested acreage by state in a given year
PROD = production by state in a given year
B_STOCK = Beginning Stock in a given year
SP_TEMP = average spring temperature (April-May) by state in a given year
SM_TEMP = average summer temperature (June-August) by state in a given year
SP_TEMP = average harvest season temperature (September-October) by state in a given year
SP_RAIN = average spring rainfall (April-May) by state in a given year
SM_RAIN = average summer rainfall (June-August) by state in a given year
SP_RAIN = average harvest season rainfall (September-October) by state in a given year

The descriptive statistics for each cotton HVI quality measure by state are listed in Appendices 12.D. For the second stage hedonic model, it was decided to run backward regression analyses by eliminating the factor contributing the least to the R-square value, one at a time, until only the significant factors remained as independent variables at α=0.10 level.

These functions are expected to be most helpful for cotton growers and buyers as tools for making purchase decisions as they have to react to any changes in the availability of a certain type of cotton with desired quality attributes so that they can adjust the selling and buying prices accordingly. Normally, producers have little or no control over pricing the base level of cotton and only adjust the quantity to be supplied to the market with various strategies for determining the selling prices.

7.3. Results and Discussion

All variables used in the estimation of the characteristic supply function are listed in Tables 46 through 53, Appendices 12.D and E. Only those parameters for which the estimated coefficients were significant at α=0.10 level are shown in the tables contained in this section. Table 55 presents the results obtained from the supply function for the first digit color code (degree of greyness; FC). As a high value of color code is undesirable, the marginal implicit price of FC is negative. That is, a higher FC means a negative MIP. Looking at the effect of other MIPs on the first digit color code, the results indicate that the marginal implicit prices of fiber length were positively correlated with the level of the first digit color code, meaning that as the MIP of fiber length increases, there is an increase in the level of the first digit color code. This indicates that an increase in the value of fiber length prompts an increase in the average supply level of the first-digit color code, providing the market with cotton containing higher level of color code (lower quality). Since the MIP for the first digit color code is negative when the color code values decrease, the average level of the color code increases. This is consistent with the normal expectation that a producer would be willing to accept less for higher levels of color.

The average color code for cotton was also shown to be affected by the temperature and rainfall of spring and harvest seasons. Especially, the harvest season temperature had negative effect on the level of the first digit color code. As explained above, since a higher color code means lower quality, the high temperature during harvest season is associated with a higher level of color code. On the other hand, the higher spring temperature and rainfall are shown to increase the level of first digit color code.

Table 55. Second Stage Estimates for FC

Dependent Variable : FC		
Independent Variable	Parameter Estimate	t Value
Intercept	-2.17759	-1.57
FC_MIP	-14.90795	-2.77
LEN_MIP	0.26781	2.19
Spring Temperature	0.09961	4.38
Harvest Season Temperature	-0.03200	-2.31
Spring Rainfall	0.07454	3.02
Harvest Season Rainfall	0.16091	5.90
R-Square = 0.7464		
Total Number of Observations (Years) = 50		

The second stage parameters estimated for the second digit color code (degree of yellowness; SC) are listed in Table 56. As was the case with the first digit color code, the MIP for fiber length was a positive value, indicating that the MIP of fiber length increases the level of color code as well.

Of the six weather variables included in the supply function, both average spring rainfall and average harvest season rainfall significantly affected the second digit color code (SC). In this function, the average harvest season rainfall was positively correlated with SC, indicating that as the harvest season rainfall increased, the average level of SC supplied to the cotton market increased.

Table 56. Second Stage Estimates for SC

Dependent Variable : SC		
Independent Variable	Parameter Estimate	t Value
Intercept	1.06254	23.38
MIC_MIP	-2.47014	-3.87
LEN_MIP	0.08082	1.97
Spring Rainfall	-0.01485	-1.95
Harvest Season Rainfall	0.02680	3.04
Harvested Acreage	0.00003767	2.45
R-Square = 0.5639		
Total Number of Observations (Years) = 50		

Table 57 presents the estimated effects on micronaire by the supply function factors. As the MIP of micronaire decreased, the average level of micronaire increased. This also means that an increase in micronaire levels lowers the value of cotton.

The weather variables in supply function for micrinaire revealed that the harvest season temperature and spring rainfall had significant effects on micronaire. As the average spring rainfall and harvest season temperature increased, the average level of micronaire increased. This result is consistent with that of Sivertooth's study [2001] for Arizona cotton. He reported that excessive heat in the field late in the harvest season clearly increased the probability of producing a high micronaire value while the seed variety and production location influenced the micronaire value significantly. Temperature also had a profound effect on micronaire. Studies conducted in South Carolina, South Africa, and Louisiana, all demonstrated a significant relationship between increased heat unit accumulation and increased micronaire [Greef and Human, 1983; Porter et al., 1996]. These studies generally manipulated heat unit accumulation by staggering planting dates so that later planting could accumulate fewer heat units and produce lower micronaire readings.

As the beginning stock level in the given year increased, the supply curve for micronaire increased. This result implies that at the beginning of the marketing year, a higher cotton stock tend to release the higher micronaire cotton was supplied and sold in the market.

Table 57. Second Stage Estimates for MIC

Dependent Variable : MIC		
Independent Variable	Parameter Estimate	t Value
Intercept	1.93634	3.51
MIC_MIP	-4.36440	-5.83
Harvest Season Temperature	0.02173	2.12
Spring Rainfall	0.03093	3.87
Beginning Stock	0.00006354	4.13
R-Square = 0.6446		
Total Number of Observations (Years) = 50		

The effect of supply factors on fiber length are summarized in Table 58. The results show that as MIP of fiber length and strength increased, the fiber length also increased, whereas the MIP of leaf grade and trash content had shown negative significant effects on the average fiber length. While summer temperature had a negative impact on fiber length, the harvest season temperature seems to have increased the fiber length, while the harvested acreage and total production quantity are shown to have influenced fiber length in opposing directions, the strong correlation between the two supply factors makes it difficult to interpret.

Table 58. Second Stage Estimates for LEN

Dependent Variable : LEN		
Independent Variable	Parameter Estimate	t Value
Intercept	1.12117	22.63
LEN_MIP	0.01988	3.09
STR_MIP	0.84105	2.50
LG_MIP	-0.25948	-1.86
TR_MIP	-0.06492	-1.69
Summer Temperature	-0.00229	-2.50
Harvest Season Temperature	0.00218	2.86
Summer Rainfall	-0.00310	-3.23
Harvested Acreage	-0.00003771	-7.43
Production	2.849628E-8	5.78
R-Square = 0.8035		
Total Number of Observations (Years) = 50		

For strength (Table 59), no MIPs of HVI quality attributes were shown to affect the average, whereas the weather variables, harvested acreage and total production are shown to have influenced the average. Studies as early as 1956 [Hanson] showed positive relationships between fiber strength and the temperature and canopy sunlight absorption. It was also shown that fiber strength increased with decreasing rainfall. As was with the results of Hanson's study, the summer rainfall amount had a negative impact on strength. Based on this study alone, the environmental factors relating to weather influence the average fiber strength most, perhaps more than fiber length and micronaire average although some other studies [Mackenzie and Van Schaik, 1963; Greef and Human, 1983; Green and Culp, 1990; Smith and Coyle, 1997].

In Table 59, an increase in summer temperature is shown to have increased the fiber strength. An earlier study [Jones and Wells, 1997] found a correlation between fiber strength and heat unit accumulation during the flowering period. They concluded that fiber strength was greatest from bolls that developed from flowers produced during the first 4 to 6 weeks of flowering, while flowers that opened during the latter two weeks of the flowering period produced bolls with the lowest fiber strength. Heat unit accumulation increases fiber strength.

Table 59. Second Stage Estimates for STR

Dependent Variable : STR		
Independent Variable	Parameter Estimate	t Value
Intercept	36.53764	12.94
Summer Temperature	0.27379	5.19
Harvest Season Temperature	0.19400	4.72
Summer Rainfall	-0.23319	-4.27
Harvested Acreage	-0.00139	-4.77
Production	0.00000126	4.53
R-Square = 0.7166		
Total Number of Observations (Years) = 50		

Table 60. Second Stage Estimates for UNI

Dependent Variable : UNI		
Independent Variable	Parameter Estimate	t Value
Intercept	88.20218	93.41
SCMIP	2.68917	1.75
MICMIP	-3.39990	-2.14
LENMIP	-0.46016	-3.44
UNIMIP	-8.50500	-2.06
STRMIP	-31.14854	-3.70
Spring Temperature	-0.09644	-7.47
Beginning Stock	-0.00007	-1.93
R-Square = 0.7122		
Total Number of Observations (Years) = 50		

Table 61. Second Stage Estimates for LG

Dependent Variable : LG		
Independent Variable	Parameter Estimate	t Value
Intercept	3.65082	7.98
FCMIP	-7.84956	-2.13
UNIMIP	4.88280	1.89
Winter Temperature	-0.02073	-2.43
Fall Rainfall	0.02036	2.87
Spring Rainfall	0.01520	1.96
Harvested Area	0.00001	3.14
R-Square = 0.7153		
Total Number of Observations (Years) = 50		

Table 62. Second Stage Estimates for TR

Dependent Variable : TR		
Independent Variable	Parameter Estimate	t Value
Intercept	-0.06387	-0.34
Winter Temperature	-0.00778	-2.54
Spring Temperature	0.01115	2.86
Fall Rainfall	0.00690	3.84
Spring Rainfall	0.00451	2.28
R-Square = 0.6971		
Total Number of Observations (Years) = 50		

8 COMPARISONS OF ACTUAL vs. HEDONIC PRICING STRUCTURE

In this section, performance of the new hedonic pricing structures is evaluated using the actual data.

In Chapter 2, a preliminary analysis was performed for the performance of the current cotton pricing structure and only several examples were shown to demonstrate some of the enormous biases that result by applying the current premium and discount schemes. It was then concluded that the current cotton pricing system is quite inconsistent and inappropriate in many cases. In this section, the magnitudes of improvement obtainable from applying the new Hedonic Pricing System are to be shown for selected states.

Figures 34 through 45 show the comparisons of the Price-Quality Indices before and after applying the hedonic pricing systems. For each of the two quality characteristics (strength and micronaire), the indices were compared for six states (Arkansas, California, Georgia, Mississippi, North Carolina and Texas) for 2004/2005 crop year. Some of the P-Q indices shown here for the current system are identical to that shown in Chapter 2.
Based on the First Stage Hedonic Model, the cotton prices with strength and micronaire discounts/premiums reflected were calculated and the P-Q indices obtained by using Equation (2.1) in Chapter 2. In all figures, the lines connected by triangles indicate the P-Q index from the current discount/premium system as already shown in Figures 3, 6, 9, 12, while the lines connected by squares present that from the new Hedonic Pricing System. As clearly seen from Figures 34 -45, most of the P-Q indices by applying the Hedonic price

models track around 1.0, the expected standard for each quality characteristic for the two states shown in Chapter 2 as well as for the other states. Namely, the significant biases observable from the current discount/premium schemes all but disappeared as a result of applying the new Hedonic Pricing System.

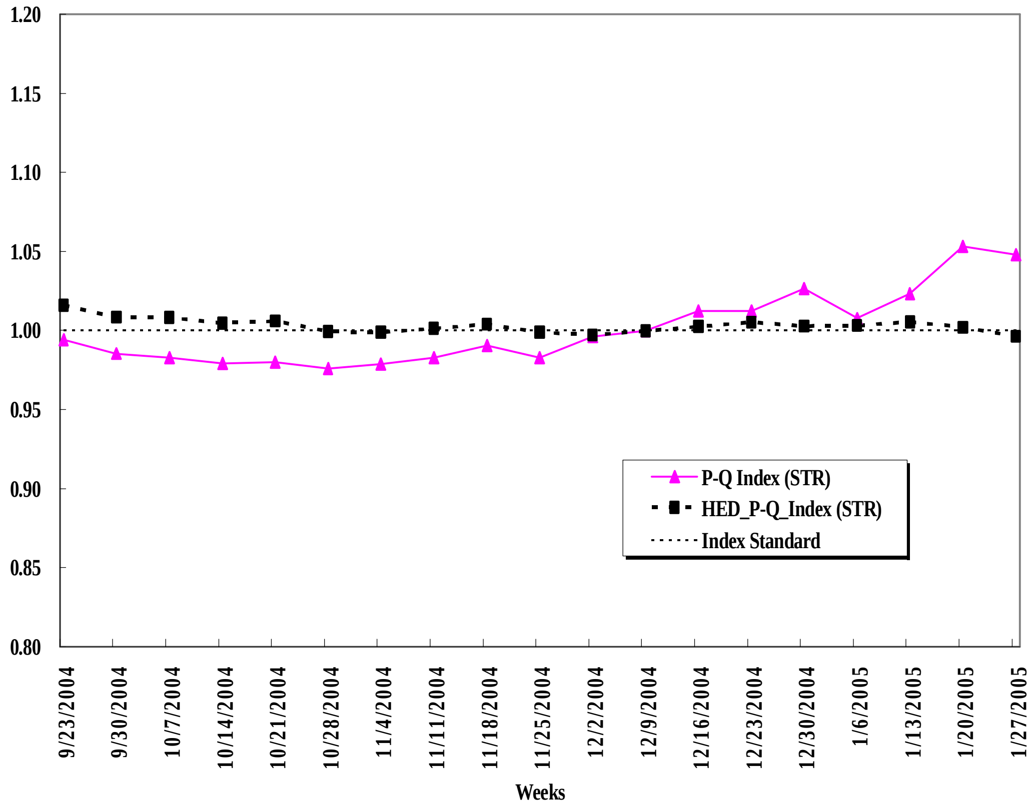

Figure 34. Comparison of P-Q Index for HVI Strength between Actual vs. Hedonic Pricing Structure (2004/2005, Arkansas)

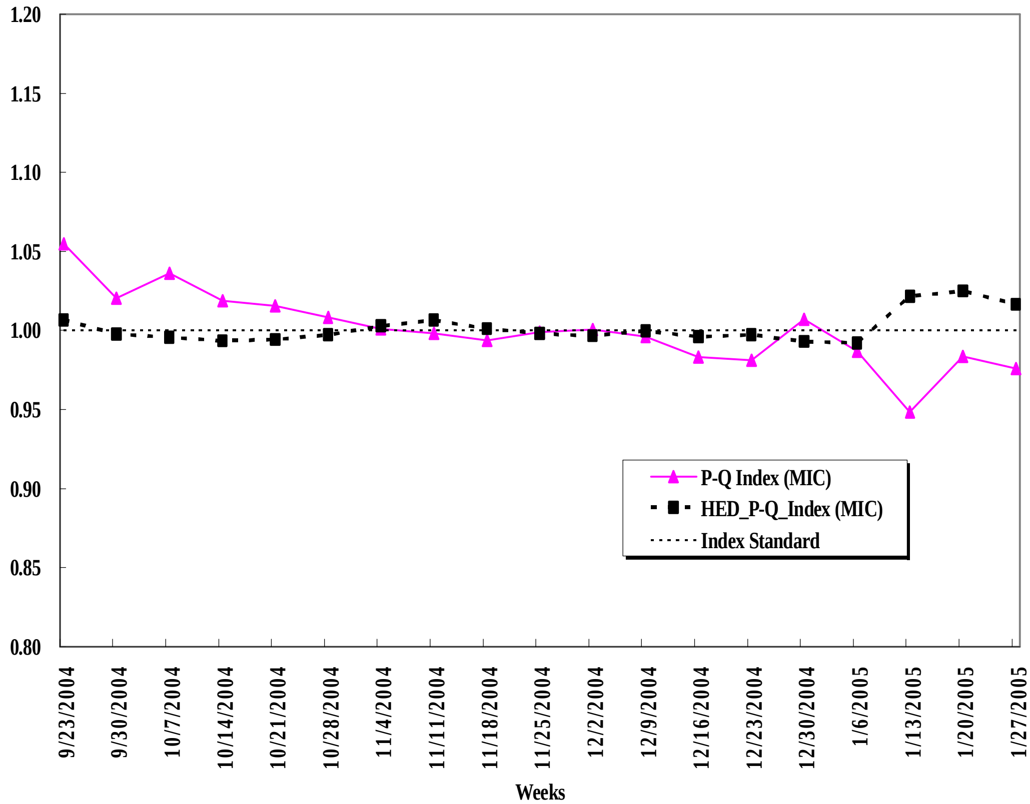

Figure 35. Comparison of P-Q Index for HVI Micronaire between Actual vs. Hedonic Pricing Structure (2004/2005, Arkansas)

