

## **Price dynamics in the U.S. Fiber Markets: Its Implications for Cotton Industry**

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## **Abstract**

The paper examines the price dynamics in the U.S. fiber market using error correction version of Granger causality test. Monthly prices are used to examine short-run and long-run price relationships simultaneously. Before specifying causal equations, time series properties of the prices are tested and are found to be first difference stationary and cointegrated. The causality results suggest weak lead-lag relationship between cotton and polyester prices in either direction. However, strongest relation is instantaneous feedback (within a month) between cotton and polyester prices. It may be interpreted from these results that any shock to the equilibrium relationships is mostly restored within a month. In addition, highly significant error correction terms in cotton and polyester equations also suggest the absence of distinct price leader which means both prices respond to restore equilibrium relationships.

# **Price dynamics in the U.S. Fiber Markets: Its Implications for Cotton Industry**

## **Introduction**

Cotton and manmade fibers are two most import textile fibers and collectively account for more than 95 percent of total U.S. fiber consumption (USDA, 2002). Although per capita fiber consumption in the U.S. has generally risen over times, changes in demand for specific fiber such as cotton and manmade fibers are normally dictated by changes in fashion trend, product acceptance and consumers' lifestyles (Meyers, 1999). For example, cotton accounted for 60 percent of total fiber demand in early 60s and over the next year, its share was cut in half due to popularity of manmade fibers. However, since early 80s, demand for cotton reversed its downward trend with per capita consumption rising from 20 pounds in 1982 to 35.8 pounds in 2000 (USDA, 2001). In addition, cotton mill demand is also affected by the relative prices of cotton to manmade fiber (Meyer, 1999).

Thus, the determination of extent of integration between cotton and manmade fibers is important and is the focus of this study. The results can be used to explore market structure, product substitutability and competitiveness of the markets. It can also be used in guiding model specification of more detailed structural analysis of fiber markets.

Literature review reveals that empirical studies dealing with price dynamics in the US fiber markets are currently limited. However, in crops such as wheat, market structure, price leadership, and efficiency of government interventions among others have been addressed in the context of international market (Goodwin and Schroeder 1991). In the context of cotton, producer spot prices of cotton from the Southwest region were

compared to futures prices for cotton to examine the cash/futures price relationship using a cointegration approach. The results showed that the cash producer price and the futures prices were not consistently related. The futures and cash prices were cointegrated in 2 of 4 years, while not cointegrated in the other 2 years (Hudson et al 1996). From previous studies, it is not clear whether there exist any price relationships between cotton and manmade fibers.

This study examines the causal relations between cotton and manmade fiber prices using error correction specification of Granger-causality analysis. The use of error correction approach allows the rigorous study of short-run and long-run price relationships simultaneously. The short-run elements describe the dynamics of moving towards a new equilibrium. The remainder of the paper is organized as follows. The next section describes the analytical approach, followed by a description of the data and the estimation procedure. Following this are the results of the analysis. The final section of the paper highlights the policy implications of the study.

### **Model Specification**

Granger causality test was first developed by Granger (1969) and then further modified by Sims (1972) and others. The definition of causality is that: ‘ $Y_t$  is causing  $X_t$  if we are better able to predict  $X_t$  using all the available information apart from  $Y_t$  (Granger, 1969). Instantaneous causality occurs when ‘the current value of  $X_t$  is better predicted if the present value of  $Y_t$  is included in the prediction than if it is not.

However, in the presence of cointegration, standard Granger causality test are mis-specified and the error correction models (ECM) should be used instead (Granger

1988). This test specifically allows for a causal linkage between two variables stemming from a common trend or equilibrium relationship (Miller and Russek, 1990).

