Common Trends, Common Cycles, and Price Relationships in the International Fiber Market- Evidence from a Seemingly Unrelated Structural Time Series

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Abstract
This study shows that the stochastic process that governs price fluctuations in the international fiber market has transitory and permanent components. The results also indicate structural relationships between cotton price and wool price, wool price and oil price, rayon price and cotton price, and between polyester price and cotton price.

Key Words: Unobserved components, state-space, Kalman filter, fiber prices, and cofeature

JEL Classification: C32, Q11

Introduction

Commodity price behavior has been the subject of numerous studies in recent years. These studies have mainly focused on the question of price instability and their effects in both developed and developing economies. Studies on speculation induced instability, commodity export instability, and domestic and international stabilization programs have widely addressed the question of commodity price instability (Labys, Badillo, and Lesourd, 1998). However, events such as China's admission into the World Trade Organization, the approaching expiration of the Agreement on Textile and Clothing (ATC), the elimination of the Multifiber Arrangement (MFA), and the spillover effects of domestic policies in major cotton exporting and importing countries have contributed to increased level of uncertainties in the world fiber market, thereby generating a renewed interest on the topic.

For cotton exporting countries such as the U.S. and the Sub-Saharan African countries, higher production and contraction or stagnation of the domestic textile industry has led to increased level of raw fibers exports. Raw fibers exports as a share of total production in the Sub-Saharan countries has increased from 60 percent in 1980/82 to 85 percent in 2000/02, and as a share of world cotton export from 6.9 to 17.3 percent, while the U.S. export of raw cotton fiber has increased from 29.5 percent to 35 percent during the same period (ICAC, 2003). Cotton export earnings for these countries depend on higher international prices for cotton.

Although there are mechanisms in place to help cope with depressed cotton prices, the instability of world cotton price remains detrimental to most producers and exporters, especially those from developing countries where financial resources to sustain such programs are rare. This is especially important for the SSA countries, which have undertaken major steps to liberalize their domestic textile sector, privatize their ginning industries, and cease most forms of subsidies allocated to their agricultural sector under the structural adjustment program advocated by the World Bank and the International Monetary Fund. This new paradigm has increased the vulnerability of producers in these countries to downturns in international prices of cotton. The uncertainties in international cotton market also have detrimental macroeconomic effects because for most of these countries cotton contributes between 5 and 10 percent of the GDP and between 20 and 40 percent of total export earnings (World Bank, 2000). Hence shortfalls in export earnings generally result in current account deficits that cause further economic damages.

For the importing countries, cotton and polyester are the dominant fibers in their import mix; however, wool and rayon are important because their behaviors are to some extent tied to the dominant fibers price dynamics. For instance, at the mill level, the degree of inter-fiber combination in the production of various blends of textile products is dictated by the attributes sought in specific end-use products and by fiber relative prices. However, studies in that regard have mainly focused on cotton and polyester although similar adjustments with respect to wool and rayon do occur.

Clearly, understanding the behavior of fiber price and their inter-relationships are important for both the importing and exporting countries. For the importing countries, it enables a more efficient planning at the mill level and reduces the uncertainties that impede their textile manufacturing activities. For the exporting countries, it enables to better cope with price risks in the international market and to limit government intervention at the domestic level that may have undesirable spillover effects, especially in vulnerable countries. However, focusing on the fibers individually cannot fully explain the dynamics of fiber prices in the international fiber market. A flexible approach is needed to accommodate all the adjustments between competing fibers. This study, therefore, utilizes a system of seemingly unrelated time series equations (SUTSE) to analyze the behavior of fiber prices in the international market. This framework provides the possibility to investigate the long run and short run dynamics of fiber prices, while modeling the observed and unobserved components associated with them. The decomposition of economic series in terms of their respective components can help understand how these components relate to the underlying economic phenomena that shape their evolution (Kasa, 1992).

The components have important policy implications for both the developing and the developed countries. For instance, the amplitude and duration of fiber prices cycle are key elements for designing policies to smooth terms of trade shocks and the resulting macroeconomic effects of cotton prices in countries such as those in Sub-Saharan Africa and to craft efficient countercyclical policies in developed countries to help producers cope with price fluctuations (Cashin and McDermott, 2002; Deaton, 1999; and Deaton and Miller, 1996). The possibility to simultaneously model the independent variables, including intervention variables with the unobserved components is an added advantage of the proposed approach in comparison to structural econometrics or pure time series modeling.