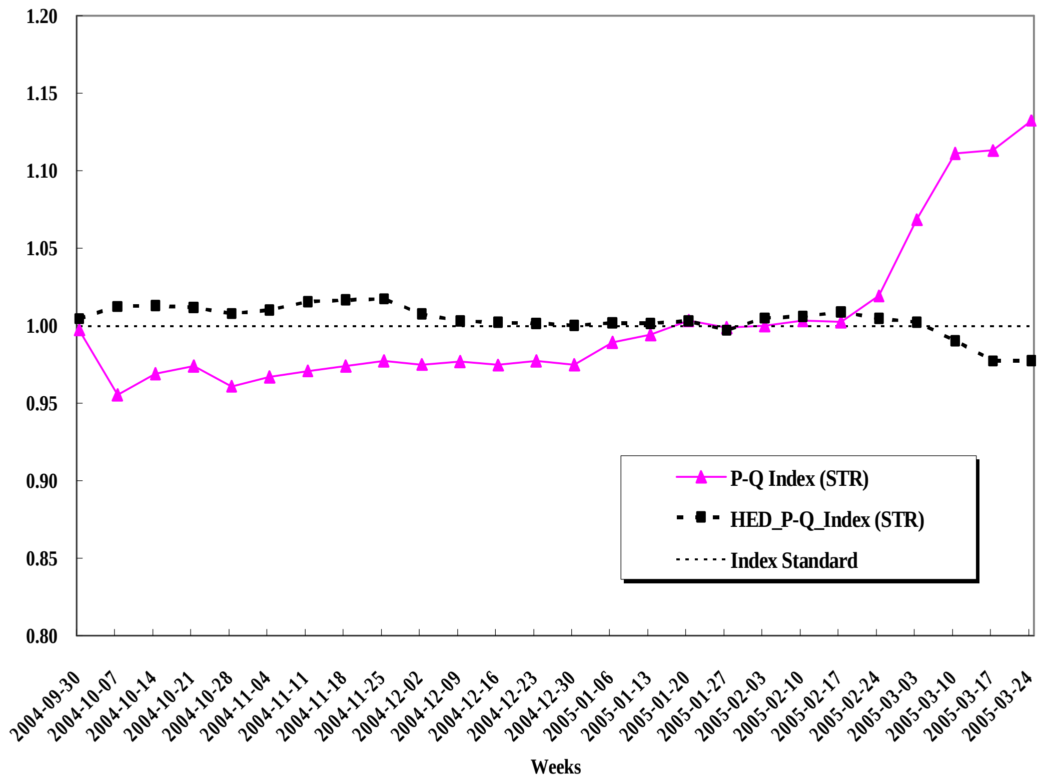

Figure 36. Comparison of P-Q Index for HVI Strength between Actual vs. Hedonic Pricing Structure (2004/2005, California)

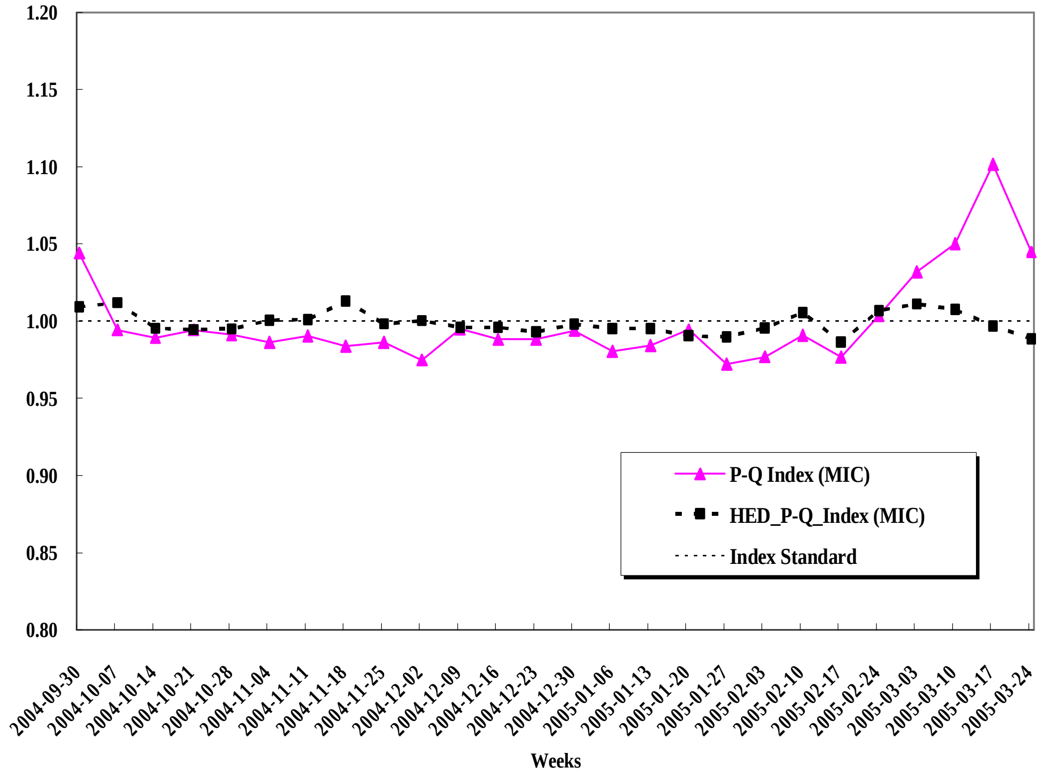

Figure 37. Comparison of P-Q Index for HVI Micronaire between Actual vs. Hedonic Pricing Structure (2004/2005, California)

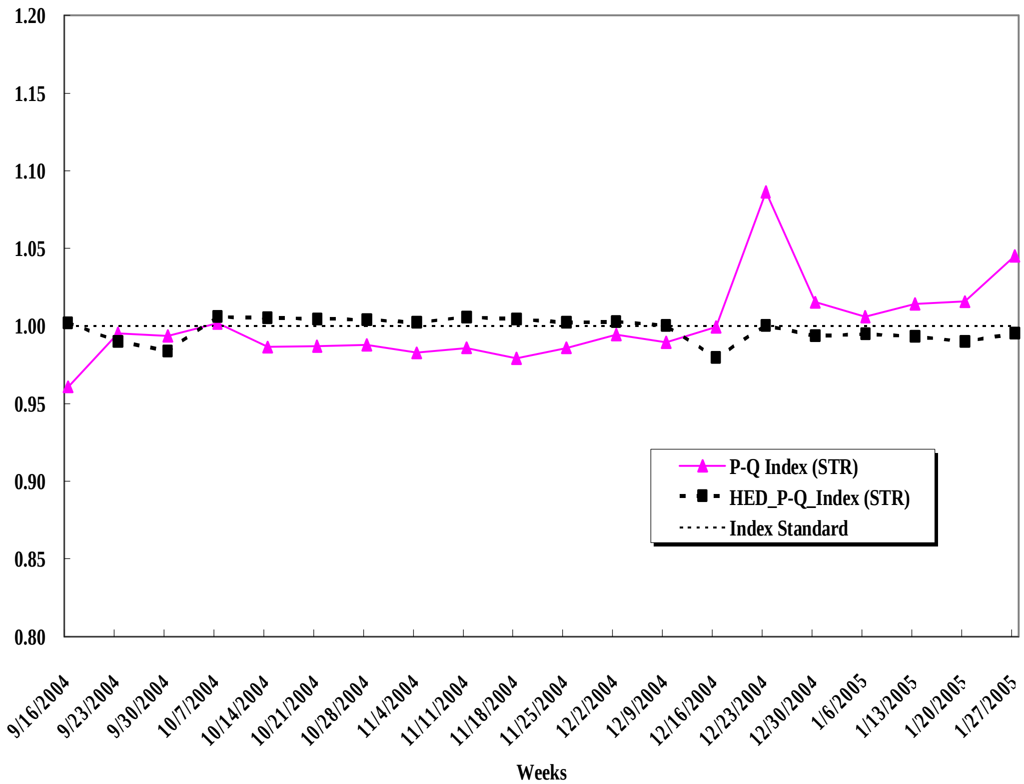

Figure 38. Comparison of P-Q Index for HVI Strength between Actual vs. Hedonic Pricing Structure (2004/2005, Georgia)

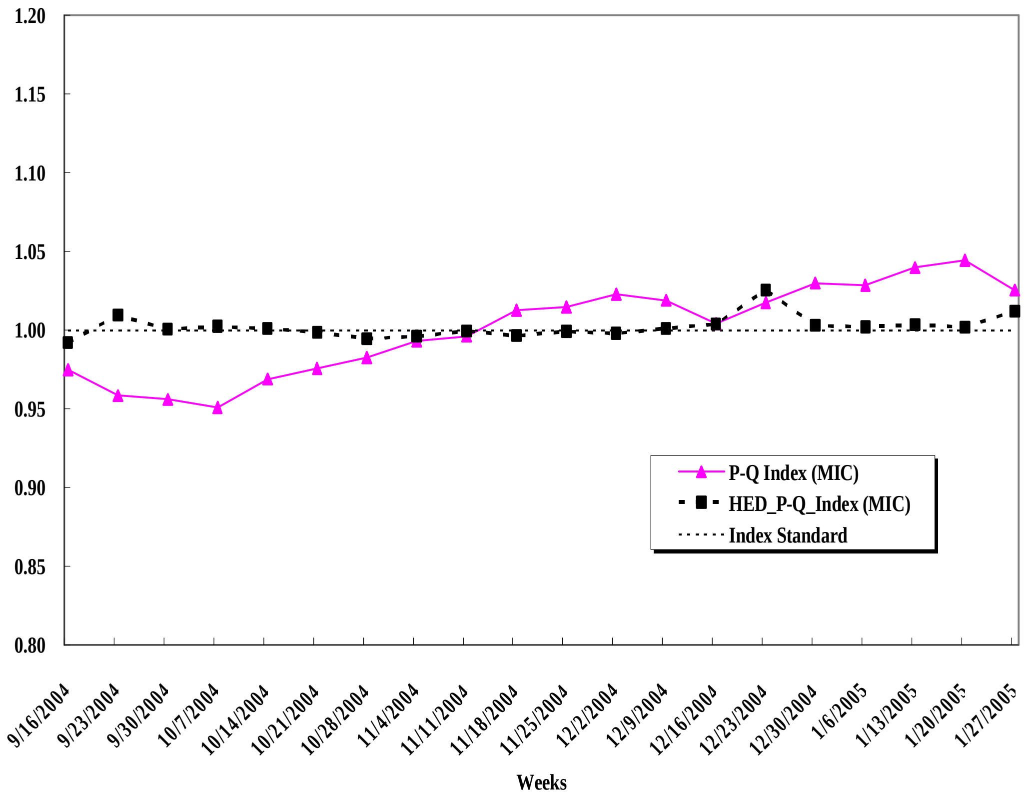

Figure 39. Comparison of P-Q Index for HVI Micronaire between Actual vs. Hedonic Pricing Structure (2004/2005, Georgia)

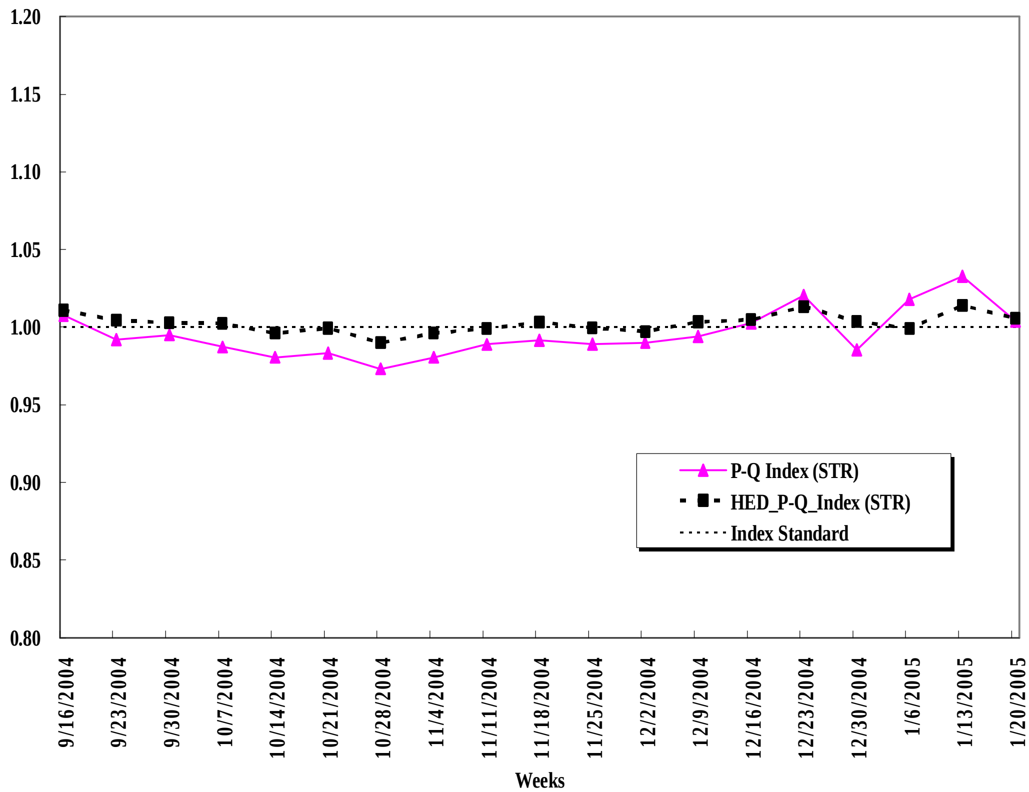

Figure 40. Comparison of P-Q Index for HVI Strength between Actual vs. Hedonic Pricing Structure (2004/2005, Mississippi)

