PASS-THROUGH ANALYSIS OF COTTON PRICES

Jon Devine
Cotton Incorporated
Cary, NC
Alejandro Plastina
International Cotton Advisory Committee
Washington, DC

Abstract

Given the unprecedented price levels and volatility experienced during the 2010/11 crop year, there have been a series of questions related to the issue of how these changes in fiber prices might result in changes in prices further downstream in textile and apparel supply chains. To address these questions, Cotton Incorporated and the International Cotton Advisory Committee (ICAC) initiated a pass-through analysis of cotton prices. Pass-through analyses are designed to investigate how changes in commodity prices affect changes in prices in manufacturing and at retail. Such research has been implemented to examine a range of other agricultural commodities, but no known existing pass-through analyses were known prior to the initial work presented by Cotton Incorporated and the ICAC at the 2011 Beltwide Cotton Conferences. Given the timing of the 2011 Beltwide Cotton Conferences relative to the changes in cotton fiber prices, only a limited amount of data were available to describe changes in prices throughout supply chains last year. Considering that additional data are currently available, this research presented in this paper is designed as an update to last year's analysis. In addition to an update in terms of the data availability for the prices examined last year, this year's analysis also includes several supplemental prices and interpretation.

Introduction

A common question when analyzing supply chains is how much a change in input costs at a given link in the supply chain affects prices downstream. To address this question, research has been conducted that examines the extent to which changes in prices are "passed-through" supply chains. In agricultural economics, pass-through analysis has explored the extent to which changes in agricultural commodity prices result in changes in consumer prices. Examples of such research include those looking at the effect of changes in coffee prices (Leibtag, Nakamura, Nakamura, & Zerom, 2007), milk prices (Kim & Cotterill, 2008), and grain prices (Berck, Leibtag, Solis, & Villas-Boas, 2009; Roeger & Leibtag, 2011). However, there is no known research analyzing the effect of changes in cotton fiber prices on prices for cotton textile goods. Given the dramatic increases in cotton prices during the 2010/11 crop year, the objective of this research is to investigate relationships between changes in cotton fiber prices and changes in prices for intermediate textile goods in the cotton textile supply chain.

Due to the multiple processes involved in the manufacture of cotton apparel (i.e., spinning, fabric manufacturing, and apparel construction), there is potential for constructing a pass-through analysis for cotton prices at different stages in the textile manufacturing process. For the purposes of this analysis, the cotton supply chain is defined in stages including fiber, yarn, fabric, assembled garment, and retail. Price data for a range of cotton fiber qualities from a range of cotton producing countries are readily available, as are price data for many qualities and sources of cotton yarn. More challenging, in terms of data availability, are prices further downstream in the supply chain. There is a wide range of fabrics used in a wide range of apparel and finished textile goods, and this variability, along with the fact that fabric prices are negotiated privately, introduces difficulty in terms of collecting representative fabric price data. Nonetheless, cotton textile supply chains are highly globalized, and trade data can be used to derive fabric prices. Similarly, trade data can be used to collect prices throughout the supply chain and, for consistency, these data are analyzed alongside price quotes for fiber and yarn export. Consumer price indexes are used to measure retail apparel prices.

In addition to measuring the extent to which the magnitude of price increases are passed through supply chains, pass-through analysis also allows researchers to investigate how long it takes changes in prices at one stage in the supply chain to produce changes in prices further downstream. This research examines both the magnitude and temporal nature of price relationships. Evidence was found that the increases in cotton fiber prices have been completely passed-through on a cost per weight basis at the fiber-to-yarn link in the supply chain and that changes in cotton fiber prices are almost immediately passed through as changes in yarn prices. Analysis regarding the extent that prices are passed through at later stages is currently underway.

While prices at intermediate manufacturing stages, including fiber, yarn, and fabric, appear to have already peaked, data further downstream, which describe prices for garments and at retail, have yet to define peaks. Given these prices have yet to form peaks, analysis continues to be somewhat limited in terms of data availability and continued monitoring and analysis of these data is a persistent feature of this research. Results are presented in terms of both descriptive statistics and time series analysis. Findings indicate that the time series characteristics of the data are sensitive to the sample being examined. Due to the instability of the time series properties inherent in the data examined, results from on-going time series analysis is limited.

Data

For this examination of the prices in the cotton supply chain, an effort was made to use the most aggregated data available in order to best represent the effects of changes in world cotton prices on the highly globalized cotton supply chain. At the first link in the supply chain, from fiber-to-yarn, figures generally recognized as reflective of world prices are readily available. Both of these prices represent quotes for exports to be delivered in the future. Price quotes for future delivery are not available for other elements of the supply chain. Only trade data are available. Due to the collection of import duties, figures related to imports are commonly accepted as being more accurate than those for exports. Import data are available to describe prices for fiber, yarn, fabric, and garments. The U.S. apparel CPI is used to describe retail apparel prices.

Brief descriptions of the data used in this analysis appear below. All data used are monthly averages. The time period covered by the analysis is from the onset of the 2004/05 crop year to December 2010. Analysis began with the 2004/05 season because this was the first complete crop year where A Index values represented delivery quotes to the Far East, where the majority of the world's cotton is spun into yarn.

Fiber

Cotlook Ltd., a company serving the cotton marketing community, has been publishing the A Index since the 1960s. Widely accepted as a proxy for the world price of cotton, the A Index is a cost and freight (CFR) price for of 1-3/32 inch staple Middling cotton delivered to ports in the Far East (Cotlook). These quotes represent price cotton merchants offer for fiber delivered to nine Asian countries.

Given that A Index values reflect quotes for future delivery, they may or may be representative of prices paid by spinning mills. To understand prices that mills may have actually paid for cotton, import prices are also investigated. Import prices for cotton fiber represent those reported by the same nine countries that are represented by the A Index. By examining both prices offered and prices delivered, it should be possible to discuss how long it takes changes in prices quoted to mills to prices actually delivered. The fiber trade data used are those from the GTIS Global Trade Atlas, who publishes official trade statistics from governments around the world.

