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Publisher Routledge

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Applied Economics Letters

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title-content=t713684190>

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First Published: June 2007

To cite this Article Pan, Suwen, Mohanty, Samarendu and Fadiga, Mohamadou (2007) 'Price asymmetry in the US fibre markets', *Applied Economics Letters*, 14:8, 545 — 548

To link to this Article: DOI: 10.1080/13504850600592523

URL: <http://dx.doi.org/10.1080/13504850600592523>

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Price asymmetry in the US fibre markets

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In this article, price linkages between cotton and polyester markets are investigated. After determining that the causality is present in both the directions, the nature of the price linkages was studied. The results suggest that polyester price responds asymmetrically to cotton price changes, whereas asymmetric response from cotton price to changes in polyester price is found to be weak. The results also did not support the hypothesis of contemporaneous effects between the polyester and cotton prices.

I. Introduction

Cotton and man-made fibres are the two most important textile fibres in the United States and they collectively account for more than 95% of total US fibre consumption (USDA, 2003). Although per capita fibre consumption in the United States has generally risen over time, changes in demand for specific fibres such as cotton and man-made fibres are normally dictated by changes in fashion trends, product acceptance and relative prices. For example, cotton accounted for 60% of total fibre demand in early 1960s but over the next few years, its share was cut in half due to the popularity of man-made fibres. However, since the early 1980s, demand for cotton reversed its downward trend with per capita consumption rising from 20 pounds in 1982 to 34.7 pounds in 2002 (USDA, 2003).

Meyer (1999) found a negative relationship between cotton consumption and the price ratio of cotton to polyester price. The price ratio captures the competitiveness of cotton with respect to polyester, i.e. if polyester is relatively lower priced, then fibre substitution may occur and less cotton is likely to be consumed. Similarly, Fang and Babcock (2003) also found a negative relationship between cotton consumption and the man-made fibre price in China while examining the factors causing the decline of

cotton share in fibre consumption. Additional studies that investigated the effects of price competitiveness on cotton market share include Shui *et al.* (1992) and Zhang *et al.* (1994). Thus, it is clear that fibre demand is dictated to some extent by relative prices. However, empirical studies focusing on price dynamics in the fibre markets are limited.

The purpose of this article is to test the relationship between cotton and polyester prices and, if it is the case that polyester price responds to cotton price and vice-versa, to determine whether such responses are asymmetric. In the next section, reasons for suspecting asymmetric price responses are presented. Then the approach used in testing for asymmetry is outlined, and the empirical results are reported.

II. Asymmetric Price Responses in the Fibre Markets

Figure 1 represents relationship between cotton and polyester prices based on the market structure. In a given year, the supply of cotton is fixed and is represented by the vertical line $S_c S_c$ whereas the supply of man-made fibre can be adjusted by changing the utilization rate depending on the fibre prices and is represented by $S_p S_p$. But the supply of

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Fig. 1. Asymmetric price relationship in the fibre markets

man-made fibre cannot be adjusted beyond certain level in the short-term because of capacity constraint. The demand for cotton and man-made fibres are represented by the $D_c D_c$ and $D_p D_p$, respectively. As the cotton price increases from P_c to P_{c1} due to shift in cotton demand from $D_c D_c$ to $D_{c1} D_{c1}$, the demand for man-made fibre also shifts out from $D_p D_p$ to $D_{p1} D_{p1}$ due to the substitution relationship between cotton and polyester at the mill level. Increase in polyester price also causes the supply to increase by moderating the effect of demand expansion on polyester price from P_p to P_{p1} . However, downward shift in cotton demand causes cotton price to drop from P_c to P_{c2} and shifts man-made fibre demand from $D_p D_p$ to $D_{p2} D_{p2}$. Although polyester demand declines because of substitution effect, its supply remains unchanged, causing the price to drop to P_{p3} instead of P_{p2} to clear the market. Overall, this model suggests that polyester market shows greater response to falling cotton prices than to rising cotton prices.

III. Analytical Approach

Following Chavas and Mehta (2002), let $y_t = (y_{1t}, y_{2t})$ be a vector of cotton and polyester prices at time t , the error correction model of vector autoregression (VAR) can be represented as

$$\Delta y_t = \alpha + B_0 y_{t-1} + \alpha_1 T + \sum_{s=1}^{S-1} \alpha_s D_{ts} + \sum_{k=1}^{K-1} B_k \Delta y_{t-k} + e_t \quad (1)$$

A time trend T and seasonal dummies D_{ts} can be included in the model if there exist long-term price trends and seasonal effects.