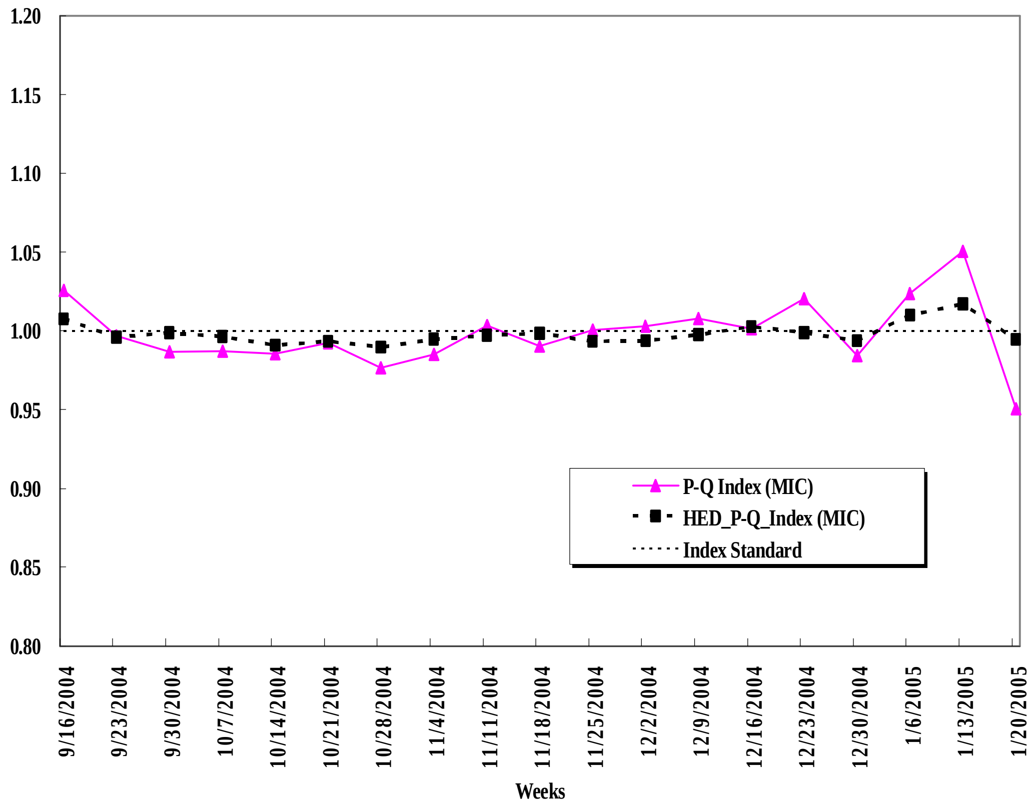

Figure 41. Comparison of P-Q Index for HVI Micronaire between Actual vs. Hedonic Pricing Structure (2004/2005, Mississippi)

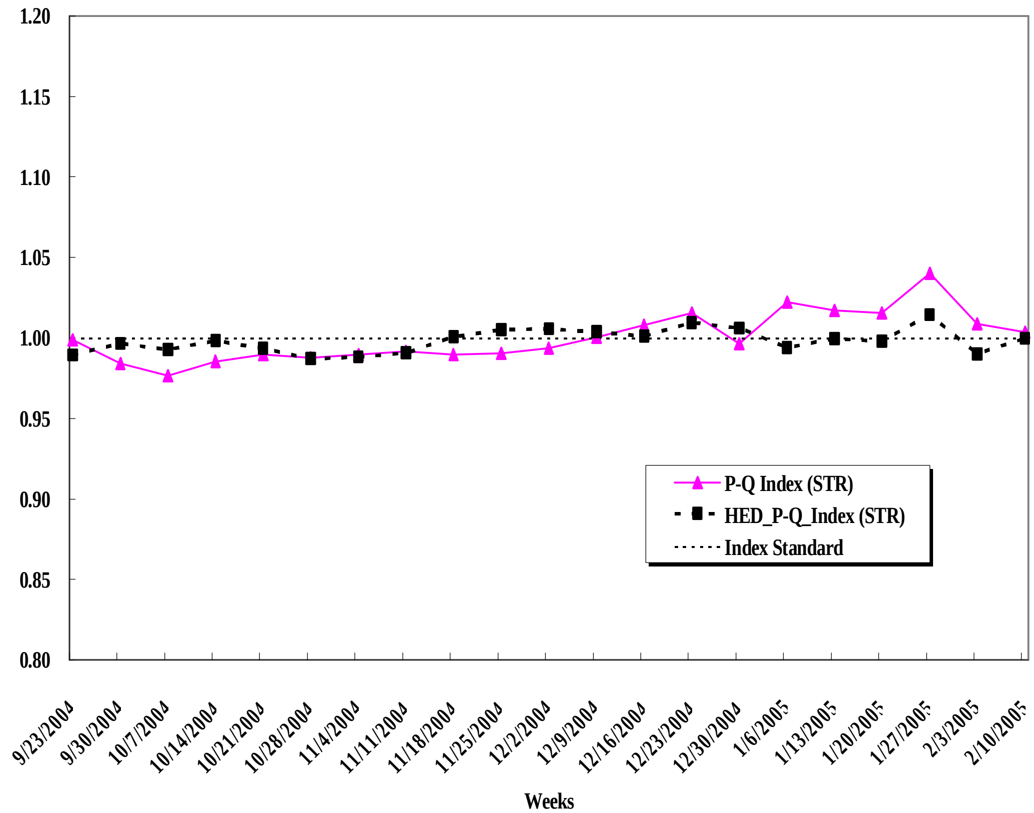

Figure 42. Comparison of P-Q Index for HVI Strength between Actual vs. Hedonic Pricing Structure (2004/2005, North Carolina)

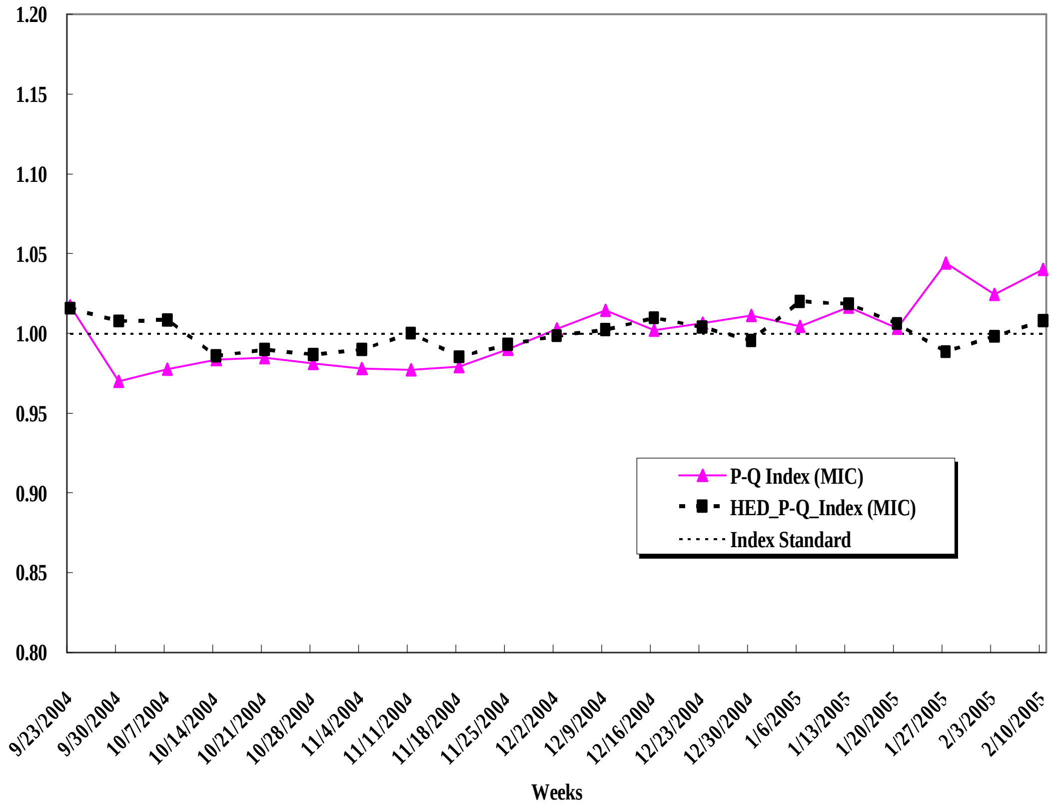

Figure 43. Comparison of P-Q Index for HVI Micronaire between Actual vs. Hedonic Pricing Structure (2004/2005, North Carolina)

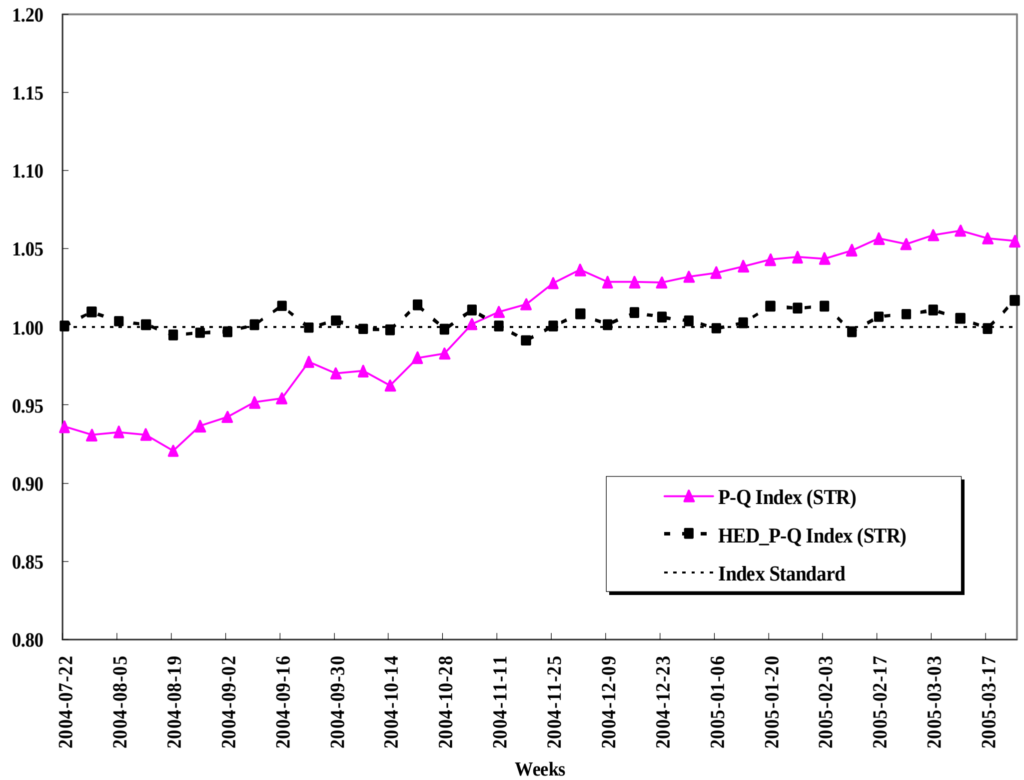

Figure 44. Comparison of P-Q Index for HVI Strength between Actual vs. Hedonic Pricing Structure (2004/2005, Texas)

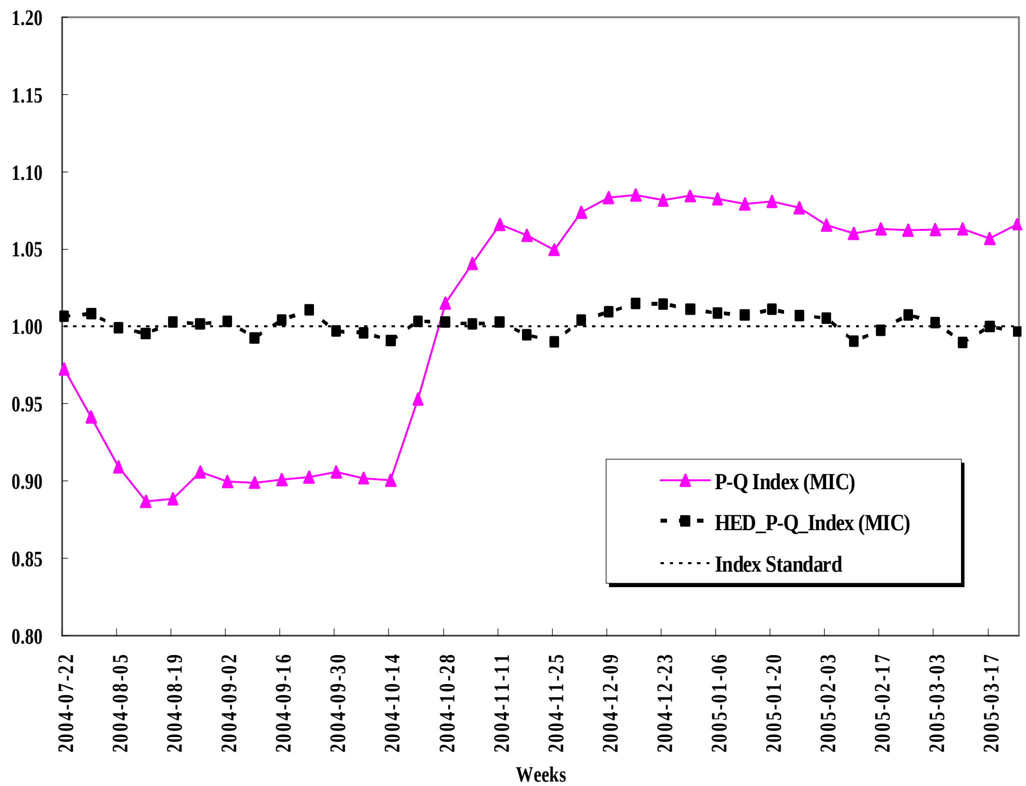

Figure 45. Comparison of P-Q Index for HVI Micronaire between Actual vs. Hedonic Pricing Structure (2004/2005, Texas)

9 SUMMARY AND CONCLUSIONS

1) This study pointed out the shortcomings of the current U.S. cotton pricing system by reviewing the outstanding technical issues. The price of U.S. upland cotton is determined by the "base price" imbedded on quantitative factors and the "implicit price" reflecting the quality characteristics of cotton. Historically, these base and implicit prices have been calculated and reported as Daily Spot Price Quotations (DSCQ) and the Commodity Credit Corporation (CCC) Loan Schedule on a daily basis. However, these indices are often misleading, less-than-scientific, and mostly non-reproducible due to the fact that a change in implicit price (discount and premium) for each quality cotton characteristic cannot be estimated accurately from these price information sources alone. For this reason an efficient pricing system was developed by employing a first-stage hedonic model.

2) A comprehensive preliminary analysis was performed of current U.S. cotton pricing system revealed that the actual cotton prices quoted, presumed to have reflected proper premium and discount values, often did not track well the expected prices obtained from the base prices and the actual premiums and discounts, thus highlighting the major shortcomings of the current system. The analysis was based on HVI cotton quality measures and the matching cotton price based on CCC loan table for each of the ten states, Alabama, Arizona, Arkansas, California, Georgia, Louisiana, Mississippi, North Carolina, Tennessee and Texas, for each of the 2000/2001-2004/2005 crop years.

3) Conceptual and empirical first-stage hedonic models were developed, directly from all quality attributes measured by HVI, and also alternatively by creating a set of

Composite Cotton Quality Indices (CCQI) from the covariance structure of the cotton qualities measured by HVI and their relationship with their matching cotton prices. In most cases, two CCQI's, one from color factors and the other from physical factors of cotton, were capable of explaining the price variation as adequately as the case with individual HVI cotton quality attributes, thus validating the concept of creating and applying the CCQIs.