Yarn

In addition to the A Index, Cotlook Ltd. publishes a yarn index. Cotlook's yarn index is a trade weighted average of 20s and 30s Ne carded ring spun weaving yarn of what Cotlook considers "average" quality. Ring-spun yarn (as opposed to open-end yarn) is estimated to represent more than 80% of the world's spinning capacity (International Cotton Advisory Committee (ICAC), 2009). Free-on-board (FOB) prices for these yarns are collected by Cotlook from China, India, Pakistan, Indonesia, and Turkey. Weightings assigned to prices used to derive the index are based on average export volumes for the two most recent calendar years. Collectively, these countries represent nearly 75% of the world's consumption of raw cotton fiber into yarn (USDA Foreign Agricultural Service).

As was the case with fiber prices, trade data are used supplement these export quotes. The yarn trade data used represent average prices for Harmonized Tariff System (HS) code 5205, which represents yarn that is at least 85% cotton fiber content. No quality specifications are used for this HS code and there is no differentiation between ring and open-end spun yarn. Yarn import prices are those for China, which is the world's largest importer.

Fabric

Unlike fiber and yarn, publicly quoted prices for fabrics are not available. As a result, fabric prices are based solely on average import prices. The fabric prices that were used in the analysis were those for cotton woven fabric (HS code 5209) imports into China, the world's largest importer of these fabrics. Woven, rather than knit, fabric prices were used because Cotlook's yarn index reflects prices for weaving yarns. Trade volumes for the 5209 HS code are significantly larger than those for both lightweight woven cotton fabrics (HS 5208) and knit cotton fabrics (various codes, HS chapter 61). A limitation with fabric prices is that fabric prices are expressed in different units for different countries in the Global Trade Atlas. Some countries report in terms of square meters and some report in kilograms. Chinese data are published in terms of square meters and the prices for fabric in this analysis represent U.S. per square meter.

Garment

Fabric is cut and sown to make garments. With the world apparel trade being highly globalized, landed import values can be used to describe prices at this stage of the supply chain. The U.S. Department of Commerce's Office of Textiles and Apparel (OTEXA) publishes value and volume data for each apparel category represented by the U.S. Harmonized Tariff Schedule. In addition to publishing data for individual categories, OTEXA also publishes figures for aggregations of apparel categories. One of these aggregated categories represents cotton dominant apparel imports, describing both the volume, in terms of square meter equivalence, and value of apparel imports made from fabric containing more than fifty-one percent cotton fiber content. Using the figures for volume and value, a cost per square meter equivalent can be derived. These values are used to describe prices at the garment stage of the supply chain. The U.S. is the largest single importer of apparel and is commonly recognized as being a cost sensitive market. As a result, U.S. import prices are assumed to be representing movement in garment prices around the world.

Retail

Since garment prices are those for the U.S. (OTEXA data), monthly U.S. apparel consumer price index (CPI) data are used to describe prices at retail. Cotton textile products represent between 60 to 70% of all textile items sold at retail (Cotton Incoportated). With cotton products representing the majority of apparel products, the apparel CPI, which covers apparel goods of all items, is thought to be representative of the effect of changes in cotton fiber prices on retail apparel prices.

Potential Data Limitations

While all of the data sources above are thought to capture changes in prices in the cotton supply chain, there may be some important details related to the data that deserve mentioning. At the fiber stage, values are 100% cotton fiber. At the yarn stage, import data represent values that are 85% or more cotton fiber content. As a result, there is the potential that these yarns may not be 100% cotton and might contain other fibers like polyester.

During the 2010/11 crop year, there were important differences between cotton and polyester prices, and these price differences may have motivated some blending of cotton with polyester in yarns described in the HS 5205 category. Nonetheless, cotton fiber prices tend to be correlated with polyester prices and any blending that might have taken place may not have introduced significant bias. Likewise, changes in blending ratios may have distorted price relationships at later stages in the supply chain. Fabric prices represent cotton fiber content greater than 85%, and garment prices reflect goods with more than 50% cotton fiber content. The apparel CPI does not account for fiber content and the full price effects of cotton may be not be completely represented in retail prices due to observed changes in fiber content in OTEXA import data.

In addition, it is also important that the changes in prices throughout the supply chain were likely not solely a product of increasing cotton fiber prices. While cotton prices were increasing in 2010/11, there were also rising costs for financing, labor, and energy in many emerging market economies where much of the world's apparel is manufactured. At the garment stage it is important to point out that exchange rates, notably the dollar's depreciation relative to the Chinese RMB, likely was another factor contributing to increasing prices.

Pass-Through: Descriptive Statistics

At last year's Beltwide conference, before observed data were available to describe how cotton prices were transmitted through supply chains, a theoretical pass-through of cotton was presented that examined how much cotton was contained in different apparel items. These theoretical figures were based on the weight of these different apparel items, or their cotton content, and the change in cotton prices. Given that twelve months have passed since last year's conference, it is possible to describe how prices in the supply have changed following the increases in 2010/11.

The general pattern is that it takes longer for prices to react further downstream in the supply chain and the magnitude of changes in prices, expressed in percentage terms, diminishes further downstream. Figure 1 shows how prices for each stage of the supply chain changed relative to their levels in August 2010, the first month of the 2010/11 crop year and just before cotton prices began to increase sharply. Table 1 summarizes the data and specifies the lag in terms of the peak values for pricing at different stages in supply chains relative to the peak in A Index values.

Fiber

Between August 2010 and March 2011, the A Index nearly tripled from values near 85 cents/lb to values over 240 cents/lb. At their peak in March, A Index values were nearly 155% higher than they were in August 2010. Following their peak, fiber prices declined sharply and are currently trading at levels near 100 cents/lb. It is important to remember that A Index prices reflect values for future delivery of cotton. As a result, it likely would be several months after spinning mills sign contracts with cotton merchants that the cotton they purchased arrives.

With trade data that describes average import prices for cotton for the same set of countries that are used for the A Index, the lag between the time that A Index prices peaked and delivered prices peaked can be identified. Landed cotton prices for this collection of Far East countries peaked in June at a level 85% higher than they were in August 2010. These data indicate a lag of three months in terms of the peak in delivered fiber prices relative to the peak in the A Index. It is also notable that the peak in landed fiber prices was considerably lower than the peak in A Index prices.