To analyse the asymmetric response in the model, Equation 1 is modified and the positive and negative changes of cotton and polyester prices are included. At time t , let $\Delta y_{t-j}^+ = \max(\Delta y_{j,t-j}, 0)$ and $\Delta y_{t-j}^- = \min(\Delta y_{j,t-j}, 0)$, then

$$\Delta y_{it} = \alpha_{i0} + \alpha_{i1} t + \sum_{j=1}^m B_{0j} y_{j,t-1} + \sum_{l=1}^{L-1} \alpha_{il} D_{il} + \sum_{k=1}^K \sum_{j=1}^m [B_{kij}^+ \Delta y_{j,t-k}^+ + B_{kij}^- \Delta y_{j,t-k}^-] + e_{it} \quad (2)$$

where $i = 1, 2$ for cotton and polyester.

Next consider the Cholesky decomposition of the variance of e_t : $\Omega = SS'$, where

$$S = \begin{bmatrix} s_{11} & 0 \\ s_{21} & s_{22} \end{bmatrix}$$

is a lower triangular matrix satisfying $S_{ii} > 0$.

Equation 2 can be alternatively written as:

$$\begin{aligned} S^{-1} \begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \end{bmatrix} &= S^{-1} \alpha + S^{-1} \alpha_1 t \\ &+ S^{-1} B_0 y_{t-1} + \sum_{l=1}^{L-1} S^{-1} \alpha_l D_{il} \\ &+ \sum_{k=1}^{K-1} S^{-1} [B_k^+ \Delta y_{t-k}^+ + B_k^- \Delta y_{t-k}^-] + \varepsilon_t \end{aligned} \quad (3)$$

where $\varepsilon_t = S^{-1} e_t$ is normally distributed with mean zero and variance I_2 . The covariance between cotton price and polyester price is $\text{cov}(y_{1t}, y_{2t}) = s_{11}s_{21}$ and the contemporaneous impact of a shock in y_{2t} on y_{1t} is $\partial y_{1t} / \partial y_{2t} = s_{21} / s_{11}$. The null hypothesis of $s_{21} = 0$ is used to test whether there are contemporaneous cross-price effects between cotton and polyester.

To test whether price respond asymmetrically to price increases vs. price decreases, we only need

Table 1. Nonstationary results using augmented Dickey–Fuller methods

Variable	Level	First difference
Cotton price	−0.40	−17.02**
Polyester price	−0.06	−15.51**

Notes: ** indicates rejection of null hypothesis of nonstationary or unit roots at 5% significance level. Critical value is 2.87.

to test whether $\mathbf{B}^+ = \mathbf{B}^-$. The lags in the equation can be used to capture the shocks after k lag, which allows for dynamic asymmetry to vary between the short run and the intermediate run. A likelihood ratio test is used for the asymmetry test.

Under cointegration, the model captures deviations from long-term relationships among prices. If $\mathbf{B}_0 = 0$, the model is the same as the Miller and Hayenga (2001) specification of time domain model. A Johnson cointegration test for the null hypothesis $H_0: \text{rank}(\mathbf{B}_0) = 0$ vs. $H_1: \text{rank}(\mathbf{B}_0) = 1$ is calculated by a likelihood ratio test.

The Granger causality between cotton price and polyester price is easy to test based on the model. The null hypothesis of no causality between y_c and y_p is the same as $B_{0ij} = 0$, $B_{kij}^+ = B_{kij}^- = 0$ for all $k = 1, 2, \dots, K-1$. The associated likelihood-ratio test also can be used to perform this test.

The S_{21} allows for situation-specific contemporaneous cross-price effects. If $S_{21} = 0$, the result implies zero contemporaneous effects between the cotton price and the polyester price.

IV. Data and Estimation

Monthly fibre prices for the period of January 1975 to December 2003 were collected from National Cotton Council to estimate the model. The specific price series for cotton and polyester were national average of mill-delivered prices. The SE of monthly changes in average cotton price and polyester price was 10.29 and 11.36, respectively.