4) The first-stage hedonic model has shown that all new models fit the data extremely well. The detrimental quality characteristics were found to be each of the two-digit color codes which lowered their respective marginal implicit prices as they increase, indicating an adverse impact on cotton prices. In contrast, desirable HVI cotton qualities for increasing their marginal implicit prices of cotton were shown to be fiber length and strength. For mocronaire, the signs of the estimates for the parameter were mixed and inconsistent. For 10 combined states and Alabama, Georgia and Texas, the coefficients were positive, suggesting that a high micronaire value increases its marginal implicit price, but opposite held for Arizona, Arkansas, California, Louisiana, Mississippi, North Carolina and Tennessee. In most models obtained, the parameter estimates for leaf grade and trash content were significantly insignificant but, inconsistent across states.

5) The best Composite Cotton Quality Index (CCQI) representing color factors of cotton was a product function between the two-digit color codes while the best CCQI from the physical factors of cotton was also a product function between fiber length and uniformity. When these two CCQIs were included as independent variables, the first-stage hedonic model could explain 84% of total cotton price variations.

6) Second-stage hedonic models were developed using the marginal implicit price derived from the first-stage hedonic model and the supply factors of cotton. Included in the supply factors were the beginning stock level, harvested acreage and production. In addition, weather variables such as temperature and rainfall by season were also included as independent variables. From this model, the effects were estimated for the marginal implicit price of each quality characteristic and that of supply factors.

7) The second stage hedonic model developed revealed that the average first digit color code was affected by the marginal implicit price of fiber length and that of the first digit color code. The major results include that the temperature and spring rainfall and rainfall during harvest seasons significantly lowered the color quality (a higher level of color code), especially the latter. On the second digit color code, a higher marginal implicit price of length is shown to have increased the average value, i.e., lowered the color quality.

8) Of the six weather variables included in the supply function, both average spring rainfall and average harvest season rainfall were shown to have affected the level of second digit color code significantly based on the second stage-hedonic model. The harvested acreage, when included as a supply factor, was shown to lower the color quality. The marginal implicit price of micronaire had shown to lower the average micronaire value, while the harvest season temperature and spring rainfall lowered the average, or affected it positively in most cases.

9) Fiber length was shown to have been affected by the marginal implicit prices of leaf grade and trash content. While the summer temperature and the harvested acreage had

negative impacts on length, the harvest season temperature and the production quantity showed positive effects.

10) Fiber strength was shown to be unaffected by levels of other HVI quality characteristics, the weather related factors, harvested acreage, and the total production seemed to have affected the average significantly. Especially, a higher temperature during summer was shown to have increased the fiber strength.

11) For verification of the First Stage Hedonic model, the cotton prices were estimated by using the model and Price-Quality Indices (PQIs) were obtained. The results were compared against the actual PQIs as shown in Chapter 2. The comparison show that the fit from the model is highly satisfactory, as it corrected most, if not all, of the biases previously detected.

12) Overall, the hedonic models developed and the CCQIs created appear highly satisfactory and facilitates not only a new and innovative cotton pricing system but also a new method for cotton classification, trade, and bale management for the cotton industry and textile mill applications.

10 RECOMMENDATIONS FOR FUTURE STUDY

The first stage hedonic cotton pricing system based on characteristic supply model constructed in this study was an attempt to judge the impact of various supply factors on each quality characteristic level. However, development of the second stage hedonic model based on demand for cotton (characteristic demand model) was not attempted due to lack of readily available data. Such demand factors as US cotton export and the pattern of global cotton trade may not be easily tied to the hedonic price of each cotton quality attribute by state, the characteristic demand function can be constructed as determinants for base prices of US cotton during an extended time period. This is a worthwhile effort for another research.

A further study is also warranted in extending and developing the use of Composite Cotton Quality Indices (CCQIs) for cotton pricing system to cotton bale storage, retrieval and laydown formations at cotton warehouses and at textile mill levels. This is an important concept apart from pricing which may have a far-reaching impact on quality improvement of cotton yarns and fabrics. If and when this is done, we can tie the pricing of cotton to utilities of cotton as found in the end products. Development of other suitable CCQIs is also an effort to be pursued continuously.

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12 APPENDICES

12. A. Durbin-Watson Test

(1) AL

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.706
Number of Observations (Weeks)	108
First Order Autocorrelation	0.133

(2) AR

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.769
Number of Observations (Weeks)	89
First Order Autocorrelation	0.172

(3) AZ

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.649
Number of Observations (Weeks)	133
First Order Autocorrelation	0.201

(4) CA

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.611
Number of Observations (Weeks)	117
First Order Autocorrelation	0.189

(5) GA

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.862
Number of Observations (Weeks)	114
First Order Autocorrelation	0.103

(6) LA

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.745
Number of Observations (Weeks)	75
First Order Autocorrelation	0.120

(7) MS

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.575
Number of Observations (Weeks)	101
First Order Autocorrelation	0.217

(8) NC

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.527
Number of Observations (Weeks)	105
First Order Autocorrelation	0.261

(9) TN

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.619
Number of Observations (Weeks)	93
First Order Autocorrelation	0.203

(10) TX

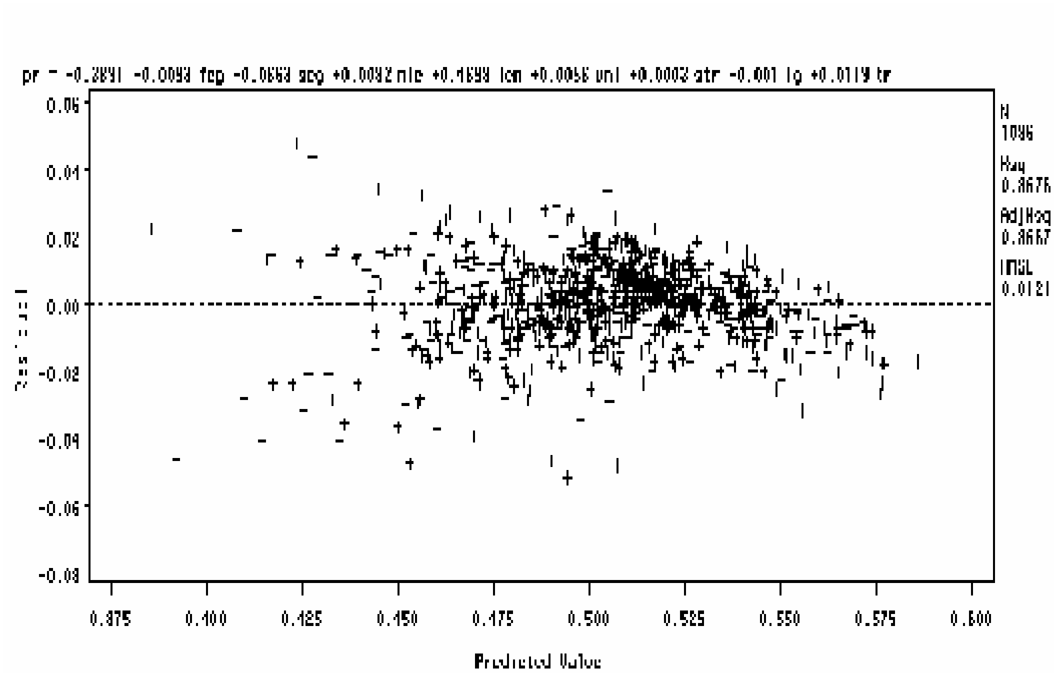
Dependent Variable : Price of Cotton	
Durbin – Watson D	1.899
Number of Observations (Weeks)	156
First Order Autocorrelation	0.091

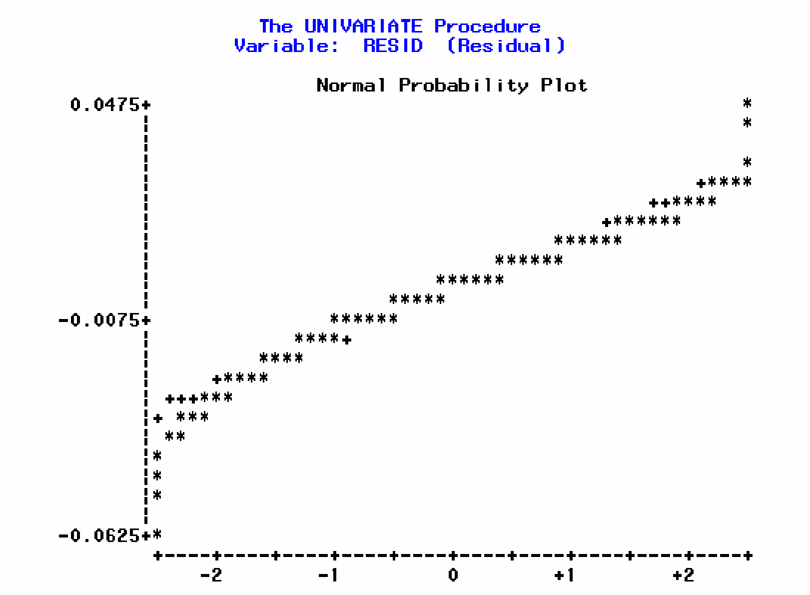
(11) Ten Combined States

Dependent Variable : Price of Cotton	
Durbin – Watson D	1.591
Number of Observations (Weeks)	1086
First Order Autocorrelation	0.223

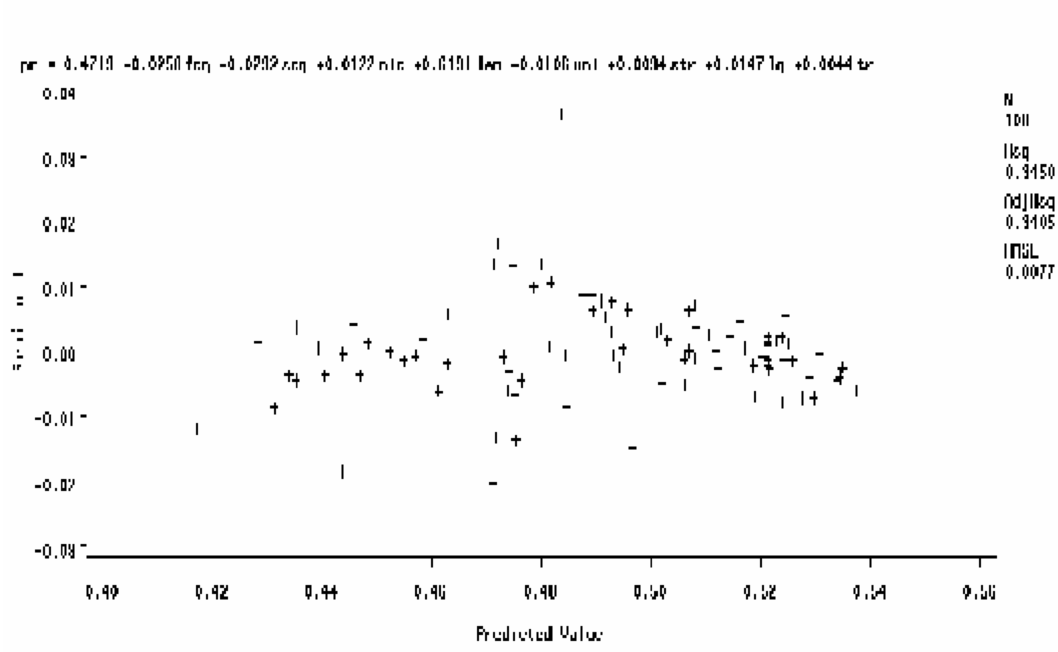
12. B. Residual Plots for the First Stage Hedonic Model I