One reason for this is likely that as prices increased, order volumes decreased. As a result, even at the peak for landed prices in June, much of the cotton could have been purchased prior to the peak in March. Another factor that could explain the lower peak in landed prices is that average import prices do not make any accommodation for quality. It had been reported that mills shifted to lower quality fiber to help offset the increases in fiber prices and this also may have been a contributing factor to the lower peak.

Yarn

Similar to fiber, yarn prices can be examined both in terms of quotes for future delivery and in terms of average landed prices for imports. As with fiber prices, an examination of both prices allows for the identification of the lag between price quotes and delivered values. The difference in the timing of the peaks for quoted and landed yarn prices was two months.

In the analysis that was conducted in last year's Beltwide presentation, it was found that fiber prices and yarn prices tend to move simultaneously with one another. Updated analysis confirms these findings and both quotes for delivered yarn and landed yarn values remain strongly contemporaneously correlated with parallel data for cotton fiber. For both yarn index and landed yarn prices, the peak values were about one half of the magnitude of the respective peaks A Index and landed fiber prices.

What is notable in the landed yarn price data relative to landed fiber price data is that yarn prices peaked a month earlier. In addition, the peak in landed yarn prices is more rounded relative to the peak in landed fiber prices and landed yarn prices did not change dramatically between April and June. The implication, with yarn prices remaining flat and beginning to decrease at the same time that landed fiber prices were increasing, is that spinning mills likely suffered challenges to profitability throughout the late spring and early summer.

Fabric

Quoted prices are not available downstream from yarn in publicly available data regarding pricing in cotton supply chains. As a result, only landed import prices are used to describe changes in prices at this stage. Fabric prices peaked in June at a level 46% higher than they were in August 2010. This represented a lag of three months relative to the peak in A Index and yarn index values and a one month lag relative to landed yarn prices.

Although price quote data for future delivery, analogous to the A Index and yarn index, are not available for fabric prices, there are some inferences that can be drawn regarding the nature of the temporal relationship between a fabric price quote series and yarn and fiber price series. From the data observed, yarn prices have been found to move simultaneously with fiber prices. This applies absolutely in the case of the A Index and the yarn index, and with a difference of only one month in landed price data. With the peak in landed fabric data being simultaneous to the peak in landed fiber prices, and only one month after the peak in landed yarn prices, the implication is that landed fabric prices had a nearly simultaneous relationship with fiber and yarn prices in 2010/11. This would suggest that fabric prices quotes, if available, would describe a nearly simultaneous relationship with A Index and yarn index prices.

Garment

Landed prices for cotton-dominant apparel arriving in the U.S. have yet to form a peak. In the latest data available at the time of this analysis, average prices for cotton-dominant apparel were 26% higher than they were in August 2010 (seasonally-adjusted data. This implies that the lag between the peak in landed garment prices and A Index prices is at least eight months.

At the garment stage, it is important to emphasize the importance of influences apart from cotton fiber that could impact prices. Garment assembly requires more labor than yarn or fabric manufacturing. As a result, rising wages in countries that export large volumes of apparel to the U.S. like China, Vietnam, and Bangladesh would contribute to increased sourcing costs for garments. Analysis is currently being conducted to determine how to include wage data as a co-integrating vector in time-series analysis. Other factors including exchange rates, energy prices, and financing costs are also being investigated.

Retail

Retail apparel prices began to increase in May 2011, marking the first significant increases in about 15 years. As with garment prices, retail prices have yet to form a peak. In the latest available data for November, retail apparel prices were about 5% higher than they were in August 2011 (seasonally-adjusted data). Correspondingly, the eventual peak in apparel prices also has to be at least eight months relative to the peak in A Index prices.

Similar to garment prices, there are also likely co-integrating vectors that will need to be analyzed in addition to fiber prices, or other prices in the cotton supply chain, in order to accurately represent changes in prices. While several other factors were discussed at the garment stage that could have contributed to increases beyond those implied by fiber prices alone, there may be factors at the retail stage that could prevent retailers from passing on higher sourcing costs in the form of higher prices.

A principal difficulty could come from the weakness in the U.S. economy. With U.S. consumers saving more to reduce debt following the recession, they are spending less. By examining changes in consumer apparel spending alongside changes in retail apparel prices, it becomes evident how changes in apparel prices have affected changes in apparel spending. Modeling of potential co-integrative relationships that can describe some of this difficulty is part of on-going research that will continue to be formalized through time series modeling. The time series methods that have been applied to analyze the relationships outlined in this section are detailed in the next section.

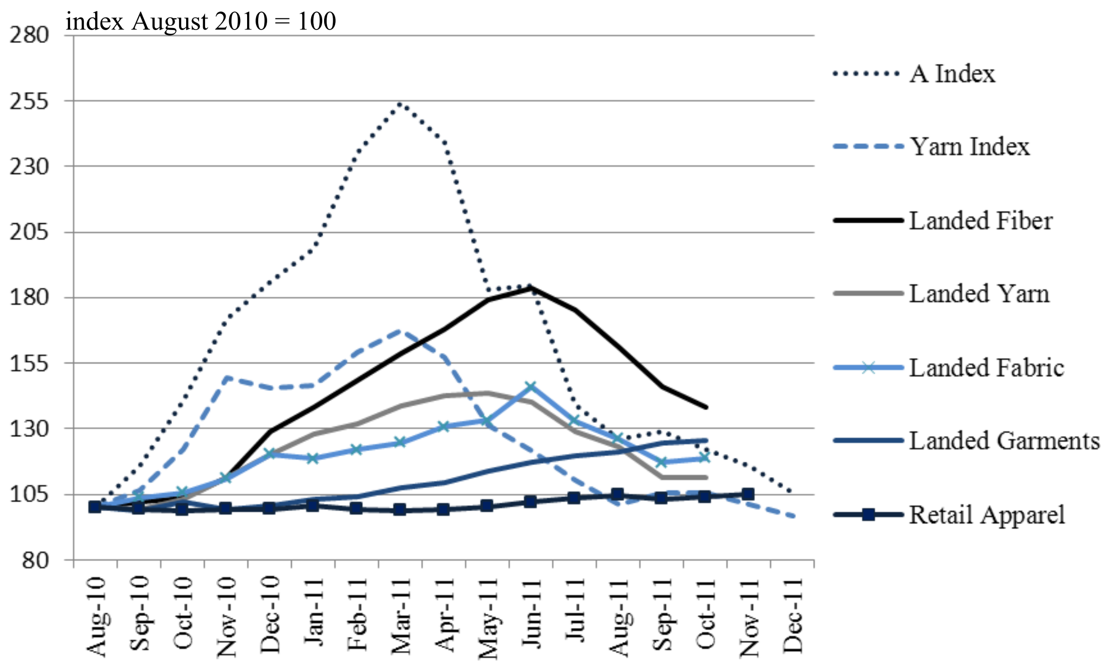

Figure 1. Changes in prices observed in the cotton supply chain since August 2010.