Numerous approaches to decompose economic series in terms of their permanent and transitory components have been proposed in the economic literature. Beveridge and Nelson (1981) proposed the use of ARIMA structure to decompose non-stationary U.S. business cycle indicators into long-run trend and transitory cycle. In this decomposition, the systematic part of the series is the combined effects of its transitory/cyclical and its long-run/permanent component. In the long run, however, the transitory component fades away and the series converges to its long run equilibrium namely its permanent component. The Beveridge-Nelson decomposition does not, *a priori,* assume a deterministic trend; however, the fact that it is based on an ARIMA model is a major weakness because for such a structure it is quite frequent that more than one specification fit the same data, thus, rendering the model selection somewhat subjective (Harvey, 1985). Consequently, the derived estimates may be perceived as representing one out of many possible specifications. This prompted Watson (1986) to guard against using such models for inferences about long-run behaviors of economic series.

The structural time series approach proposed in this study uses the Kalman filtering procedure in a state-space form to model the components (trend and cycle) and the structural relationships between the fiber prices and their determinants. Unlike the decomposition approach based on ARIMA model, the state-space modeling using the Kalman filtering approach does not require stationary series and does not make any prejudgment with respect to the nature of the trend or cycle. Under this procedure, the stochastic or deterministic nature of the trend or the cycle is solely driven by the data. The deterministic trend/cycle is a limiting case of their stochastic counterparts when their respective disturbance converges to zero.

Data Considerations

The data used in this study consists of current international price of cotton (A-index), wool, rayon and polyester in U.S. dollar per kilogram between 1960 and 2002, cotton change in stock, and West Texas Intermediate (WTI) crude oil price. The fiber prices are primarily from the World Bank and the International Cotton Advisory Committee and summarized in Baffes (2004), cotton change in stocks are from USDA-FAS PS&D in thousand of metric tons. The WTI crude oil prices are in U.S. dollars per barrel retrieved from Economagic website. The WTI is chosen and used as a proxy of world oil price because the oil market is integrated and follows the law of one price (Ewing, 2000 and Serletis, 2002). Nominal prices were used instead of real prices. Doing so enables to avoid contamination problems that could arise from the secular and cyclical properties of the price deflator used to convert nominal prices into real prices (Labys, Badillo, Lesourd, 1998). Moreover, because all real fiber prices are linked through the price deflator renders the estimation prone to autocorrelation problems. All the price data were transformed in logarithm format before their use.

Instability in the International Fiber Market

As Table 1 suggests, on average, wool prices are higher, followed by polyester, rayon, and cotton. Polyester and wool prices are more skewed and kurtotic than cotton and rayon prices. The negative skewness observed for cotton and rayon are indicative of a predominance of downward spikes for both of these fibers throughout the sample periods. Meanwhile the high kurtosis observed in wool and polyester prices suggests occurrence of large price movements through the sample period (Cashin and McDermott, 2002). These dynamics are consistent with an uncertain fiber market subject to shocks from various sources, including climatic, economic, and biologic.

The instability index measured by the ratio of the standard deviation of the series to its mean indicates a certain degree of instability over the sample period for all fiber prices. However, the instability of the four fiber prices has been declining over the years. For instance, polyester price variability was evaluated at 46.37 percent for the 1960-75 period, 16.76 percent for the 1975-1990, and 15.79 percent for the 1990-2002 period. Clearly, the degree of instability as presented depends on the chosen sample. In the case of cotton, the results suggest an increased level of instability from 16.37 to 22.85 percent for 1975-1990 and the 1990-2002 periods, respectively. The increased level of instability may be a result of expanding supply due to higher production from the U.S. and SSA countries.

Instability index as a measure of uncertainty in commodity price, though widely used, presents serious shortcomings because it is a descriptive measure while the process that generates the unpredictability in price is stochastic in nature embedded in the series' permanent and transitory components (Dehn, 2000). While Dehn recognized the importance of filtering out the price series of its permanent components to generate meaningful structural relationships, he used a GARCH (1, 1) model to measure uncertainty in which the conditional mean equation (first difference of the series) was specified as a function of a quadratic deterministic trend, lags of the dependent variable, seasonal dummies, and a constant term. This approach, however, has three shortcomings: first, it assumes a deterministic trend, which is a limiting case of its stochastic counterpart; second, it does not account for the variance due to the transitory component; and third, it is less accurate because the GARCH model is sensitive to the underlying distribution of the error term, which is known to be non-normal in the case of price series.