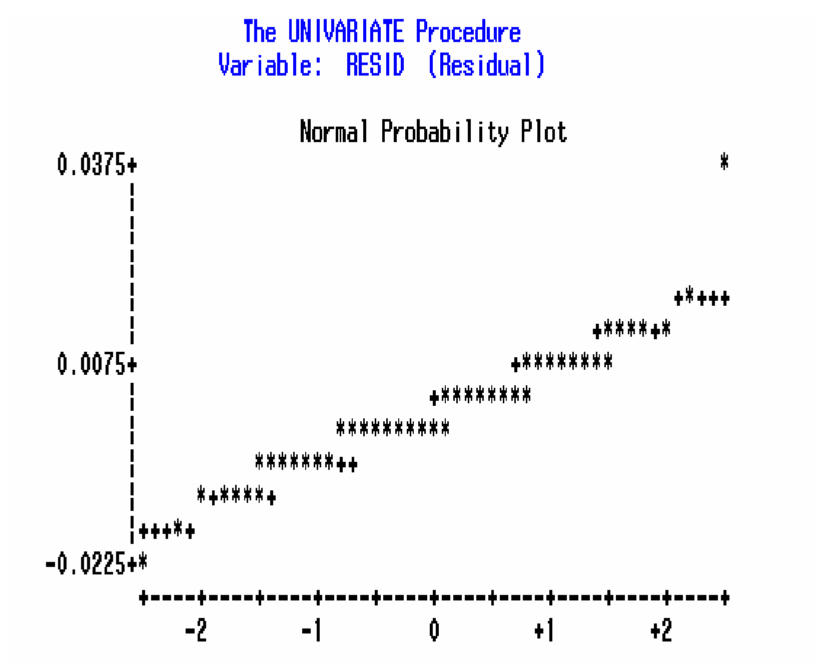
(1) Ten Combined States



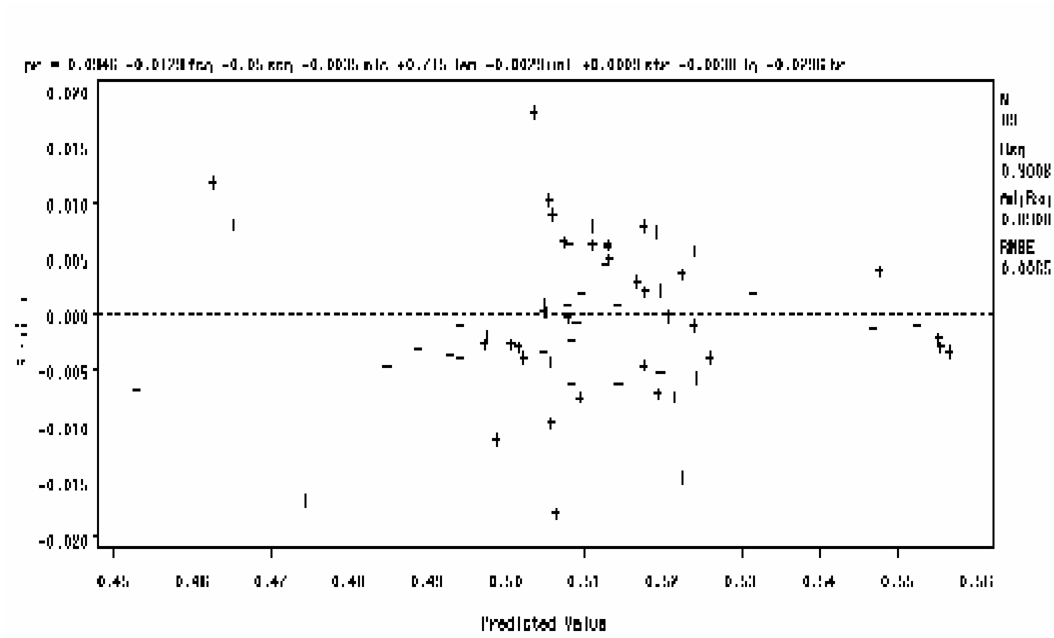


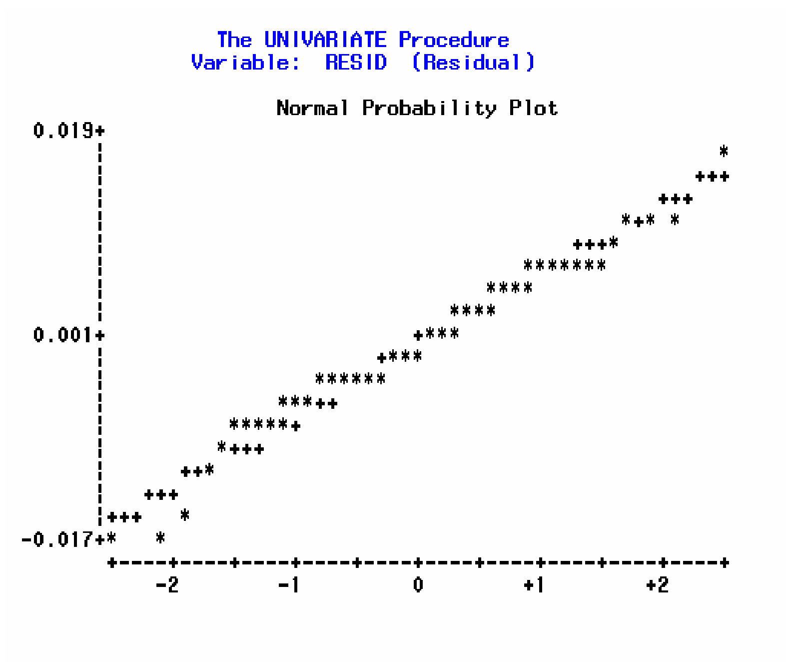
(2) AL


Predicted Value
N
100
Rsq
0.3150
AdjRsq
0.3105
RMSE
0.0077

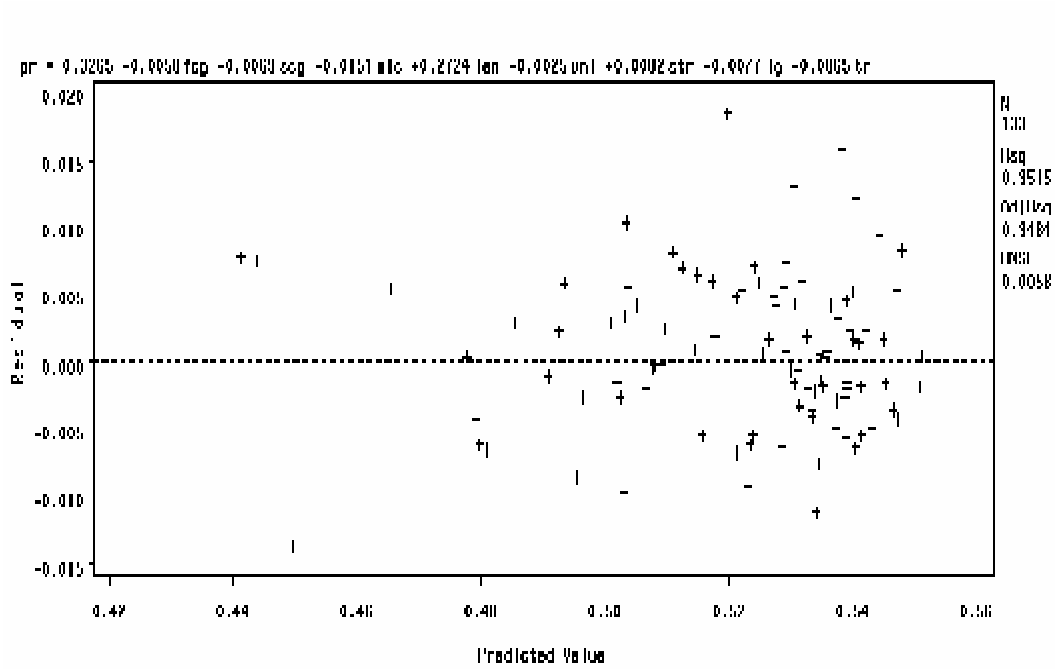

The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.0375
0.0075
-0.0225
-2
-1
0
+1
+2

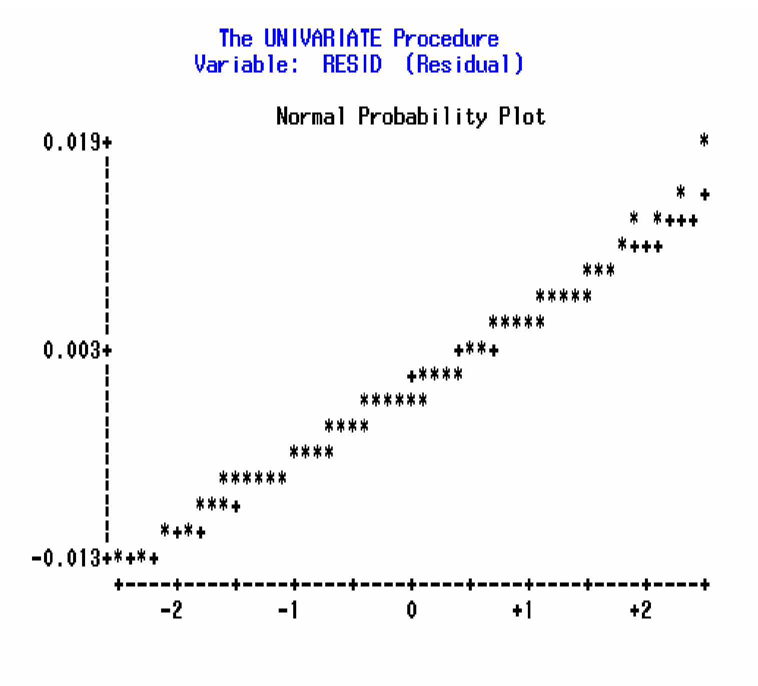
(3) AR


0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
0.45
0.46
0.47
0.48
0.49
0.50
0.51
0.52
0.53
0.54
0.55
0.56
Predicted Value

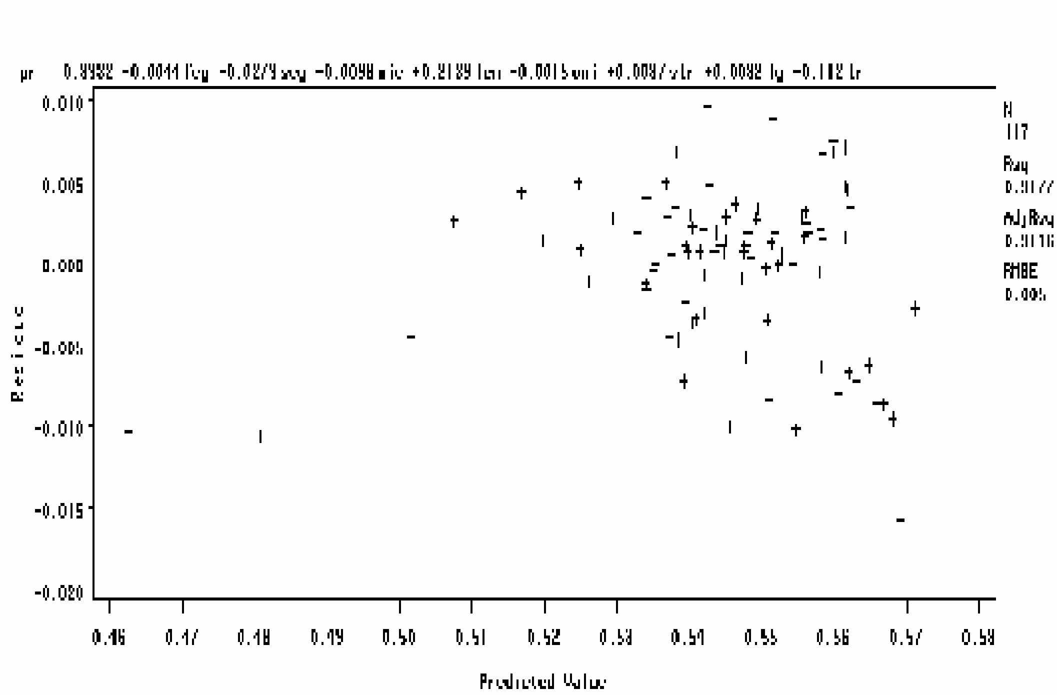

The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.019+
0.001+
-0.017+
-2
-1
0
+1
+2

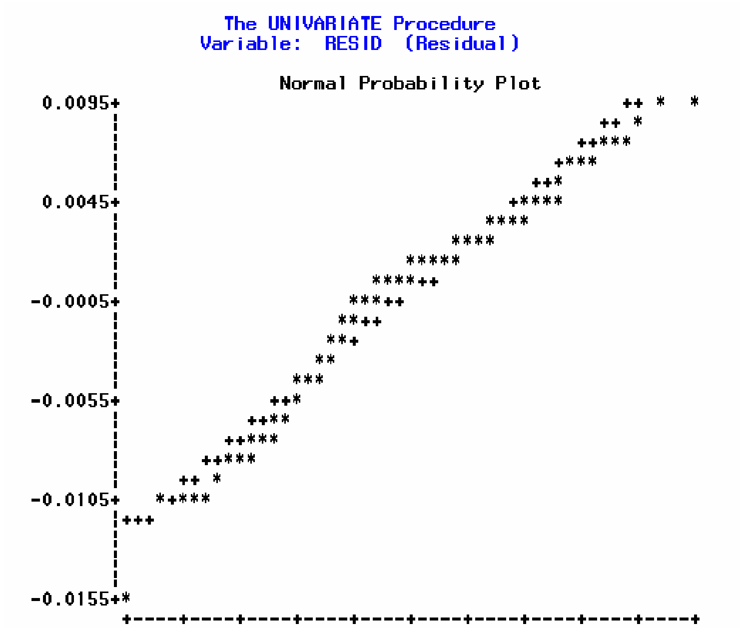
(4) AZ


0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
Residual
0.44
0.46
0.48
0.50
0.52
0.54
Predicted Value
N
Rsq
0.9515
RMSE
0.0058

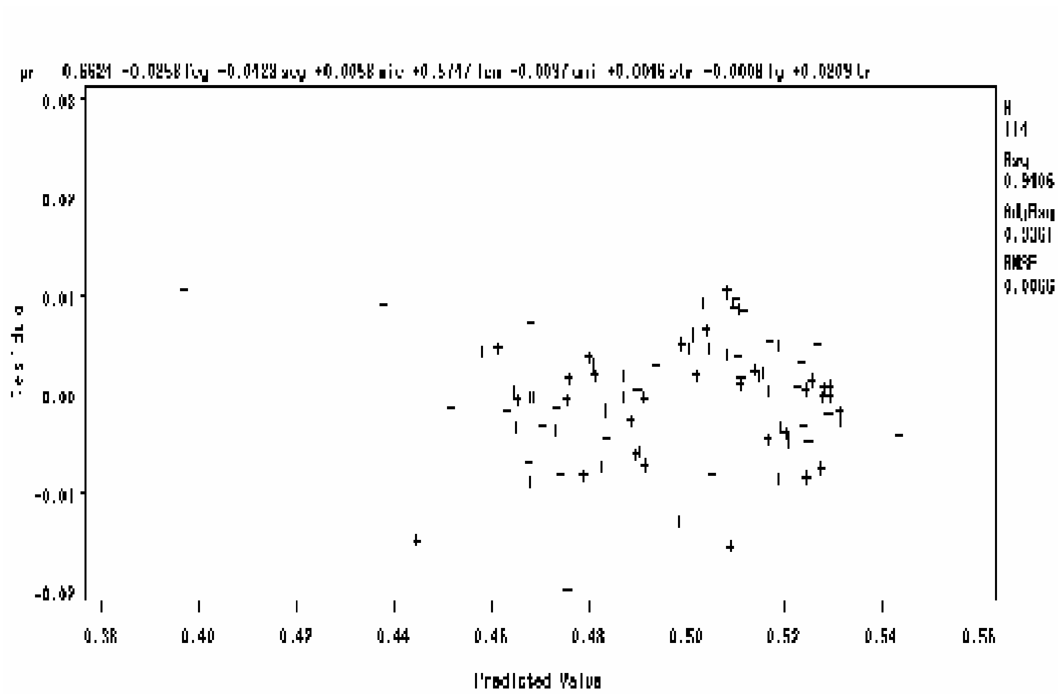

The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.019+
0.003+
-0.013+
-2
-1
0
+1
+2

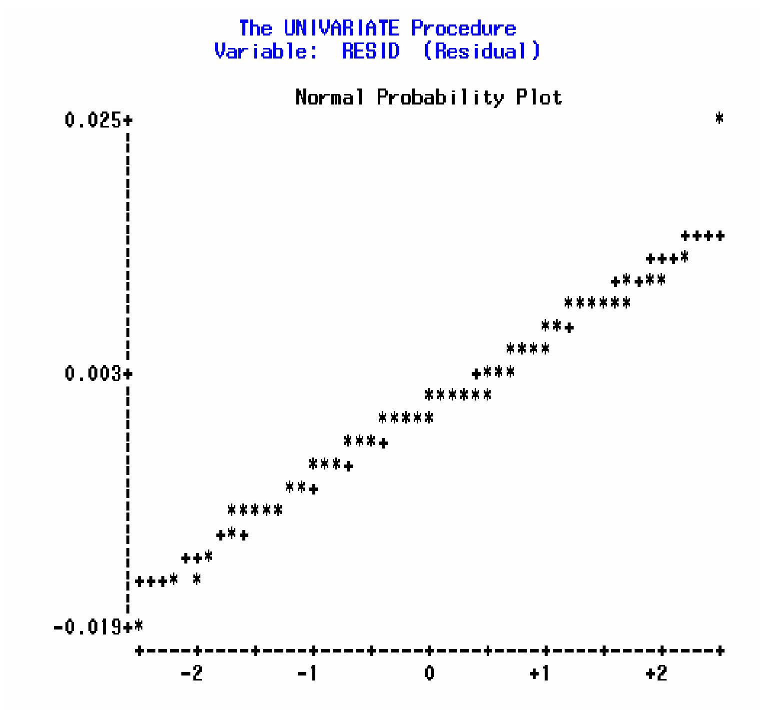
(5) CA


0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
0.46 0.47 0.48 0.49 0.50 0.51 0.52 0.53 0.54 0.55 0.56 0.57 0.58
Predicted Value
N
117
RMSE
0.005