Table 1. Summary of changes in prices observed in the cotton supply chain since August 2010.

	Month of Peak	Magnitude of Peak (versus Aug. 2010)	Lag of Peak Relative to A Index
Quoted Prices			
A Index	March	+154%	n/a
Yarn Index	March	+67%	contemporaneous
Landed Prices			
Fiber	June	+84%	3 months
Yarn	May	+43%	2 months
Woven Fabric	June	+46%	3 months
Cotton-Dom. Apparel	n/a	+26%	>9 months
Cotton-Dom. Towels	July	+29%	4 months
Cotton-Dom Sheets	n/a	+28%	>9 months
Retail			
Apparel CPI	n/a	+5%	>9 months

Time Series Methods

To formalize the process of describing how prices at various stages of the cotton supply chain are linked, time series methods were implemented. In order to obtain a parsimonious representation of the relationship between cotton prices and prices of processed textile product, a multi-step approach is followed, starting from a very general unrestricted model. The first step is to analyze the time series properties of individual price series. The second step is to test for cointegration among collections of prices. The third step is to test for alternative restrictions on the parameters to arrive at a parsimonious model.

The classical regression model requires that all series be stationary and that the errors have a zero mean and finite variance to avoid the "spurious regression" problem, which consists of high statistical significance of the estimated model, but lack of a causal connection. A series is said to be (weakly or covariance) *stationary* if the mean and autocovariances of the series do not depend on time. Correspondingly, the first step of the modeling process is to analyze the time series properties of each price series with Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. If prices in levels are non-stationary, the series must be differenced *n*-times until the hypothesis of stationarity cannot be rejected. A series is said to be integrated of order *n*, *I(n)*,.for the minimum *n* required to achieve stationarity.

If a collection of time series are integrated of the same order and $n>0$, a long-run linear relationship might exist between the series expressed in levels in which the error term is stationary despite the fact that the individual time series expressed in levels are non-stationary. If such a long-run relationship exists, the series are said to be *cointegrated*. When series are cointegrated, they cannot move independently from each other. In that case, an error-correction model is used to capture short- and long-term relationships among prices. The (Johansen, 1988) methodology is used to test the null hypothesis of no cointegration among prices.

The (Johansen, 1988) approach requires the following error correction model (ECM) be estimated:

$$\Delta x_t = Bz_t + \pi_0 x_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta x_{t-i} + \tilde{\varepsilon}_t \qquad (1)$$

where x_t is the vector of prices, z_t is a vector of deterministic variables, B, π_0 and the π_i's are matrices of coefficients, *p* is the lag length of the vector autoregression (VAR), and $\tilde{\varepsilon}_t$ is the vector of white noise errors. Since results depend on the number of lags considered, the general-to-specific modeling approach delineated in Enders (2004) is followed to determine the appropriate number of lags to consider: unrestricted VAR models in levels ($x_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_p x_p + \varepsilon_t$) with alternative lag structures are estimated and the appropriate lag structure (*p*) is indicated by the model with the lowest Akaike Information Criteria (AIC).

The number of independent cointegrating vectors equals the rank of π_0, r(π_0). If r(π_0)=0 then prices are not cointegrated; if *r*(π_0)=*M*, the vector process is stationary, i.e. all prices are jointly stationary; if *r*(π_0)=*1*, there is a single cointegrating vector and the expression $\pi_0 x_{t-1}$ is the error-correction term; if 2≤r(π_0)<M, there are multiple cointegrating vectors. The Trace (λ_{trace}) and Maximum Eigenvalue (λ_{max}) tests are used to test alternative hypotheses on r(π_0).

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_i\right) \qquad (2)$$

$$\lambda_{max}(r, r+1) = -T\, ln\left(1 - \hat{\lambda}_{r+1}\right) \qquad (3)$$

where the $\hat{\lambda}_i$'s are the estimated values of the eigenvalues obtained from the estimated $\hat{\pi}_0$ matrix, T is the number of usable observations, and $n=0,1,2,\ldots,M$. λ_{trace} tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to r against a general alternative (greater than r). λ_{max} tests the null hypothesis that the number of cointegrating vectors is r against the alternative of $r+1$ cointegrating vectors.

If prices in levels are non-stationary and not cointegrated, then a VAR model in the stationary differenced prices is estimated:

$$\Delta x_t = A_0 + \sum_{i=1}^{p-1} \pi_i \Delta x_{t-i} + \varepsilon_t \qquad (4)$$

In this framework, since differenced prices are stationary, tests of hypothesis can be conducted using classical regression techniques.

Cross-equation restrictions in the final model are tested with the LRT suggested by Sims (1980):

$$LR = (T - c)\left(ln\left|\Sigma_r\right| - ln\left|\Sigma_u\right|\right) \qquad (5)$$

where $ln\left|\Sigma_r\right|$ is the natural logarithm of the determinant of the variance-covariance matrix of the residuals of the restricted model, $ln\left|\Sigma_u\right|$ is the natural logarithm of the determinant of the variance-covariance matrix of the residuals of the unrestricted model, c is the number of parameters in the unrestricted model, and T is the number of observations in the time space. The LRT follows a Chi-square distribution with degrees of freedom equal to the number of restrictions in the system.