The error correction equations used for testing causality between cointegrated variables are as follows:

$$\Delta Y_t = \alpha_1 + \mu_1 Z_{t-1} + \sum_{k=1}^m \beta_{1,k} \Delta Y_{t-k} + \sum_{k=1}^n \gamma_{1,k} \Delta X_{t-k} + \varepsilon_{1,t} \quad (1)$$

$$\Delta Y_t = \alpha_2 + \mu_2 Z_{t-1} + \sum_{k=1}^m \beta_{2,k} \Delta Y_{t-k} + \sum_{k=0}^n \gamma_{2,k} \Delta X_{t-k} + \varepsilon_{2,t} \quad (2)$$

$$\Delta X_t = \alpha_3 + \mu_3 Z_{t-1} + \sum_{k=1}^m \gamma_{3,k} \Delta X_{t-k} + \sum_{k=1}^n \beta_{3,k} \Delta Y_{t-k} + \varepsilon_{3,t} \quad (3)$$

$$\Delta X_t = \alpha_4 + \mu_4 Z_{t-1} + \sum_{k=1}^m \beta_{4,k} \Delta X_{t-k} + \sum_{k=0}^n \gamma_{4,k} \Delta Y_{t-k} + \varepsilon_{4,t} \quad (4)$$

where  $Y_t$  and  $X_t$  are cotton and manmade fiber prices in period t respectively.  $Z_{t-1}$  is the lagged error correction term. Equation 1 tests the hypothesis that manmade fiber price does not cause cotton price (i.e.  $H_0: \gamma_{1,k} = 0$  for all k). Equation 2 tests the instantaneous causality between cotton and manmade fiber prices. Finally, equation 3 tests the reverse causality that cotton price does not cause manmade fibers. However, ‘ $X_t$  causes  $Y_t$  instantaneously exists if and only if  $Y_t$  causes  $X_t$  instantaneously’ (Pierce and Haugh, 1977). Thus, equation 2 alone is enough to test instantaneous feedback between cotton and manmade fiber prices.

If both prices are found to have a long-run equilibrium relationship with unidirectional causality from cotton to manmade fiber, then it may imply that change in cotton price will influence manmade price but not vice-versa. Under this situation, any effort to expand cotton demand by lowering cotton price may not be very effective. In

addition, the information may be helpful in specifying structural model of demand and supply more accurately. For example, if we find cotton and manmade fiber prices move together without any distinct leader, then it may be appropriate to solve each of the price separately but allow them to stay within a band.

### **Data and Estimation**

The data used in this analysis are monthly spot price of upland cotton (Y) and mill-delivered price of polyester (X) between January 1975 and June 2002. The data are compiled from the National Cotton Council of America website which administers various price series for the U.S. fiber markets.

Prior to their use, the overall data set is seasonally adjusted and transformed into logarithm of prices. The test for stationarity is conducted on the logged series following Enders (1994) sequential test for stationarity using the Augmented Dickey Fuller (ADF). The method is a four-step procedure starting with the ADF model in its most unrestrictive form, which includes a drift and a time trend. The model is specified as follows:

$$\Delta Y_t = \alpha_0 + \alpha_j \sum_1^p \Delta Y_{t-j} + \gamma Y_{t-1} + \beta t + \varepsilon_t \quad (5)$$

where  $\Delta Y_t$  represents the change of  $Y_t$  and  $\varepsilon_t$  is a covariance stationary random error term. If  $\gamma$  is significantly different from zero, the test concludes no unit roots, otherwise, the coefficient on the time trend is tested in the second stage. If  $\beta$  is not significant, a second model is specified with the constant only. In the event that the constant is not significant, the model is run without the drift in the third stage. The test statistics is based on the McKinnon (1991) critical values. If the test finds that the series is not stationary,

while its first order difference is stationary, then  $Y_t$  is integrated of order 1 (i.e.,

$Y_t \sim I(1)$ ) and  $\Delta Y_t$  is integrated of order 0 ( $\Delta Y_t \sim I(0)$ ).