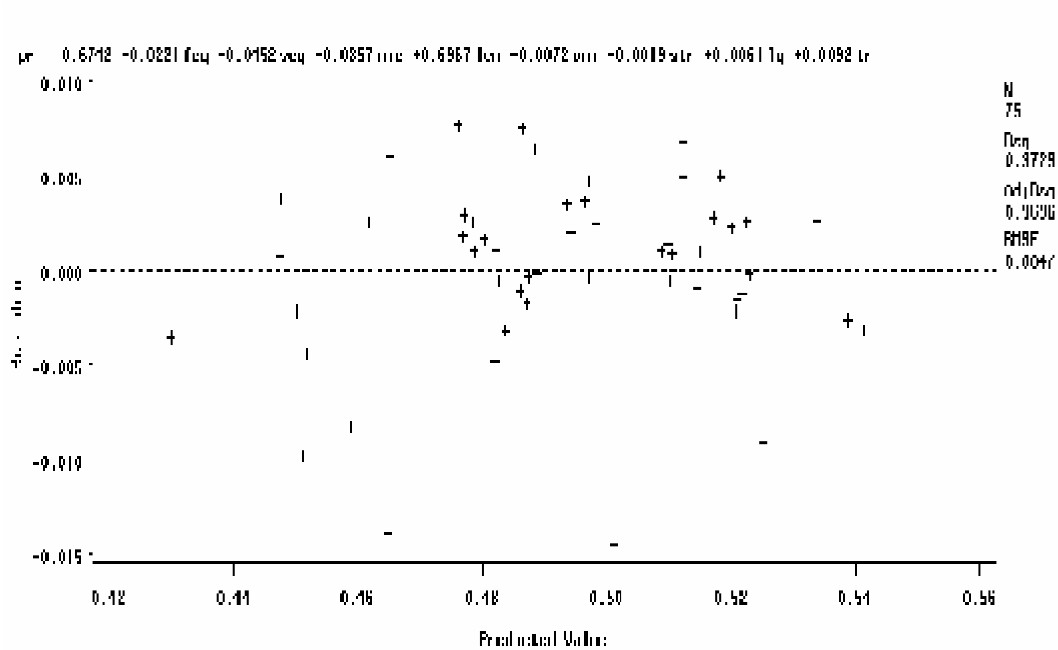

The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.0095+
0.0045+
-0.0005+
-0.0055+
-0.0105+
-0.0155+

(6) GA

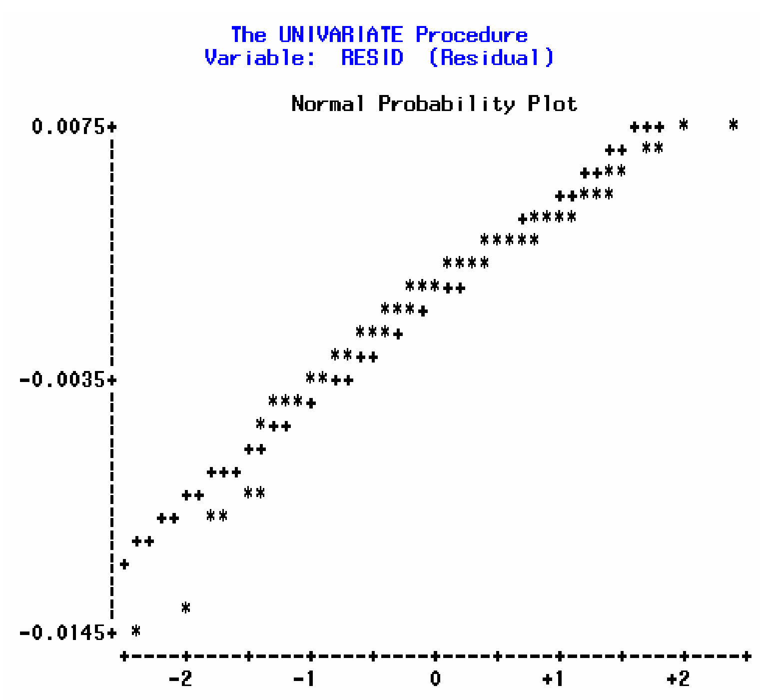

0.02
0.01
0.00
-0.01
-0.02
0.38
0.40
0.42
0.44
0.46
0.48
0.50
0.52
0.54
0.56
Predicted Value
N
114
Rsq
0.9106


The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.025+
0.003+
-0.019+
-2
-1
0
+1
+2

(7) LA

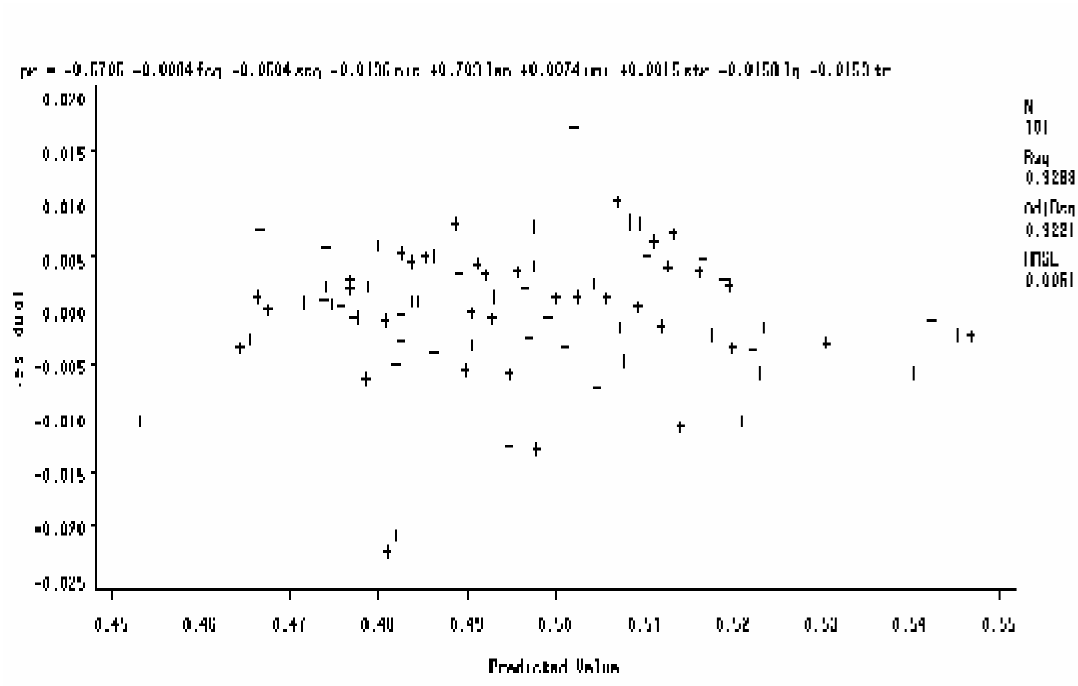


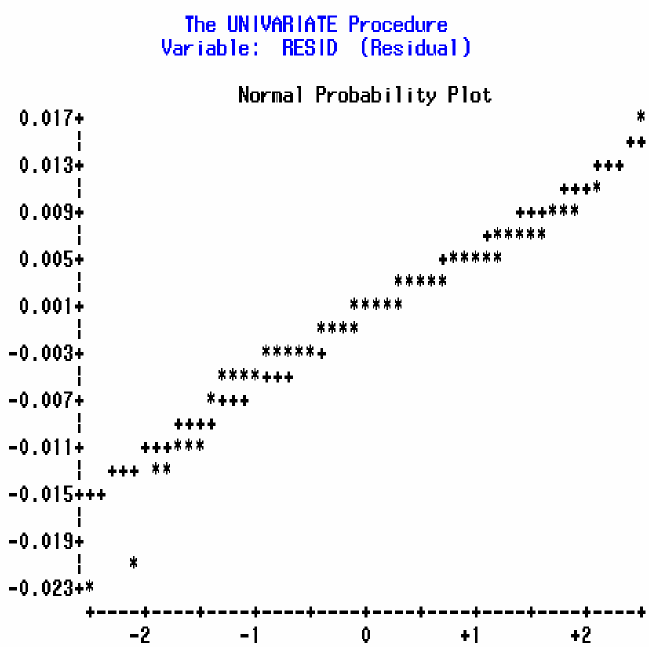
0.010
0.005
0.000
-0.005
-0.010
-0.015
N
75
Rsq
RMSE
0.0047
0.42
0.44
0.46
0.48
0.50
0.52
0.54
0.56
Predicted Value



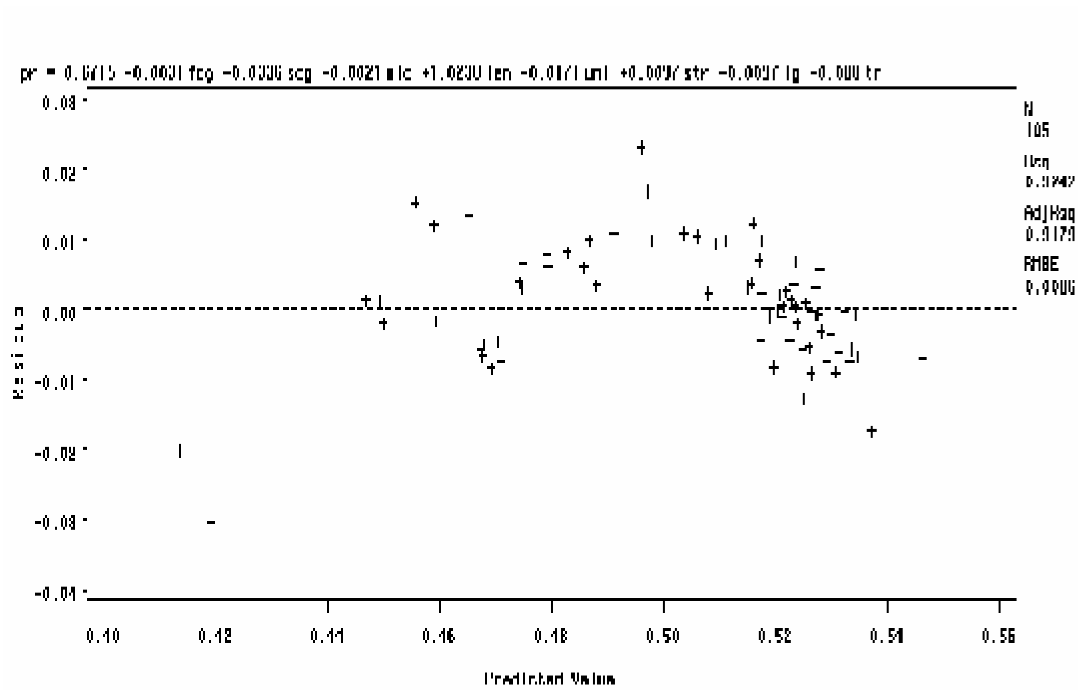
The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.0075
-0.0035
-0.0145
-2
-1
0
+1
+2

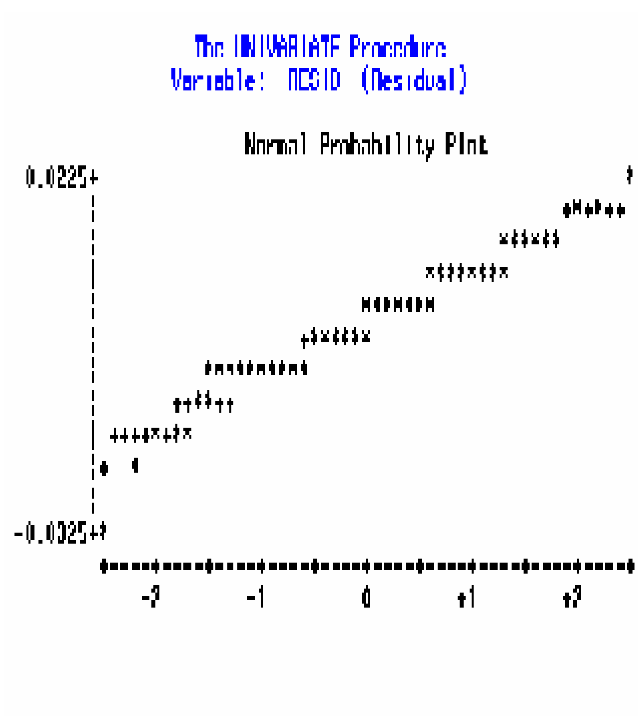
(8) MS


0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
0.45
0.46
0.47
0.48
0.49
0.50
0.51
0.52
0.53
0.54
0.55
Predicted Value
N
101

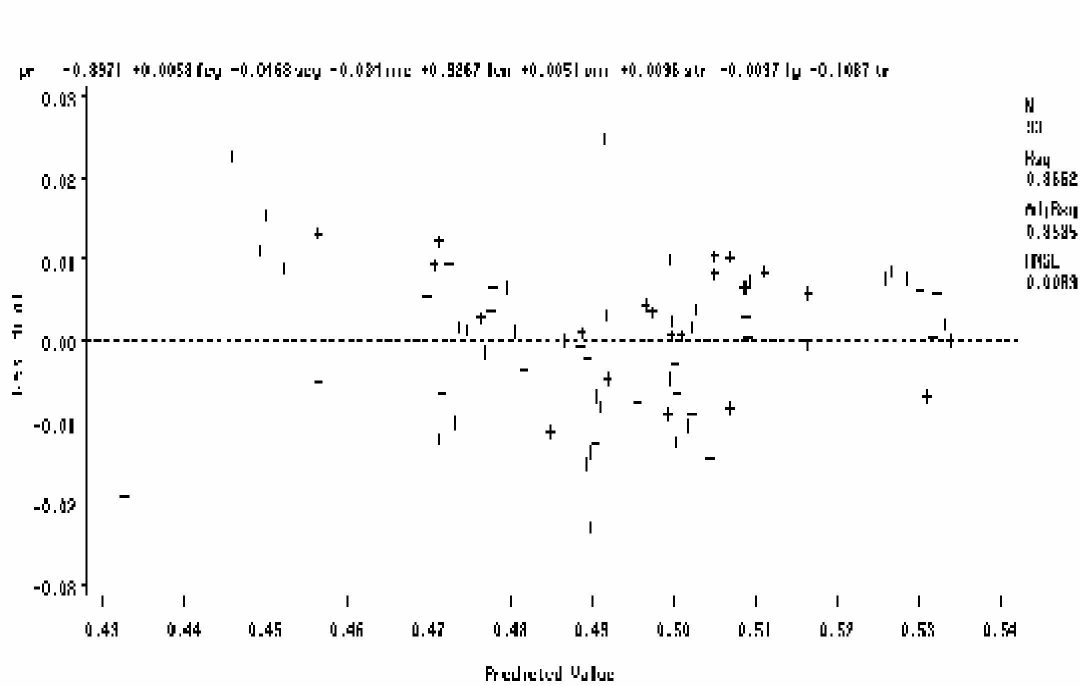

The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.017+
0.013+
0.009+
0.005+
0.001+
-0.003+
-0.007+
-0.011+
-0.015+
-0.019+
-0.023+
-2
-1
0
+1
+2