In particular, we are interested in determining whether one or more prices do not receive significant feedback from changes in other prices and therefore do not need a VAR representation, i.e. they can be treated as weakly exogenous and their equation can be eliminated from the system. This is done by testing for block causality. The test for block-causality restricts all lags of one series of prices in the other series of prices to zero. The unrestricted model in (4) consists of the VAR equations of the 2 endogenous prices including p lags of the potentially block-exogenous price. The restricted model excludes all lags of the potentially block-exogenous price. The LRT test has $2p$ degrees of freedom, since p lags are excluded in each of the equations of the model. If the hypothesis of block causality is rejected, then that price is said to Granger-cause the other price.

The forecasting power of the final model is tested by estimating the model for a shorter period, T_1 $(T_1<T)$ and comparing the forecasts ($\hat{y}_t$) with the out-of-sample observed values, y_t ($T_1 < t \leq T$). The forecast evaluation is conducted through a graphical analysis, a decomposition of the mean squared forecast error, and the Theil Inequality coefficient. The mean squared forecast error, $\sum(\hat{y}_t - y_t)^2 / T_2$, where $T_2 = T - T_1$, is decomposed into a bias proportion, $T_2\left(\sum(\hat{y}_t / T_2) - \bar{y}\right)^2 / \sum(\hat{y}_t - y_t)^2$, a variance proportion $T_2\left(s_{\hat{y}} - s_y\right)^2 / \sum(\hat{y}_t - y_t)^2$, and a covariance proportion, $2T_2(1-r)s_{\hat{y}}s_y / \sum(\hat{y}_t - y_t)^2$, where $\sum(\hat{y}_t)/T_2$, $\bar{y}$, $s_{\hat{y}}$, s_y are the means and (biased) standard deviations of $\hat{y}_t$ and y_t, respectively, and r is the correlation between $\hat{y}_t$ and y_t. The greater the covariance proportion and the smaller the bias and variance proportions, the greater the proportion of forecasting errors stemming from non-systematic sources and the better the quality of the forecasts are (EViews, 2007). The Theil Inequality coefficient (TIC) takes values between 0 and 1, zero indicating a perfect fit of the forecast to the observed series. The TIC is calculated as (EViews, 2007):

$$TIC = \sqrt{\sum_{t=T_1+1}^{T} (\hat{y}_t - \bar{y}_t)^2 / T_2} \Bigg/ \left[\sqrt{\sum_{t=T_1+1}^{T} \hat{y}_t^2 / T_2} + \sqrt{\sum_{t=T_1+1}^{T} y_t^2 / T_2} \right] \quad (6)$$

The stability of the final model, i.e. the absence of structural breaks, is tested with the Quandt-Andrews (Q-A) and the Chow Forecast tests (EViews, 2007). These tests evaluate whether the parameters of the model are stable across various sub-samples of the data. The Chow's Forecast test estimates two models using the whole sample: the restricted regression uses the original set of regressors, while the unrestricted regression adds a dummy variable for each forecast point. The Chow Forecasts log likelihood ratio statistic compares the maximum of the (Gaussian) log likelihood function of each model and has an asymptotic Chi-squared distribution with T_2 degrees of freedom.

The logic behind the Q-A test is that a single Chow Breakpoint test is performed at every observation between two dates, τ_1 and τ_2. The Breakpoint Chow test fits the model separately for each subsample and one (restricted) model for the entire period, and tests whether there are significant differences in the estimated parameters across models. The resulting test statistics are then summarized into one test statistic to test the null hypothesis that there are no breakpoints between τ_1 and τ_2. The test trims a small percentage of observations at the beginning and the end of the full sample period to avoid the degeneration of the non-standard distribution followed by the test. The Maximum Q-A statistic, MaxF, is the maximum of the individual Chow F-statistics, calculated as:

$$MaxF = \max_{\tau_1 \le \tau \le \tau_2} \left(F(\tau) \right) \quad (7)$$

$$F(\tau) = \frac{\left(\bar{u}'\bar{u} - \left(u_1'u_1 + u_2'u_2 \right) \right) / k}{\left(u_1'u_1 + u_2'u_2 \right) / \left(T - 2k \right)} \quad (8)$$

where $\bar{u}'\bar{u}$ is the restricted sum of squares and $u_i'u_i$ is the sum of squared residuals from subsample *i*. Each F-statistic follows an F-distribution with (k, T-k) degrees of freedom, where k is the number of parameters in the equation, and T is the number of observations in the time space. Therefore, failing to reject the null hypothesis of the Q-A test indicates stability of the model over the trimmed sample.

In order to analyze whether the extreme volatility of cotton prices in 2010/11 altered the relationships among the series of prices, three periods are analyzed. The first period is one of relative stability of cotton prices, with a spike in March 2008, but showing relatively smooth changes in most months. The second period is one of extreme volatility in cotton prices, starting in August 2010 and ending in December 2012. Finally, the properties for the entire sample are analyzed.

Results from Time Series Analysis

Note: This is section is under current development and only partial results are reported in this version of the study.

Fiber-Yarn

The A Index is *I(1)* over the entire sample and for the earliest sub-period, i.e. over the 2004/05-2009/10 crop years (Table 2). However, for the latest sub-period, i.e. between August 2010 and December 2012, the A Index is *I(2)*.

The Yarn Index is stationary in levels according to the Augmented Dickey Fuller test over the entire sample. However, the Phillips Perron test contradicts that conclusion. Both tests suggest that the Yarn Index is *I(1)* over the entire sample and over the earliest sub-period, but it is *I(2)* over the latest sub-period. Since the order of integration coincides for each sample period between the A Index and the Yarn Index, cointegration analyses are performed for the three sample periods (Table 3). The maximum lag allowed in all cointegration analyses for each sampling period is 12 months for the full sample and the earliest sub-sample, and 4 lags for the latest sub-sample. A single cointegrating vector exists between the Yarn Index and the A Index for each sample period, so error correction models can be estimated.