The state-space model under the Kalman filtering procedure offers the possibility to decompose each fiber price in terms of their respective components and generate filtered series through a recursive process that holds true regardless of distribution of the error term (Tsay, 2003).

Co-movements and Cofeatures in the International Fiber Market

Test of stationarity based on the Augmented Dickey-Fuller (ADF) method revealed that cotton price, polyester price, wool price, and rayon prices are nonstationary; while their first-differences are stationary that is $I(0)$. Thus all four fibers are integrated of order one ($I(1)$) and the underlying trends governing their evolution are stochastic. Cointegration test based on the Johansen method was conducted and the likelihood ratio statistics in Table 2 confirmed a rejection of the null of "no cointegrated" relationship at the 1 percent significance level. Thus the four fiber prices establish a long run equilibrium relationship and are governed by three stochastic trends.

The next step was to investigate whether the fiber prices share common cycles following a procedure first proposed by Engle and Koziki (1993) and empirically applied in Vahid and Engle (1993; 1997). Per Vahid and Engle, first-difference stationary variables that share common features also share common cycle at their level. Features in this context refer to characteristics such as heterokedasticity, serial correlation, and seasonality (Vahid and Engle, 1993). The test is basically a cointegration test that uses the canonical correlations between the first difference stationary fiber prices and their past values in a vector error correction model (VECM) that contains the common features and cointegration information.

Following Vahid and Engle (1993), a system of $n = 4$ elements containing r cointegrated vectors was developed using a VECM of order $p - 1$ which also contains s cofeatures. Under this framework, the number of common trend is $n - r$ and that of common cycle is $n - s$ with $n = r + s$. This approach enables to test the null of no serial correlation cofeature against the alternative of at most s serial correlations. The test statistic used is based on Tiao and Tsay (1985) test of significance of the smallest s canonical correlations. The statistic is defined as $C(p,s) = -(T - p - 1)\sum_{i=1}^{s}\log\left(1 - \lambda_i^2\right)$ where T is the sample size and $\lambda^2{}_i$ is the squared canonical correlation between ΔY_t and $\left(\Delta Y_{t-1}, \Delta Y_{t-2}, \ldots\ldots \Delta Y_{t-p}\right)$. It is distributed as a Chi-square with $s^2 + snp + sr - sn$ degrees of freedom.

The results in Table 3 indicate that the canonical correlations were not significantly different from zero at the 1-percent level. Thus the test concluded there were three independent cofeature vectors, which correspond to one common cycle. The results of the cointegration and cofeature analysis are incorporated in the structural time series equations to restrict the number of trend to three and that of cycle to one.

Seemingly Unrelated Structural Time Series

Following Harvey (1989, 1990) and Koopman et al. (2000), a structural time series of international fiber market may be modeled using a two-step procedure consisting of a stochastic component formulation and explanatory variables specification. The stochastic component formulation that is consistent with the above cointegration and cofeature analysis can be formulated as follows

$$Y_t = \Theta_\mu \mu_t + \mu_\theta + \Theta_\psi \psi_t + X_t B + \varepsilon_t$$

$$\mu_t = \mu_{t-1} + \eta_t$$

$$\begin{bmatrix} \psi_t \\ \bar{\psi}_t \end{bmatrix} = \rho \begin{bmatrix} \cos \lambda_c & \sin \lambda_c \\ -\sin \lambda_c & \cos \lambda_c \end{bmatrix} \begin{bmatrix} \psi_{t-1} \\ \bar{\psi}_{t-1} \end{bmatrix} + \begin{bmatrix} \varpi_t \\ \bar{\varpi}_t \end{bmatrix} \tag{4}$$

where Y_t is an 4×1 vector of fiber prices, μ_t is a stochastic trend, ψ_t is a stochastic cyclical component, while ε_t represents the irregular component. The stochastic properties of the trend and cycle are solely driven by η_t , ϖ_t , and $\bar{\varpi}_t$. Each of the unobserved components in equation (4) is assumed to be normally distributed with mean 0 and variance Σ_ε , Σ_η , and Σ_ϖ for the irregular, the trend, and the cycle, respectively. The variance pertaining to the cycle disturbance is the common variance of $\left[\varpi_t, \bar{\varpi}_t\right]'$. Under a typical SUTSE the specification the variances matrices in this case is a 4×4 matrix. In the event that any of the variances matrices are zero, the stochastic specification reduces to a deterministic model.