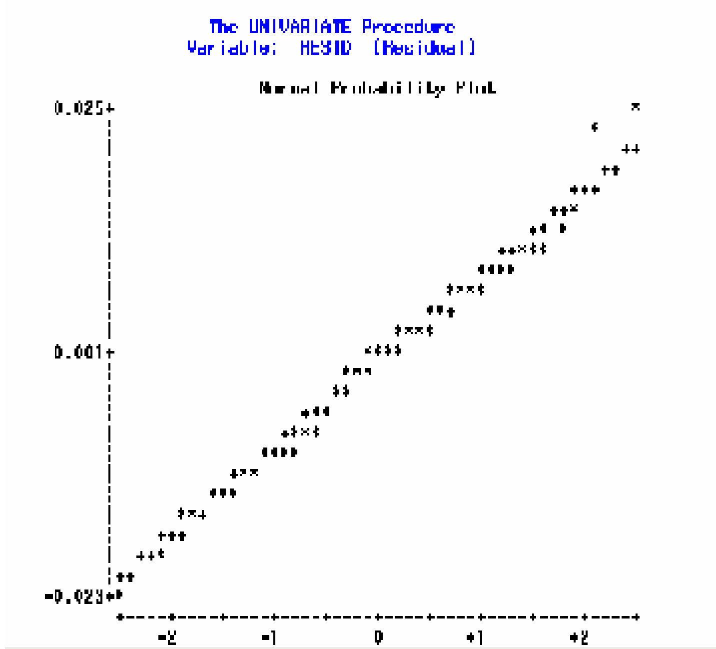
(9) NC



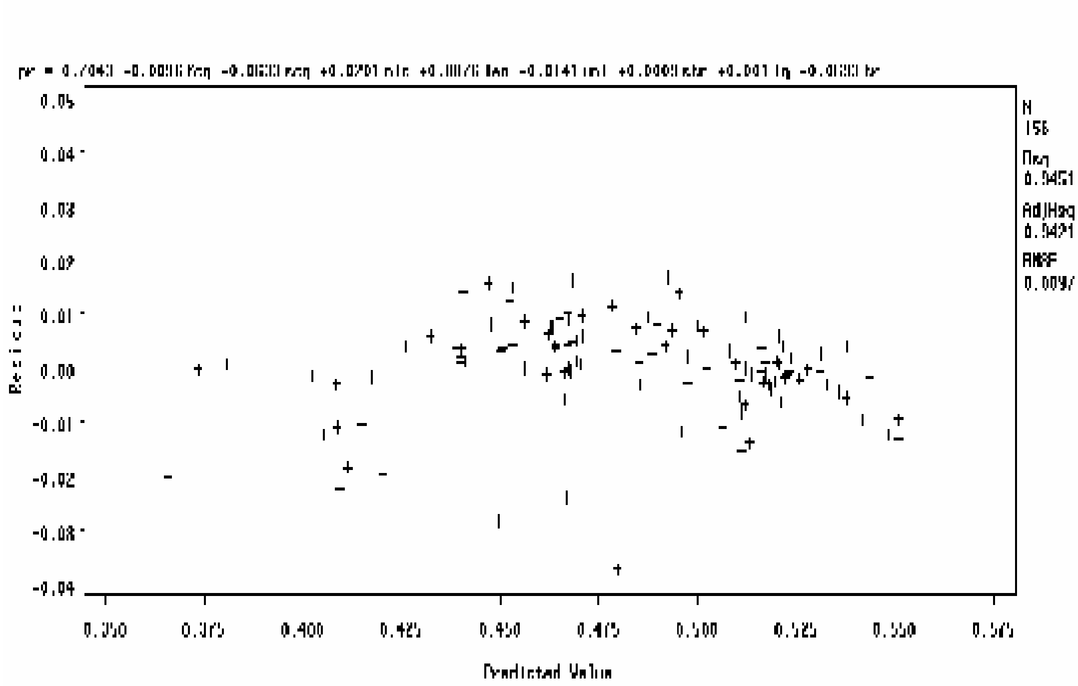


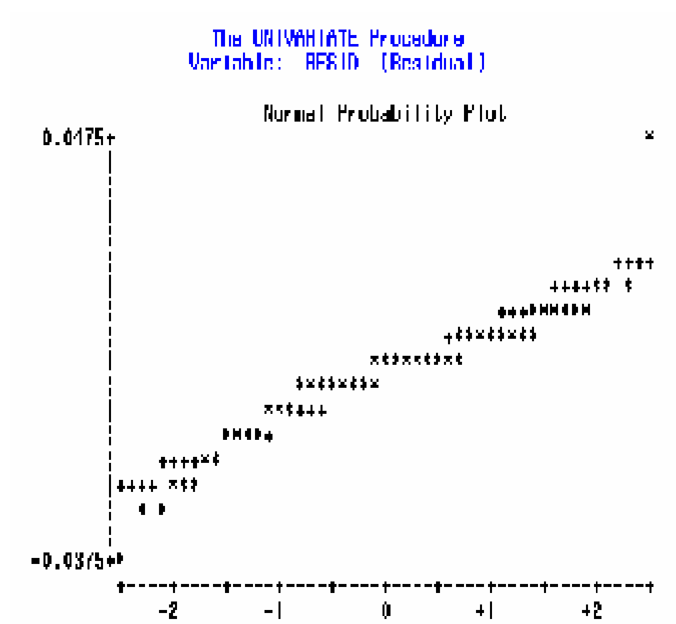
(10) TN


Predicted Value
0.43
0.44
0.45
0.46
0.47
0.48
0.49
0.50
0.51
0.52
0.53
0.54


The UNIVARIATE Procedure
Normal Probability Plot

(11) TX


Residual
Predicted Value
N
158
Rsq
0.9451
AdjRsq
0.9421
RMSE
0.0097


The UNIVARIATE Procedure
Variable: RESID (Residual)
Normal Probability Plot
0.0475+
-0.0375+
-2
-1
0
+1
+2

12. C. Multicollinearity

(1) First Stage Estimates with Eleven Independent Variables
(Ten Combined States)

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Variance Inflation**
Intercept	-1.48574	-19.38*	0
FC	-0.00269	-1.55	21.39367
SC	-0.05602	-14.67*	10.32739
MIC	0.43901	19.04*	491.60545
MICSQ	-0.04929	-18.73*	490.32831
LEN	0.47919	22.57*	3.86727
UNI	0.00547	7.34*	1.97526
STR	-0.00076121	-2.13*	3.26639
RD	0.00172	5.69*	10.83330
+b	0.00340	2.04*	10.94899
LG	-0.00370	-2.11	7.47814
TR	0.02246	3.50*	6.15350
R-Square = 0.9006			
Total Number of Observations (Weeks) = 1086			

Where:

FC = first digit of the color grade

SC = second digit of the color grade

MIC = micronaire reading

MICSQ = MIC$\times$MIC

LEN = fiber length (inches)

UNI = fiber length uniformity (%)

STR = strength (g/tex)

RD = Reflectance

+b = Degree of Yellowness

LG = leaf grade

TR = trash content

Note; * the coefficient is significant with $p < 0.05$.

(2) First Stage Estimates with Eleven Independent Variables (AR)

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Variance Inflation**
Intercept	-1.34051	-4.58*	0
FC	0.00403	0.58	64.04974
SC	-0.03567	-3.79*	12.59274
MIC	0.57353	7.48*	844.08456
MICSQ	-0.06573	-7.56*	857.47708
LEN	0.38729	3.86*	4.31016
UNI	-0.00323	-1.05	2.48074
STR	0.00377	2.33*	5.25093
RD	0.00451	2.84*	72.82366
+b	0.00696	1.84	7.62940
LG	-0.00592	-1.31	5.86091
TR	-0.00420	-0.19	8.31450
R-Square = 0.9444			
Total Number of Observations (Weeks) = 89			

(3) First Stage Estimates with Eleven Independent Variables (GA)

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Variance Inflation**
Intercept	-1.67038	-5.76	0
FC	0.04391	4.40	106.84632
SC	-0.02723	-3.63	13.38778
MIC	0.32543	5.25	1359.23562
MICSQ	-0.03573	-5.08	1397.58872
LEN	0.52283	8.18	5.71248
UNI	-0.00764	-3.79	2.75466
STR	0.00298	3.75	3.15135
RD	0.01425	7.59	113.46525
+b	0.02571	5.25	36.79287
LG	0.00183	0.42	5.77118
TR	0.00813	0.52	5.85343
R-Square = 0.9708			
Total Number of Observations (Weeks) = 114			

(4) First Stage Estimates with Eleven Independent Variables (MS)

Dependent Variable : Price of Cotton			
Independent Variable	**Parameter Estimate**	**t Value**	**Variance Inflation**
Intercept	-1.46014	-6.71*	0
FC	-0.00248	-1.04	6.88844
SC	-0.07801	-9.37*	11.89113
MIC	0.24806	4.82*	466.64948
MICSQ	-0.02993	-5.15*	476.03392
LEN	0.56860	6.87*	5.04443
UNI	0.00971	4.04*	2.04806
STR	0.00315	2.30*	6.83934
RD	0.00007676	0.44	2.10909
+b	0.01244	3.23*	9.55863
LG	-0.00767	-1.54	3.65750
TR	-0.02428	-1.60	3.86526
R-Square = 0.9525			
Total Number of Observations (Weeks) = 101			

12. D. Descriptive Statistics of Average Cotton Quality Measures during 2000-2004

		BALES	FC	SC	MIC	LEN(inches)	UNI(%)	STR(g/tex)	LG	TR
AL	2004	797201	3.89	1.18	4.28	1.07	81.10	27.91	3.51	0.51
	2003	799810	3.52	1.06	4.16	1.07	81.00	27.86	3.51	0.52
	2002	566334	4.38	1.69	4.65	1.05	80.74	26.87	3.51	0.48
	2001	907608	3.55	1.07	4.19	1.06	80.97	26.65	3.26	0.42
	2000	533558	3.84	1.29	4.36	1.05	81.07	27.16	3.16	0.39
AZ	2004	671574	2.65	1.21	4.51	1.10	80.64	28.90	2.54	0.33
	2003	505340	2.47	1.18	4.56	1.10	80.43	28.67	2.64	0.30
	2002	505340	2.60	1.11	4.48	1.10	80.52	28.49	2.54	0.27
	2001	633233	2.13	1.15	4.61	1.10	80.61	27.67	2.40	0.25
	2000	752977	2.89	1.07	4.72	1.10	80.86	27.74	2.63	0.28
AR	2004	2017069	3.76	1.26	4.40	1.09	81.68	28.61	3.43	0.47
	2003	1736566	3.36	1.08	4.49	1.08	81.64	27.75	3.42	0.44
	2002	1617857	3.84	1.16	4.54	1.08	81.68	28.25	3.71	0.49
	2001	1769580	3.60	1.33	4.69	1.08	81.74	27.84	3.36	0.43
	2000	1412925	3.48	1.20	4.52	1.08	81.53	27.03	3.05	0.37
CA	2004	1761712	2.69	1.16	4.29	1.12	81.14	31.43	2.68	0.26
	2003	1474599	1.08	1.05	4.17	1.16	81.80	32.03	2.60	0.23
	2002	1464899	1.97	1.05	4.31	1.14	81.93	32.11	2.56	0.21
	2001	1741415	2.05	1.11	4.34	1.12	81.31	30.73	2.49	0.23
	2000	2164536	2.27	1.05	4.40	1.12	81.91	31.31	2.54	0.23
GA	2004	1749066	3.72	1.08	4.36	1.08	80.63	29.05	3.37	0.48
	2003	2042146	3.69	1.05	4.31	1.06	80.47	27.46	3.43	0.47
	2002	1549962	4.12	1.45	4.74	1.05	80.76	27.45	3.63	0.49
	2001	2175541	3.72	1.09	4.27	1.06	80.82	27.34	3.19	0.39
	2000	1623530	4.07	1.24	4.45	1.07	81.05	27.28	3.21	0.44
LA	2004	888439	3.76	1.25	4.72	1.10	81.21	29.27	3.45	0.49
	2003	1028400	3.28	1.07	4.77	1.08	81.05	28.32	3.27	0.44
	2002	748930	4.22	1.40	4.91	1.07	81.33	27.07	3.28	0.40

10. A. (Continued)

	2001	1033932	3.93	1.46	4.90	1.07	81.26	27.40	3.35	0.46
	2000	925905	3.58	1.25	4.67	1.06	81.01	26.86	2.74	0.33
MS	2004	2273867	3.48	1.22	4.58	1.09	81.59	29.14	3.43	0.48
	2003	2058957	3.39	1.10	4.51	1.07	81.59	27.88	3.43	0.48
	2002	1879619	4.09	1.29	4.74	1.07	81.69	27.30	3.43	0.43
	2001	2340165	3.62	1.51	4.82	1.07	81.74	27.20	3.35	0.44
	2000	1679692	3.70	1.35	4.47	1.06	81.16	26.51	3.06	0.36
NC	2004	1324036	3.71	1.12	4.53	1.09	81.78	27.63	3.53	0.53
	2003	1007111	3.49	1.03	4.12	1.08	81.29	27.56	3.37	0.48
	2002	782055	4.48	1.38	4.67	1.04	80.56	26.35	3.80	0.50
	2001	1639854	3.18	1.04	4.38	1.08	81.51	27.66	3.42	0.44
	2000	1407421	3.31	1.16	3.90	1.06	81.02	25.82	3.52	0.55
TN	2004	958644	3.85	1.18	4.41	1.05	81.35	27.38	3.38	0.43
	2003	853876	3.30	1.06	4.35	1.06	81.54	27.28	3.36	0.43
	2002	789058	3.59	1.41	4.92	1.06	81.46	27.62	3.38	0.38
	2001	936822	3.14	1.35	4.55	1.06	81.53	27.07	3.14	0.37
	2000	695679	3.40	1.12	4.21	1.04	80.67	26.51	2.92	0.37
TX	2004	7497295	3.38	1.31	4.01	1.09	80.87	29.41	3.50	0.52
	2003	4237096	2.63	1.17	4.46	1.07	81.02	29.29	2.95	0.33
	2002	4990055	3.24	1.20	4.32	1.05	80.76	28.87	3.53	0.44
	2001	4118454	2.75	1.43	4.48	1.05	80.98	28.42	2.98	0.33
	2000	3886054	3.08	1.48	3.93	1.02	80.04	26.90	3.28	0.45