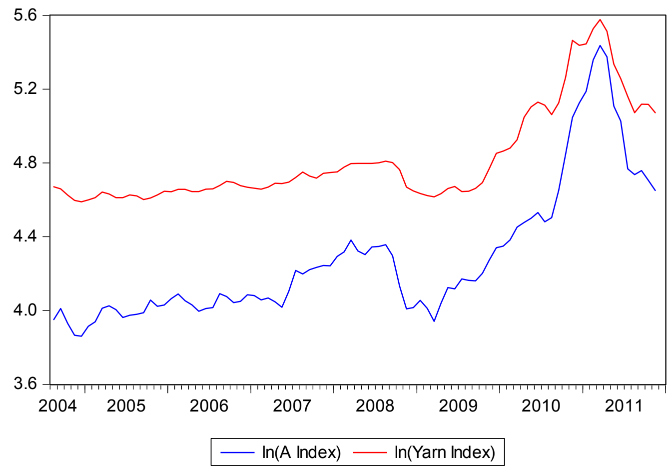

Figure 2. A Index and Yarn Index in natural logs, August 2004-December 2011.

The vector error correction model for the entire sample is reported in Table 4 explains about two-thirds of the variability of both the A Index and the Yarn Index. The t-ratio for the cointegrating term in the A Index equation is not significant, indicating that the A Index is weakly exogenous. Further testing with the LR test confirms this finding (p-value[LR(df=1)]=0.3862). However, a joint test of significance of all coefficients for the Yarn Index along with the cointegrating term in the A Index equation suggests that the A Index is not fully independent of the Yarn Index(p-value[LR(df=11)]=0.000456). It can be concluded that although the A Index does not maintain a stable long-term relationship with the Yarn Index, fluctuations in the latter affect the former. The Yarn Index, on the other hand, does keep a stable long-term relationship with the A Index, as indicated by the significance of the cointegrating term in the Yarn Index equation. The speed of adjustment of the Yarn Index to deviations from the long term equilibrium with the A Index is 0.24, so the Yarn Index corrects any discrepancy from the long-term equilibrium in levels in roughly four months. Furthermore, current changes in the Yarn Index also respond to past changes in the A Index and to its own lagged changes, with a lag of up to 10 months.

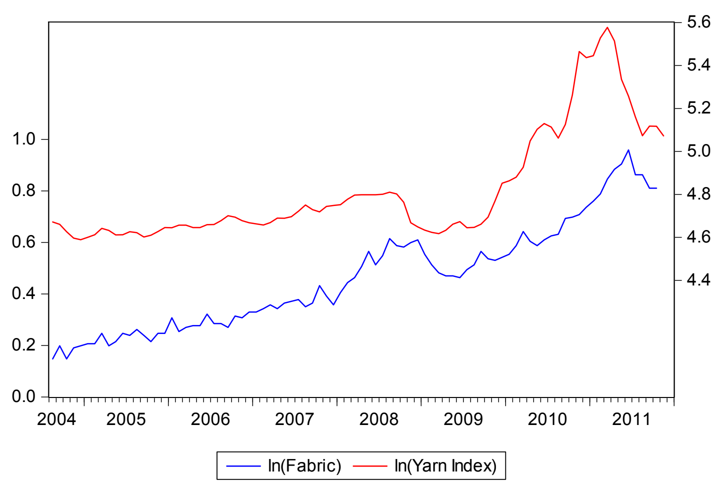

Figure 3. Yarn Index and Fabric prices in natural logs, August 2004-December 2011.

Yarn-Fabric

Fabric prices are *I(1)* for each sample period (Table 2). Therefore, cointegration analysis with the Yarn Index are performed only for the entire period and for the earliest sub-period (Table 3). In both sample periods there is at least one identified cointegrating relationship between the variables. Note: Cointegration analyses over the latest sub-period between the Yarn Index, I(2), and fabric prices, I(1), will be the subject of future research.

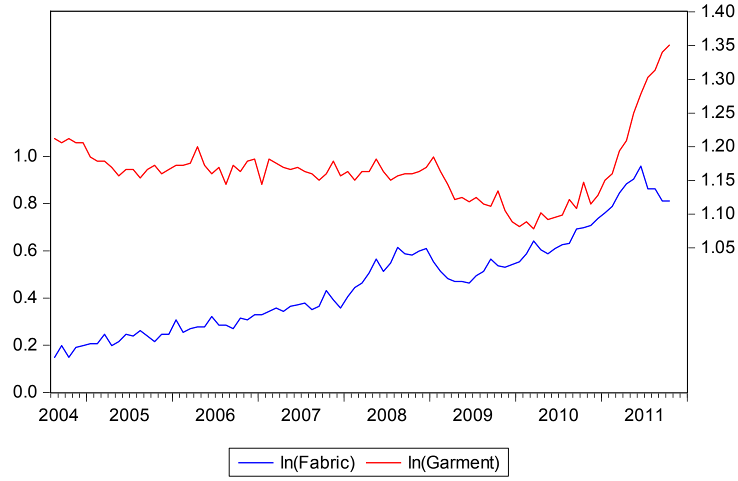

Figure 4. Fabric and Garment prices in natural logs, August 2004-December 2011.

Fabric-Garment

Garment prices are *I(1)* over the entire sample, and over the earliest sub-period, but they are *I(2)* over the latest subperiod (Table 2). Cointegration analysis between garment and fabric prices are conducted over the entire sample and the earliest sub-period only (Table 3). Interestingly, no cointegrating relationship exists between garment and fabric prices between August 2004 and July 2010, i.e. the series moved independently from one another. But once the additional data until December 2012 is incorporated to the analysis, the series become cointegrated. As reflected in Figure 4, garment prices showed no trend between 2005 and 2008, while fabric prices fluctuated over a positive trend. Due to the abrupt increase in garment prices in 2011, the entire series of garment prices show a positive trend and therefore cointegration tests fail to reject the series are found to be cointegrated. Note: Cointegration analyses over the latest sub-period between the garment prices, I(2), and fabric prices, I(1), will be the subject of future research.

Garment-Retail

Retail prices are *I(1)* over the entire sample, but stationary over August 2004-July 2010, and *I(2)* over August 2010-December 2011. Similarly to garment prices, fabric prices went through a long period of fluctuations around a stable mean before shooting up in 2011. Cointegration tests indicate the existence of a single cointegration vector between retail and garment prices over the entire sample and over August 2010-December 2011. Note: A VAR representation of the relationship between retail and garment prices (stationary and I(1), respectively) over August 2004 - July 2009 will be the subject of future research.