Diagnostic tests were conducted on both cotton and polyester prices. The augmented Dickey–Fuller (ADF) test for a unit root was implemented for each price separately with a drift component and time trend. This was done based on a model with six lags in prices themselves and five lags in price differences. The lag structure was determined using the Akaike information criterion (AIC). Based on ADF test statistics, unit roots cannot be rejected for both price series in levels at the 5% significance level. However, the unit root hypothesis is rejected for both series when they are expressed as first differences at the

same significance level (Table 1). Because determination of the lag order using statistical tests alone has been criticized, the ADF test is conducted using different lag orders. These alternative representations did not alter the results discussed earlier in this article.

Given that we are not interested in asymmetric responses among all of the variables (e.g. lagged cotton price on current cotton price, lagged polyester price on current polyester price), we only include asymmetric adjustment terms for the lagged polyester price on cotton and lagged cotton price on polyester. The error correction specification (Equation 3) was estimated using the maximum likelihood estimation. The number of lags to include in both the equation was determined using the AIC and was found to be five.

V. Results

The parameter estimates along with SE for both cotton and polyester equations are reported in Table 2. The negative and significant time trend in the cotton price equation and its insignificance in the polyester equation reflect that the spread between these two prices has increased over time during the sample period. The statistical significance of the coefficients of lagged own and cross price variables in the cotton and polyester equations indicate the presence of significant dynamic adjustments in the fibre markets.

The likelihood ratio test for Granger causality is -16.66 for the effects of lagged cotton on polyester prices and -14.82 for the effects of lagged polyester price on cotton price. Comparing the calculated test statistic with the critical value at the 5% significance level (i.e. 12.59), we reject the null hypothesis that cotton prices do not Granger cause the polyester prices and polyester prices do not Granger cause cotton prices. Similarly, own lagged prices are found to be statistically significant at 5% level both in cotton and polyester equations.

Similarly, a likelihood ratio test was adopted to test asymmetric price transmission between cotton and polyester prices. The results suggest that positive and negative cotton price changes generate different responses on polyester price whereas the asymmetry response on cotton price due to increase and decrease in polyester price tends to be weak. Finally, the statistical insignificance of S_{21} implies no contemporaneous relationship between cotton and polyester prices.

Table 2. Joint estimation for cotton and polyester prices

Parameters	Cotton price estimate	SE	Polyester price estimate	SE
Constant	4.44***	1.66	1.44***	0.09
Trend	-0.35**	0.16	0.06	0.18
Lag of cotton price	-0.12***	0.03	-0.004	0.01
Lag of polyester price	0.08**	0.04	-0.02**	0.01
Positive cotton price shock after lag 1			0.07**	0.04
Positive cotton price shock after lag 2			-0.07**	0.03
Positive cotton price shock after lag 3			0.09**	0.04
Positive cotton price shock after lag 4			-0.06**	0.04
Positive cotton price shock after lag 5			0.07*	0.04
Negative cotton price shock after lag 1			-0.04**	0.02
Negative cotton price shock after lag 2			0.05**	0.02
Negative cotton price shock after lag 3			0.03*	0.02
Negative cotton price shock after lag 4			0.03	0.02
Negative cotton price shock after lag 5			0.01	0.02
Positive polyester price shock after lag 1	-0.09	0.24		
Positive polyester price shock after lag 2	0.23	0.23		
Positive polyester price shock after lag 3	0.23	0.23		
Positive polyester price shock after lag 4	-0.03	0.23		
Positive polyester price shock after lag 5	-0.16	0.24		
Negative polyester price shock after lag 1	0.28	0.32		
Negative polyester price shock after lag 2	-0.06	0.35		
Negative polyester price shock after lag 3	0.15	0.32		
Negative polyester price shock after lag 4	0.21	0.32		
Negative polyester price shock after lag 5	-0.27	0.31		
Dummy between January 1975 and January 1982 (D1)	0.98	1.29	0.57*	0.33
Dummy for 1989, 1990 (D2)	2.85*	1.65	1.49***	0.51
Dummy for 1995 (D3)	0.16	1.28	1.35***	0.44
S_{11}	4.75**	0.18		
S_{22}	1.47**	0.06		
S_{21}	0.06	0.06		

Notes: Log-likelihood = -1002.06; Number of observations = 342.

*Significant at 10%; **Significant at 5%; and ***Significant at 1%.

VI. Concluding Remarks

This study used Chavas–Mehta model to determine cotton and polyester price dynamics in the US fibre market. The results provide strong evidence of long-term asymmetrical price transmissions for cotton price on polyester price. However, we did not find any evidence that there exists asymmetrical transmission for polyester price on cotton price. Our results also did not support the contemporaneous effects hypothesis between cotton and polyester prices.

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