12. E. Marginal Implicit Price of Each HVI Quality Measure

		FC_MIP	SC_MIP	MIC_MIP	LEN_MIP	UNI_MIP	STR_MIP	LG_MIP	TR_MIP
AL	2004	-0.00803	-0.04258	0.00586	0.31838	0.01343	-0.00077	-0.01614	0.01799
	2003	-0.01965	-0.07905	0.00852	0.44319	0.00224	0.01104	0.00309	-0.11826
	2002	0.00049	-0.04101	-0.03401	0.75119	0.00574	0.01370	0.00416	-0.03978
	2001	-0.01366	0.03601	-0.00446	0.99490	0.00401	0.00785	-0.03886	-0.07078
	2000	-0.03149	-0.04047	-0.02195	0.43652	-0.01860	0.00681	0.03182	0.00594
AZ	2004	-0.00892	-0.02912	-0.01242	0.52563	0.00897	-0.00098	-0.00634	-0.02793
	2003	0.00059	-0.04827	-0.03756	0.32500	-0.00432	0.00273	-0.01660	-0.06168
	2002	-0.00645	-0.03127	-0.00661	0.22919	0.00024	0.00127	-0.00313	-0.08811
	2001	0.00222	0.00044	0.03549	0.92162	-0.01152	-0.00560	-0.00409	-0.05698
	2000	0.00005	-0.03985	-0.03203	0.22093	0.00789	0.00053	-0.00628	-0.08888
AR	2004	-0.01729	-0.01542	-0.02715	0.77493	-0.00011	-0.00219	-0.01727	0.01833
	2003	0.00790	0.06076	0.00092	0.16582	0.00780	0.02306	-0.01102	-0.11083
	2002	-0.01375	-0.00597	0.03865	1.60454	-0.02009	-0.00083	0.00127	-0.05880
	2001	-0.00915	-0.04812	-0.02564	0.67815	-0.00068	0.00076	-0.01415	-0.01759
	2000	-0.00796	-0.09313	-0.07179	0.16143	-0.02481	0.01803	0.04126	-0.10127
CA	2004	-0.00508	-0.05258	0.02232	0.65319	-0.00624	-0.00089	-0.00056	-0.06016
	2003	-0.00529	-0.01577	0.00516	-0.07159	0.01131	0.00400	0.00005	-0.08575
	2002	0.00295	-0.01540	-0.00390	0.02087	0.00621	0.00140	0.01335	-0.14725
	2001	-0.00578	-0.03531	-0.01877	0.19986	-0.00604	0.00440	0.00393	-0.05177
	2000	-0.00403	-0.06616	-0.01009	0.20737	-0.00750	0.00458	-0.01335	0.10094
GA	2004	-0.01729	-0.05894	0.01767	0.58469	0.00097	-0.00054	-0.00468	-0.02569
	2003	-0.00685	-0.05880	0.00200	0.78731	0.00048	0.00147	-0.01713	-0.00482
	2002	-0.01507	-0.03629	-0.00447	0.24163	0.00817	0.00272	-0.02587	0.04230
	2001	-0.01924	-0.03359	0.01255	1.35492	-0.01244	0.00393	-0.02204	-0.00674
	2000	-0.01488	-0.03227	0.03420	0.44180	0.01576	0.00061	0.00754	-0.08977
LA	2004	-0.00785	-0.04820	-0.05766	0.04308	0.00324	0.00617	-0.01929	0.00019
	2003	-0.00648	-0.07214	-0.01620	0.92453	-0.00648	-0.00401	0.01525	-0.10633
	2002	-0.02206	-0.03209	-0.06082	-0.36434	0.01360	0.00165	0.03291	0.05306
	2001	-0.00810	-0.03630	-0.04812	0.62267	-0.00564	-0.00141	-0.01494	-0.01709

C. (Continued)

	2000	-0.01356	-0.00545	-0.00590	0.98761	-0.01895	0.01533	-0.01734	0.03307
MS	2004	-0.01343	-0.04950	-0.03529	0.61968	0.00667	-0.00183	-0.00125	-0.02015
	2003	-0.00524	-0.14188	-0.02037	-0.51183	0.01368	0.01108	0.00016	-0.02672
	2002	-0.02272	-0.00483	-0.00043	0.71973	0.01031	-0.00869	0.00269	0.01285
	2001	-0.01073	-0.05244	-0.03793	0.31271	0.00672	-0.00100	-0.00162	0.02160
	2000	0.00950	-0.03557	0.00044	1.46149	0.03746	-0.01526	-0.04640	-0.09284
NC	2004	-0.01381	-0.02622	-0.01167	0.45281	-0.00048	0.00194	-0.00649	-0.01828
	2003	0.00698	-0.02805	0.01927	0.14653	0.00815	0.00585	-0.00646	-0.00089
	2002	-0.02953	-0.01223	-0.01000	0.75035	-0.01092	-0.00085	-0.01273	0.00183
	2001	-0.01559	-0.04478	-0.00988	0.57176	0.00069	-0.00042	-0.01434	-0.01433
	2000	-0.00721	-0.05442	0.06876	0.03222	-0.00134	0.00649	-0.00506	-0.03640
TN	2004	-0.00979	-0.00467	-0.01647	0.69616	-0.00079	0.00713	-0.00164	-0.02759
	2003	0.00046	-0.01402	0.00115	0.87101	-0.00031	0.00362	-0.00635	-0.08998
	2002	0.00387	-0.01563	-0.04433	0.98325	-0.00183	0.00398	-0.02568	-0.09280
	2001	0.00317	-0.03644	-0.00728	0.98266	0.00067	-0.00030	0.01918	-0.19605
	2000	-0.01286	0.04313	-0.03098	0.86195	-0.02244	0.02836	0.05089	-0.21243
TX	2004	0.01009	-0.05978	0.04579	1.13033	-0.03731	0.00856	-0.00192	-0.04008
	2003	-0.00485	-0.04631	-0.00560	0.42911	-0.00155	0.00384	-0.00575	-0.01612
	2002	-0.00210	-0.06018	0.05402	0.28020	-0.00833	-0.00706	-0.00680	-0.08985
	2001	-0.03348	0.00953	-0.03323	1.18042	-0.05660	0.01966	0.01037	-0.00663
	2000	-0.00692	-0.09019	-0.00141	0.45074	0.01748	-0.00194	0.01665	-0.08224

12. F. Variable Selections

(1) Ten Combined States

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	LG	0.0000	0.8651	7.3349	0.5629
2	STR	0.0001	0.8650	5.7268	0.5313

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	LEN	0.5982	0.5982	2025.87	< 0.0001
2	SC	0.2235	0.8217	343.629	< 0.0001
3	FC	0.0275	0.8492	126.204	< 0.0001
4	UNI	0.0121	0.8613	31.4830	< 0.0001
5	MIC	0.0033	0.8645	7.4630	< 0.0001
6	TR	0.0005	0.8650	5.7368	0.0534

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
5.73	6	0.8650	FC, SC, MIC, LEN, UNI, TR
7.33	7	0.8651	FC, SC, MIC, LEN, UNI, STR, TR
7.46	5	0.8645	FC, SC, MIC, LEN, UNI
7.60	7	0.8650	FC, SC, MIC, LEN, UNI, LG, TR
8.16	6	0.8647	FC, SC, MIC, LEN, UNI, LG

(2) AL

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	TR	0.0000	0.9450	7.0387	0.8445

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	FC	0.7084	0.7084	420.673	< 0.0001
2	LEN	0.1798	0.8883	99.0615	< 0.0001
3	STR	0.0188	0.9071	67.2023	< 0.0001
4	SC	0.0238	0.9309	26.3851	< 0.0001
5	LG	0.0074	0.9383	15.0610	0.0007
6	MIC	0.0021	0.9404	13.3076	0.0630
7	UNI	0.0046	0.9450	7.0387	0.0047

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
7.04	7	0.9450	FC, SC, MIC, LEN, UNI, STR, LG
9.00	8	0.9450	FC, SC, MIC, LEN, UNI, STR, LG, TR
10.60	7	0.9430	FC, SC, MIC, LEN, UNI, STR, TR

(3) AR

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	STR	0.0003	0.9005	7.2205	0.6399
2	UNI	0.0005	0.9005	5.6360	0.5190
3	LG	0.0005	0.8995	4.0364	0.5252
4	MIC	0.0021	0.8974	3.6923	0.1964

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	SC	0.6301	0.6301	213.137	< 0.0001
2	FC	0.1344	0.7645	106.801	< 0.0001
3	LEN	0.1258	0.8903	7.4391	< 0.0001
4	TR	0.0071	0.8974	3.6923	0.0179
5	MIC	0.0021	0.8995	4.0364	0.1964

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
3.69	4	0.8974	FC, SC, LEN, TR
4.04	5	0.8995	FC, SC, MIC, LEN, UNI, TR
4.07	5	0.8994	FC, SC, LEN, UNI, TR
7.22	7	0.9005	FC, SC, MIC, LEN, UNI, LG, TR

(4) AZ

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	UNI	0.0005	0.9511	8.2084	0.2738
2	SC	0.0010	0.9501	8.8234	0.1087

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	TR	0.8515	0.8515	251.027	< 0.0001
2	STR	0.0543	0.9058	113.950	< 0.0001
3	FC	0.0367	0.9426	21.9837	< 0.0001
4	MIC	0.0017	0.9442	19.6734	0.0514
5	LG	0.0032	0.9475	13.4133	0.0060
6	LEN	0.0026	0.9501	8..8234	0.0120
7	SC	0.0010	0.9511	8.2084	0.1087
8	UNI	0.0005	0.9515	9.0000	0.2738

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
7	8.2094	0.9511	FC, SC, MIC, LEN, STR, LG, TR
6	8.8234	0.9501	FC, MIC, LEN, STR, LG, TR
8	9.000	0.9515	FC, SC, MIC, LEN, UNI, STR, LG, TR
7	9.4273	0.9506	FC, MIC, LEN, UNI, STR, LG, TR

(5) CA

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	UNI	0.0006	0.9171	7.7929	0.3752

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	LEN	0.6954	0.6954	286.753	< 0.0001
2	TR	0.1689	0.8643	67.1003	< 0.0001
3	STR	0.0259	0.8902	35.1518	< 0.0001
4	SC	0.0147	0.9048	17.8888	< 0.0001
5	MIC	0.0038	0.9087	14.8752	0.0334
6	LG	0.0031	0.9117	12.8402	0.0528
7	FC	0.0054	0.9171	7.7929	0.0091
8	UNI	0.0006	0.9177	9.0000	0.3752

C(p)	Number of X's in Model	R-Square	Variables in Model
7.79	7	0.9171	FC, SC, MIC, LEN, STR, LG, TR
9.00	8	0.9177	FC, SC, MIC, LEN, UNI, STR, LG, TR
11.94	7	0.9140	FC, SC, LEN, UNI, STR, LG, TR

(6) GA

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	LG	0.0000	0.9406	7.0229	0.8801
2	TR	0.0013	0.9393	7.3067	0.1319

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	SC	0.6147	0.6147	571.067	< 0.0001
2	STR	0.2470	0.8616	136.565	< 0.0001
3	FC	0.0374	0.8990	72.5130	< 0.0001
4	LEN	0.0286	0.9276	23.9027	< 0.0001
5	UNI	0.0099	0.9375	8.4118	< 0.0001
6	MIC	0.0018	0.9393	7.3067	0.0813
7	TR	0.0013	0.9406	7.0229	0.1319

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
7.02	7	0.9406	FC, SC, MIC, LEN, UNI, STR, TR
7.30	6	0.9393	FC, SC, MIC, LEN, UNI, STR
8.41	5	0.9375	FC, SC, LEN, UNI, STR

(7) LA

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	TR	0.0001	0.9728	7.2088	0.6492
2	STR	0.0005	0.9723	6.4013	0.2759
3	LG	0.0011	0.9712	7.1295	0.1017

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	SC	0.7576	0.7576	519.117	< 0.0001
2	STR	0.1431	0.9088	172.583	< 0.0001
3	MIC	0.0218	0.9226	121.477	< 0.0001
4	FC	0.0178	0.9404	80.1726	< 0.0001
5	LEN	0.0266	0.9670	17.3131	< 0.0001
6	UNI	0.0042	0.9712	9.1270	0.0025
7	LG	0.0016	0.9728	7.2088	0.0505

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
6.40	6	0.9723	FC, SC, MIC, LEN, UNI, LG
7.13	5	0.9712	FC, SC, MIC, LEN, UNI
7.21	7	0.9728	FC, SC, MIC, LEN, UNI, STR, LG
7.21	6	0.9720	FC, SC, MIC, LEN, UNI, LG
7.93	7	0.9725	FC, SC, MIC, LEN, UNI, STR, TR
8.40	7	0.9723	FC, SC, MIC, LEN, UNI, LG, TR

(8) MS

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	TR	0.0006	0.9278	7.7237	0.3971
2	STR	0.0003	0.9274	6.1445	0.5175

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	SC	0.5983	0.5983	418.603	< 0.0001
2	LEN	0.2184	0.8167	140.269	< 0.0001
3	FC	0.0835	0.9003	35.0183	< 0.0001
4	LG	0.0168	0.9170	15.4871	< 0.0001
5	MIC	0.0049	0.9219	11.2379	0.0168
6	UNI	0.0055	0.9274	6.1445	0.0088

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
6.15	6	0.9274	FC, SC, MIC, LEN, UNI, LG
7.72	7	0.9278	FC, SC, MIC, LEN, UNI, STR, LG
9.00	8	0.9283	FC, SC, MIC, LEN, UNI, STR, LG, TR

(9) NC

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	MIC	0.0001	0.9242	7.1130	0.7375
2	FC	0.0016	0.9225	7.1962	0.1503

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	LEN	0.6445	0.6445	349.351	< 0.0001
2	TR	0.2257	0.2257	65.5029	< 0.0001
3	SC	0.0155	0.0155	47.8599	0.0004
4	STR	0.0161	0.0161	29.5132	0.0001
5	UNI	0.0147	0.0147	12.9205	< 0.0001
6	LG	0.0061	0.0061	7.1962	0.0066
7	FC	0.0016	0.0016	7.1130	0.1503

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
7.1130	7	0.9241	FC, SC, LEN, UNI, STR, LG, TR
7.1962	6	0.9225	SC, LEN, UNI, STR, LG, TR
7.6839	7	0.9237	SC, MIC, LEN, UNI, STR, LG, TR
7.7101	6	0.9221	SC, MIC, LEN, UNI, STR, TR

(10) TN

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	UNI	0.0028	0.8634	8.7516	0.1893
2	FC	0.0039	0.8596	9.1792	0.1246
3	LG	0.0041	0.8555	9.7528	0.1168

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	LEN	0.3657	0.3657	309.293	< 0.0001
2	SC	0.4004	0.7662	59.8319	< 0.0001
3	LG	0.0426	0.8088	35.0660	< 0.0001
4	MIC	0.0172	0.8260	26.2431	0.0040
5	STR	0.0171	0.8431	17.4943	0.0028
6	TR	0.0164	0.8596	9.1792	0.0021
7	FC	0.0039	0.8634	8.7516	0.1246
8	UNI	0.0028	0.8662	9.0000	0.1893

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
7	7	0.8634	FC, SC, MIC, LEN, STR, LG, TR
8	8	0.8662	FC, SC, MIC, LEN, UNI, STR, LG, TR
6	6	0.8596	SC, MIC, LEN, UNI, STR, TR

(11) TX

Summary of Backward Elimination					
Step	Variable removed	Partial R-Square	Model R-Square	C(p)	Pr > F
1	LG	0.0000	0.9451	7.0480	0.8269
2	STR	0.0001	0.9450	5.3685	0.5709

Summary of Forward Selection					
Step	Variable entered	Partial R-Square	Model R-Square	C(p)	Pr > F
1	SC	0.6711	0.6711	728.670	< 0.0001
2	LEN	0.1864	0.8575	231.562	< 0.0001
3	TR	0.0810	0.9385	16.5892	< 0.0001
4	MIC	0.0006	0.9391	17.0783	0.2388
5	UNI	0.0024	0.9415	12.6978	0.0146
6	FC	0.0035	0.9450	5.3685	0.0025

C(p)	**Number of X's in Model**	**R-Square**	**Variables in Model**
5.37	6	0.9450	FC, SC, MIC, LEN, UNI, TR
7.05	7	0.9451	FC, SC, MIC, LEN, UNI, STR, TR
9.00	8	0.9451	FC, SC, LEN, UNI, TR
7.22	7	0.9005	FC, SC, MIC, LEN, UNI, STR, LG, TR