Test for stationarity is the first step in the cointegration analysis. Two series  $X_t$  and  $Y_t$  are said to be cointegrated if for  $X_t \sim I(1)$ , and  $Y_t \sim I(1)$ , there exists a series  $Z_t = Y_t - AX_t$  and a unique  $A$  such that  $Z_t \sim I(0)$ . Following Labys and Lord (1992), in the event that  $X_t$  and  $Y_t$  are cointegrated, there exists an ECM model in the form of, say, equations (1) and (3) for which at least one of  $\mu_1, \mu_3$  is non-zero and  $\varepsilon_{1,t}$  and  $\varepsilon_{3,t}$  are joint white noise. The white noise structure of the error terms will be tested using the Ljung-Box Q statistics.

If the series  $X_t$  and  $Y_t$  are found to be first-difference stationary, a cointegration test is conducted. Given the bivariate nature of the study, cointegration test between upland spot price and mill-delivered price of polyester is performed based on Engle and Granger (1987) method. The test consists of estimating the bivariate equations:

$$Y_t = c_j + b_j X_t + e_{j,t} \quad (6)$$

where  $X_t$  and  $Y_t$  remained as previously defined and  $j = 1, 2$ . The residuals  $e_{j,t}$  are collected and tested for stationarity using the ADF method. If the residuals are stationary then  $X_t$  and  $Y_t$  are cointegrated. In presence of cointegration, the lags of the residuals  $e_{j,t}$  in equation (6) are factored into the causality equation as an error correction term, which is specified as  $Z_{t-1}$  in equations (1) to (4).

## Results

The results of the stationarity test are summarized on table 1. Based on the values of the Akaike Information Criterion (AIC), the ADF was conducted using four lags. The final ADF test using the sequence described above includes a constant and a trend for upland spot price and mill-delivered price of polyester. The test shows that the null hypothesis of unit root is not rejected at the 1-percent for the upland spot price series and mill-delivered price of polyester. However, ADF test conducted on the first-difference indicates that both series are stationary at the 1-percent significance level. The results of the ADF show that both series are first-difference stationary, which leads to the cointegration test.

The cointegration test based on the Engle and Granger methods are summarized in table 2. The ADF tests on the residuals indicate that for both series, the residuals are stationary which confirm that mill-delivered price of polyester and upland spot price of cotton are cointegrated. This has some policy implications. That is if decision makers base their analysis solely on estimates derived from OLS and fail to account for the cointegration equations, they either under-predict or over-predict future price of cotton and polyester. The presence of cointegration is an indication that cotton and polyester markets are competitive markets and return to their long-run equilibrium following shocks in either market.

A correct estimation of the price relationships between mill-delivered price of polyester and upland spot price of cotton requires an estimation of ECM. The number of lags included in the ECM is the same as in the tests for the unit roots and cointegration. Validation of the ECM estimates is obtained by examining the Box-Pierce Portmanteau Q-statistic associated with the fitted residuals. The test shows no indication of



autocorrelation as the values of the Q-statistics at lag 10 were estimated at 10.517 and 8.201 for the polyester and the upland cotton price equations, respectively. Both values are less than  $\chi^2$  evaluated at the 5-percent significance.

The results of ECM based on equations 1 to 4 are summarized in table 3. Statistical insignificance of lag polyester prices in cotton equation and lag cotton prices in polyester equation indicates weak lead-lag relationship between these two prices. However, strongest relation is found to be instantaneous feedback (within a month) between cotton and polyester prices. Statistically significant error correction terms both in cotton and polyester equations may suggest that both prices adjust to restore long-run equilibrium. This is an indication that there is no distinct price leader in the fiber market. Following Ewing et al. (2000), the coefficient of the error correction term in an ECM is interpreted as a measure of the speed at which the series adjust to a change in equilibrium conditions. Thus, the results of the ECM estimation indicate that mill-delivered price of polyester returns to its equilibrium at a rate of 1.80 percent a month. Similarly, upland cotton price adjusts to change in its equilibrium conditions at a rate of 5.50-percent a month, three times faster than mill-delivered price of polyester.