The above specification reflects the presence of common factors in the trend and cycle through the parameter vector Θ also referred to as factor loading matrix. Because the international fiber market is governed by three common stochastic trends and one common cycle as found in the cointegration and cofeature tests, the variance of the stochastic component governing the trend is $\Sigma_\eta = \Theta D_\eta \Theta'$ while that of the cycle is $\Sigma_\varpi = \Theta_\psi D_\varpi \Theta'_\psi$ with D_η and D_ϖ the diagonal matrices containing the standard deviation of the innovations of the trend and cycle of each fiber prices. This is a multivariate random walk comprised of three common stochastic trends, a common stochastic cycle with a damping factor $\rho \in [0,1]$ and frequency $\lambda_c \in [0,\pi]$ common to all four series. Lastly, X_t is a vector of explanatory variables containing the lags of cotton, wool, rayon, and polyester prices, current oil price and changes in stocks and B is a vector of their respective coefficients. The specification of each fiber price with the independent variables differs from one another. Each fiber price was specified as a function of its own lag and current oil prices. Cotton price was also function of changes in stock and lag of wool price, rayon price was specified as a function of lag of cotton and wool price, while polyester was specified a function of lag cotton price.

Statistical Treatment and Estimation

The structural time series model as defined in equation (4) and (5) can be put into a state- space form and estimated efficiently via maximum likelihood procedure using the Kalman filtering process (Harvey 1989, 1990; De Jong, 1991; Koopman et al. (2000). The state-space form consists of a measurement and transition equations also referred to as signal and state equations. The measurement and transition equation (ignoring the vector of explanatory variables for simplicity) may be specified as follows

$$Y_t = Z_t\alpha_t + G_t u_t \,, \tag{6}$$

$$\alpha_{t+1} = T_t\alpha_t + H_t u_t \tag{7}$$

In equations (6) and (7), Y_t is the vector of interest and remained as earlier defined, α_t is the state vector, Z_t and T_t are fixed matrices of known values, while G_t and H_t are sparse matrices for which the non-zero values are unknown and will be estimated. Since the specified model is a stochastic trend without slope and a stochastic cycle, its state-space representations under a SUSTE is as follows

$$Y_t = \begin{pmatrix} I & 0 & 0 \end{pmatrix}\alpha_t + \begin{pmatrix} \Gamma_\varepsilon & 0 & 0 & 0 \end{pmatrix}u_t$$

$$\alpha_t = \begin{pmatrix} I & 0 & 0 \\ 0 & \rho\cos\lambda_c I & \rho\sin\lambda_c I \\ 0 & \text{-}\rho\sin\lambda_c I & \rho\cos\lambda_c I \end{pmatrix}\alpha_{t-1} + \begin{pmatrix} 0 & \Gamma_\eta & 0 & 0 \\ 0 & 0 & \Gamma_\varpi & 0 \\ 0 & 0 & 0 & \Gamma_\varpi \end{pmatrix}u_t \tag{8}$$

In this specification, I is a 4×4 identity matrix, $\alpha_t = \left(\mu_t, \psi_t, \bar{\psi}_t\right)'$, $u_t = \left(\varepsilon_t, \eta_t, \varpi_t, \bar{\varpi}_t\right)'$, while Γ_ε, Γ_η, and Γ_ϖ also referred to as hyper-parameters are, respectively, the lower triangles of the variance covariance matrix of the irregular, trend, and cycle stochastic components. These parameters along with the factor loading matrix, the damping factor, the frequency of the cycle, and the parameters of explanatory variables are simultaneously estimated by maximum likelihood procedure using the Structural Time Series Analyzer, Modeler, and Predictor (STAMP). The Kalman procedure follows a recursive method that uses all available information up to time $t-1$ to compute the optimal estimates of the mean and the parameters of the state vector at time t that minimize the mean-squared error of the conditional mean of the series (Harvey, 1989). Once the parameters of the state vector have been estimated that is at steady level, the procedure then estimates the structural relationships between the filtered series (dependent variables) and the specified independent variables.