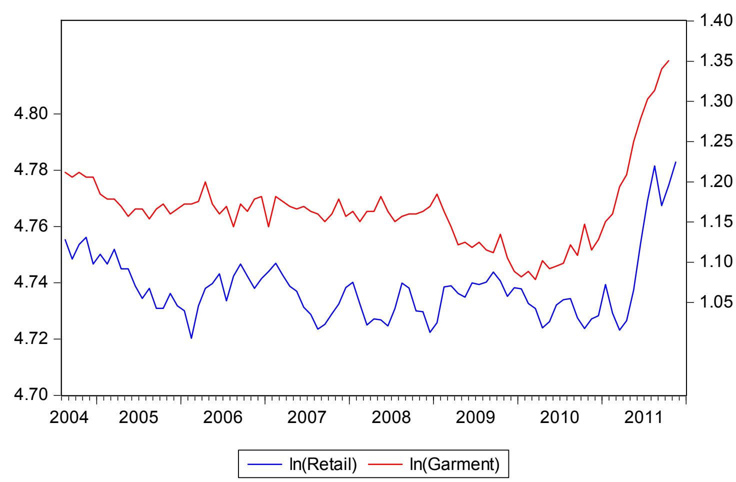

Figure 5. Garment and Retail prices in natural logs, August 2004-December 2011.

Future Work and Conclusions

The sharp increases in cotton prices that began with the onset of the 2010/11 crop year have been unprecedented and led to a series of all-time record cotton prices across the globe. The dramatic movement in fiber prices led A Index values to peak in March 2011 at levels nearly triple those at the onset of the crop year in August 2010. Due to the magnitude of price the increases in cotton fiber prices, it was anticipated that there will be consequences for prices throughout the entire cotton textile supply chain.

Descriptive statistics currently available suggest that effects from the higher cotton fiber prices in 2010/11 are being passed through the cotton supply chain. There is evidence that prices for fiber, yarn, fabric, assembled garments, and at retail have been affected by the increase in fiber prices last crop year. Statistics suggest that the volatility last year may have impacted profitability. This is the case at the fiber-to-yarn stage, where data show that yarn prices, reflecting per-unit revenue to spinning mills, started to decline while prices for fiber, reflecting costs paid by spinning mills, were still rising. At the garment-to-retail level, there is also some potential evidence of some damage to margins. Average prices for landed cotton-dominant apparel are up 26% (October) relative to the level from August 2010, while average retail apparel prices are up only 5% (November) relative to the level from August 2010. However, when examining relative percentage changes across different stages in the supply chain, it is important to remember that prices downstream are higher than prices upstream. This complicates interpretations related to profitability. Future work will examine changes in terms of cost-per-weight in order to better inform discussion relating to potential damage to manufacturers related to 2010/11 volatility.

Current efforts are focused on expanding the time series analysis. Please contact the authors for updated versions of the time series analysis.

Table 2. Unit Root Test Results

	Augmented Dickey-Fuller Test				Phillips-Perron			
	In Levels		In First Differences		In Levels		In First Differences	
ln(A Index)	**C**	**C+T**	**C**	**C+T**	**C**	**C+T**	**C**	**C+T**
Aug04-Dec11	0.522	0.242	**0.000**	**0.000**	0.621	0.472	**0.000**	**0.000**
Aug04-Jul10	0.656	0.259	**0.000**	**0.000**	0.851	0.583	**0.000**	**0.000**
Aug10-Dec11	0.213	0.660	0.324	0.259	0.483	0.886	0.328	0.263
ln(Yarn Index)								
Aug04-Dec11	**0.028**	**0.005**	**0.000**	**0.000**	0.715	0.556	**0.000**	**0.001**
Aug04-Jul10	0.798	0.601	**0.001**	**0.003**	0.996	0.978	**0.001**	**0.005**
Aug10-Dec11	0.399	0.675	0.220	0.314	0.626	0.861	0.220	0.381
ln(Fabric)								
Aug04-Dec11	0.869	0.259	**0.000**	**0.000**	0.885	0.238	**0.000**	**0.000**
Aug04-Jul10	0.747	0.116	**0.000**	**0.000**	0.793	0.125	**0.000**	**0.000**
Aug10-Dec11	0.400	0.969	**0.021**	**0.024**	0.407	0.965	**0.019**	**0.025**
ln(Garment)								
Aug04-Dec11	0.990	1.000	**0.019**	**0.000**	0.963	1.000	**0.000**	**0.000**
Aug04-Jul10	0.636	0.072	**0.000**	**0.000**	0.444	0.093	**0.000**	**0.000**
Aug10-Dec11	0.997	0.854	0.247	**0.001**	0.989	0.694	**0.001**	**0.001**
ln(Retail)								
Aug04-Dec11	0.656	0.913	**0.000**	**0.000**	0.533	0.929	**0.000**	**0.000**
Aug04-Jul10	**0.015**	0.052	**0.000**	**0.000**	**0.020**	0.052	**0.000**	**0.000**
Aug10-Dec11	0.954	0.700	0.059	**0.048**	0.954	0.674	0.057	0.118

p-values significant at the 5% critical level are in bold. C: constant; C+T: constant and trend

Table 3. Number of significant cointegrating relationships between pairs of prices.