The overall results suggest that both cotton and polyester prices adjust to return to long-run equilibrium from any short-term deviations. More importantly, most of the adjustments take place instantaneously, i.e., within a month. Based on the magnitudes of the equilibrium errors, it may also be interpreted that cotton price adjust to any disequilibria at a much faster rate than polyester price. These results may imply that any attempt to alter one price may have similar effects on the other price. For example, any policy designed to expand cotton demand by artificially lowering cotton price may also

result in decline in polyester. The end result may be much less increase in cotton demand than expected.

### **Concluding Remarks**

The objective of the study is to examine causal relationships in the U.S fiber market using monthly data on upland cotton spot prices and mill-delivered price of polyester from January 1975 to June 2002. An Error Correction Models (ECM) is used to conduct the Granger-causality test. The analysis indicates that the cotton and polyester markets are competitive and the two establish long run causal relationships and adjust to changes in their equilibrium conditions. However, the study found no evidence of leadership role between the two prices. Moreover, there is no indication of short run causality between upland cotton prices and polyester prices and vice versa. The analysis further suggests that upland cotton price adjusts to change in its equilibrium condition three times faster than the mill-delivered price of polyester. Since long run equilibrium with bi-directional causality exist, it can be inferred that any measure taken to expand cotton demand by lowering the cotton price will be much effective. In sum, it can be concluded that there is no distinctive leadership role between upland cotton and mill-delivered polyester market

Table 1. Nonstationary results using augmented Dickey-Fuller methods

Variable	Levels	First-difference
Polyester	-2.84	-5.52**
Cotton	-2.92	-7.89**

Notes: \*\*indicates significances at the 1% level using the McKinnon (1991) critical values. The test uses four lags for each variable.

Table 2. Cointegration test using Engle-Granger methods

Dependent variable	$c_j$	$b_j$	$R^2$	ADF
Polyester	2.23	0.48	0.30	-2.34*
Cotton	1.43	0.62	0.30	-2.66**

Notes: \*\* and \* indicate significance at 1% and 5 % levels, respectively. The test is based on equation (6), and the significance levels are based on the McKinnon (1991) critical values.

Table 3. SUR estimates for mill-delivered price of polyester and upland cotton price using a VECM

Independent variable	Equations		
	Cotton-led-polyester	Polyester-led-cotton	Instantaneous feedback
X(-1)	0.107 (1.978)	-0.004 (0.036)	-0.039 (0.304)
X(-2)	0.088 (1.636)	0.065 (0.507)	0.037 (0.291)
X(-3)	0.046 (0.847)	0.091 (0.712)	0.078 (0.608)
X(-4)	0.197 (3.643)	-0.036 (0.285)	-0.097 (0.751)
Y			0.323 (2.487)
Y(-1)	0.023 (0.963)	0.101 (1.768)	0.094 (1.629)
Y(-2)	0.0237 (0.991)	0.020 (0.355)	0.012 (0.216)
Y(-3)	0.0254 (1.064)	0.076 (1.315)	0.067 (1.166)
Y(-4)	-0.011 (0.470)	-0.004 (0.081)	-0.001 (0.017)
EC	-0.018 (2.141)	-0.055 (2.763)	-0.058 (2.901)
Q-statistics	10.517	8.201	8.369
Chi-square	3.402	0.873	

Notes: DPP represents the change in logarithm of mill-delivered price of polyester, DPC represents the change of logarithm of upland cotton price, EC is the error correction term and represents the lag of the residuals series derived from equation (6).

Q-statistics is the Ljung-Box statistics evaluated at lag 10. The Q-statistics has a chi-square distribution with a critical value evaluated at 8.31 at the 5% significance level, and the numbers in the parentheses are the absolute values of the t-statistics.

Chi-square statistics is used to test the joint hypothesis of causality. Critical values are evaluated at 9.49 using a 5 % significance level at 4 degrees of freedom. Number of degree of freedom is equal to the total number of restrictions used to test the null of no causality.

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