Empirical Results

The estimated model is a multivariate random walk that is a common stochastic trend with no slope. Overall three stochastic trends and one stochastic cycle were fitted. The results are presented in Table 4. The estimated factor loading matrix pertaining to the level components lead to the following relationships between prices in the international fiber market that is $\mu_{wt} = 0.131\mu_{ct}$, $\mu_{rt} = 0.157\mu_{ct} + 1.997\mu_{wt}$, and $\mu_{pt} = 0.086\mu_{ct} - 0.196\mu_{wt} - 0.064$ where c, *w, r*, and *p* refer to cotton, wool, rayon, and polyester. The estimated factor loading matrix of the cycle using the same subscripts as in the trend indicate cycles are proportional to each other that is $\psi_{wt} = 4.129\psi_{ct}$, $\psi_{rt} = 0.844\psi_{ct}$, and $\psi_{pt} = -1.265\psi_{ct}$. The common cycle has a period of 4.427 years (close to standard business cycle) with a frequency of 1.419 and a damping factor of 0.936, which is indicative of a stationary cycle. Thus in the long run, the cyclical component dissipates and the forecast of each price series converges toward their trend value.

The results in Table 4 also indicate that the stochastic nature of international fiber price originates from the irregular, trend, and cycle components all of which are stochastic because the estimated variances (hyper-parameters) are greater than zero. In general, most of the disturbances in fiber price originate from innovations from the trend components followed by the irregular, and then by the cyclical component. With respect to the trend component, cotton exhibits more variability. The standard deviation of cotton trend is eleven times larger than that of polyester price, four and a half times that of wool, and three an a half times that of rayon. Thus, forecasting future price using trends is less reliable for cotton price than for polyester because of the uncertainty and variability pertaining to cotton price. Wool price exhibits the highest cyclical innovation, followed by polyester, cotton, and rayon. The decomposition and estimation of the trend and cyclical innovations enables to measure the importance of permanent (trend) shocks relative to transitory (cycle) by calculating the ratio of the permanent innovation to the cycle innovation (i.e., $\sigma_\eta / \sigma_\omega$). The results confirm the importance of permanent innovations compared to transitory innovations for all fibers. Permanent shocks last longer for cotton and rayon than for polyester and wool.

An important finding of this study pertains to the estimated values of the correlation coefficients of trend disturbances between all fibers. While the values enable to measure the degree of relationship between fibers in the long run, they also confirm the necessity to jointly estimate the dynamics of all fibers and therefore confirm the validity of the approach followed in this study. The correlation coefficients of the disturbances between wool and rayon (0.977), cotton and polyester (0.923), cotton and wool (0.579) are high and suggest shocks from either fiber have repercussion on the other fiber. The results further indicate some degree of transmission of shocks between rayon and cotton (0.395) and wool and polyester (0.222), while rayon and polyester appear not sensitive to shocks from each other because of their correlation coefficient estimated at 0.013.

The maximum likelihood estimates of the final state vector and the explanatory variables are presented in Table 5. The parameter estimates μ_T is the estimates of the true value of the trend at steady state (i.e., $t = T$). Taking the exponential of μ_T yields the trend value corresponding to the level of each price. Thus, the trend value at the end of the period is 0.388 for cotton, 1.277 for wool, 0.916 for rayon, and 0.803 for polyester. With regard to the cycle, the amplitude is calculated from the estimated state parameters ψ_T and $\bar{\psi}_T$ of the cycle. The results indicate that the amplitude of the cycle as a percent age of the trend is 1.381 percent for cotton price, 5.704 for wool, 1.165 for rayon, and 1.748 for polyester.

Finally, the relationship between the each fiber price and a set of pertinent independent variables is evaluated. As previously pointed the dynamics in the international fiber market are driven by the interaction of complex phenomena, which determine market clearing conditions and the price level in each sector. It is understood that relative prices determine fiber demand at the mill level. In this paradigm shocks from various sources including climatic, technological, and economic, trigger spillover effects to other sectors because of price realignments, thereby condition demand, price, and supply level. From this viewpoint, price relationships between different fibers measure whether such spillover effects are taking place. The results show cotton price in the international market responds positively to wool price, oil price, and changes in stocks. The results also indicate that current cotton price responds negatively to past cotton price. Wool price is positively related to past wool price and oil price. Price of rayon responds positively cotton price, wool price, past rayon price, and oil price. Lastly, polyester responds negatively to price of cotton and positively to past polyester price and oil price.

Conclusion

This study proposed a state-space model using the Kalman filtering technique to decompose international cotton, wool, rayon, and polyester prices into their irregular, trend, and cyclical component. The study found all components (trend, cycle, and irregular) are stochastic and determine the degree of uncertainty in the international fiber market. For instance cotton price had experienced the most volatile trend, while polyester price trend was the most stable. Furthermore, the ratio of the cycle innovation to the permanent innovation confirms the importance of permanent innovations compared to transitory innovations for all fibers. Thus, while the study confirms the cyclical nature of international fiber market, shocks pertaining to the cycle are indeed transitory, while shocks pertaining to the trend (permanent) last longer. Among these fibers, permanent shocks for cotton and rayon last longer than permanent shocks for polyester and wool.