	Lags	Coint. Relations according to Trace Test (at 5% level MHM)					Coint. Relations according to Max-EigTest (at 5% level MHM)				
	(p-1)	(a)	(b)	(c)	(d)	(e)	(a)	(b)	(c)	(d)	(e)
Fiber-Yarn											
Aug04-Dec11	10	0	**1**	2	2	2	0	**1**	2	2	2
Aug04-Jul10	10	0	0	0	**1**	2	0	0	0	**1**	2
Aug10-Dec11	1	0	**1**	2	**1**	1	0	**1**	2	**1**	**1**
Yarn-Fabric											
Aug04-Dec11	11	**1**	**1**	**1**	**1**	2	**1**	**1**	**1**	**1**	2
Aug04-Jul10	1	0	0	0	**1**	2	0	0	0	**1**	2
Aug10-Dec11*											
Fabric-Garment											
Aug04-Dec11	1	2	**1**	2	**1**	**1**	2	1	2	**1**	**1**
Aug04-Jul10	1	0	0	0	0	0	0	0	0	0	0
Aug10-Dec11**											
Garment-Retail											
Aug04-Dec11	1	0	**1**	**1**	**1**	**1**	0	**1**	**1**	**1**	**1**
Aug04-Jul10	1	0	0	**1**	0	2	0	0	**1**	0	0
Aug10-Dec11	2	0	**1**	**1**	**1**	2	0	**1**	**1**	**1**	2

(a) No deterministic trend in the data, and no intercept or trend in the cointegrating equation.
(b) No deterministic trend in the data, and an intercept but no trend in the cointegrating equation.
(c) Linear trend in the data, and an intercept but no trend in the cointegrating equation.
(d) Linear trend in the data, and both an intercept and a trend in the cointegrating equation.
(e) Quadratic trend in the data, and both an intercept and a trend in the cointegrating equation.
* Fabric is I(1) and the Yarn Index is I(2). This cointegration analysis is the subject of future research.
** Fabric is I(1) and Garment is I(2). This cointegration analysis is the subject of future research.

Table 4. Vector Error Correction Model for ln(A Index) and ln(Yarn Index), August 2004-December 2011

Vector Error Correction Estimates
Sample (adjusted): 2005M07 2011M11
Included observations: 77 after adjustments
Standard errors in ( )

Cointegrating Eq:	CointEq1	
L_A_INDEX(-1)	1.000000	
L_YARN_INDEX(-1)	-1.610042	
	(0.07694)	
C	3.440162	
	(0.36262)	
Error Correction:	**D(L_A_INDEX)**	**D(L_YARN_INDEX)**
CointEq1	-0.123980	0.241616
	(0.14407)	(0.08998)
D(L_A_INDEX(-1))	0.537527	0.185453
	(0.18759)	(0.11715)

D(L_A_INDEX(-2))	-0.251735	-0.172484
	(0.16016)	(0.10002)
D(L_A_INDEX(-3))	0.150074	-0.118043
	(0.16385)	(0.10233)
D(L_A_INDEX(-4))	-0.038755	-0.133838
	(0.15580)	(0.09730)
D(L_A_INDEX(-5))	-0.125619	-0.150310
	(0.15845)	(0.09896)
D(L_A_INDEX(-6))	0.030172	-0.294015
	(0.16837)	(0.10515)
D(L_A_INDEX(-7))	-0.134428	-0.093294
	(0.17644)	(0.11020)
D(L_A_INDEX(-8))	-0.256714	-0.224011
	(0.18676)	(0.11664)
D(L_A_INDEX(-9))	-0.107001	-0.046642
	(0.18474)	(0.11538)
D(L_A_INDEX(-10))	0.104269	0.065373
	(0.16951)	(0.10586)
D(L_YARN_INDEX(-1))	0.462776	0.651530
	(0.28086)	(0.17541)
D(L_YARN_INDEX(-2))	-0.415676	-0.010996
	(0.29490)	(0.18417)
D(L_YARN_INDEX(-3))	0.116992	0.080451
	(0.26101)	(0.16301)
D(L_YARN_INDEX(-4))	0.404210	0.594731
	(0.27844)	(0.17390)
D(L_YARN_INDEX(-5))	-0.208854	0.234780
	(0.27631)	(0.17257)
D(L_YARN_INDEX(-6))	-0.462162	-0.024178
	(0.26728)	(0.16693)
D(L_YARN_INDEX(-7))	1.183249	1.003107
	(0.30178)	(0.18847)
D(L_YARN_INDEX(-8))	-1.405698	-0.316710
	(0.36613)	(0.22866)
D(L_YARN_INDEX(-9))	1.040027	0.320983
	(0.33605)	(0.20987)
D(L_YARN_INDEX(-10))	-0.000126	0.376232
	(0.34241)	(0.21384)
R-squared	0.664097	0.696037
Adj. R-squared	0.544131	0.587479
Sum sq. resids	0.150450	0.058682
S.E. equation	0.051833	0.032371
F-statistic	5.535735	6.411653
Log likelihood	130.9020	167.1497
Akaike AIC	-2.854596	-3.796096
Schwarz SC	-2.215376	-3.156876
Mean dependent	0.008950	0.005987
S.D. dependent	0.076768	0.050401
Determinant resid covariance (dof adj.)		1.66E-06
Determinant resid covariance		8.79E-07
Log likelihood		318.3291
Akaike information criterion		-7.099457
Schwarz criterion		-5.729701

References

Berck, P., Leibtag, E., Solis, A., & Villas-Boas, S. (2009). Patterns of Pass-Through of Commodity Price Shocks to Retail Prices. *American Journal of Agricultural Economics*.

Cotlook. (n.d.). Retrieved from Cotton Outlook: www.cotlook.com

Cotton Incoportated. (n.d.). *Retail Monitor.* Cary, NC: Cotton Incoportated.

Enders, W. (2004). *Applied Econometric Time Series.* Wiley.

EViews. (2007). EViews 7 Users Guide.

International Cotton Advisory Committee (ICAC). (2009). *World Textile Demand.* Washington DC: ICAC.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control, 12*, 231-54.

Kim, D., & Cotterill, R. W. (2008). Cost Pass-Through in Differentiated Product Markets: The Case of U.S. Processed Cheese. *Journal of Industrial Economics*, 32-48.

Leibtag, E., Nakamura, A., Nakamura, E., & Zerom, D. (2007). *Cost Pass-Through in the U.S. Coffee Industry.* Washington DC: USDA ERS.

Roeger, E., & Leibtag, E. (2011). *How Retail Beef and Bread Prices Respond to Changes in Ingredient and Input Costs.* Washington DC: USDA ERS.

Sims, C. A. (1980). Macroeconomics and Reality. *Econometrica, 48*(1), 1-48.

USDA Foreign Agricultural Service. (n.d.). Retrieved 2010, from Production, Supply, and Distribution Online: http://www.fas.usda.gov/psdonline/psdQuery.aspx