The study identifies the existence of co-movements and cofeatures in the international fiber market. Based on the Johansen cointegration test and the Vahid and Engle cofeature test, the study identifies there common stochastic trends and one common stochastic cycle. These features were factored in the modeling approach and the result confirm that international fiber market follow a periodicity similar to that of a standard business cycle.

Lastly, the estimated structural relationships, after filtering out these components, show cotton price positively responds to wool price, oil price, and cotton changes-in-stock. Wool price responds positively to oil price, rayon price responds positively to oil price, cotton price, and wool price, while polyester responds positively to current oil price.

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Table1. Summary Statistics

	Cotton	Wool	Rayon	Polyester
Mean	1.274	2.532	1.531	1.540
Standard Deviation	0.473	1.125	0.772	0.472
Skewness	-0.105	0.612	-0.022	0.744
Kurtosis	1.625	3.168	1.468	3.279
Instability index				
1960-2002	37.13%	44.43%	50.42%	30.65%
1960-1975	34.01%	38.42%	27.95%	46.37%
1975-1990	16.37%	35.87%	24.01%	16.76%
1990-2002	22.85%	19.23%	8.45%	15.79%

Notes: Instability index refers to the ratio of the standard deviation to the mean.

Table 2. Evidence of Cointegration in the International Fiber Market

Hypothesis about rank r	Eigenvalue	Likelihood Ratio	Critical Value (5%)	Critical Value (1%)	Decision
r = 0	0.586	60.510	47.210	54.460	None **
r ≤ 1	0.296	24.350	29.680	35.650	At most 1
r ≤ 2	0.194	9.935	15.410	20.040	At most 2
r ≤ 3	0.026	1.069	3.760	6.650	At most 3

Note: ** indicates that the null hypothesis of no cointegrating relationship is rejected at the 1-percent level in favor of at least one cointegrating relationship. The Johansen likelihood ratio test concludes that there are at least three common trends in the international fiber market.

Table 3. Evidence of Cofeatures in the International Fiber Market

Null Hypothesis	Canonical Correlations λ	χ^2 Statistics C(s,p)	Degrees of Freedom	Critical value	P-value
s>0	0.068	2.760	2	5.990	0.252
s>1	0.110	7.285	6	12.590	0.295
s>2	0.218	16.859	12	21.030	0.155
s>3	0.497	43.696	20	31.410	0.002

Notes: The canonical correlations that are not significantly different from zero are indicative of the number of independent cofeatures vector. Thus test shows the existence of one common cycle in the international fiber market.

Table 4. Estimation of Common Trend and Common Cyclical Components

Fibers	Factor (Θ_μ)			Factor (Θ_ψ)	Fixed Value (μ_θ)	Trend S.D. (σ_η)	Irregular S.D.(σ_ε)	Cycle S.D. (σ_ϖ)
Cotton	1	--	--	1	0	0.122	0.068	0.005
Wool	0.131	1	--	4.129	0	0.027	0.021	0.021
Rayon	0.157	1.997	1	0.844	0	0.048	0.029	0.004
Polyester	0.086	-0.196	0.000	-1.265	-0.064	0.011	0.098	0.006

Notes: The matrix Θ_μ (Θ_ψ) is a proportionality factor between trends (cycles) of the four fibers, while μ_θ refers to the fixed value of the trend. The trend, irregular, and cycle S.D. refer to the standard deviations of the disturbance associated to the trend and cycle of each fiber and govern their stochastic nature. The additional parameters associated with the cycle are a damping factor ρ estimated at 0.936, a cycle period is $2\pi / \lambda_c$ evaluated at 4.427 (4 and 1/2 years) and frequency λ_c estimated at 1.419. The likelihood function is evaluated at -637.539.

Table 5. Maximum Likelihood Estimates of the Coefficients of the Final State Vector and Explanatory Variables

		Cotton		Wool		Rayon		Polyester	
Variable	Label	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
				State Vector Coefficients Estimation					
μ_T	Level	-0.946***	0.271	0.244*	0.131	-0.087	0.127	-0.218***	0.089
ψ_T	Cycle	0.011	0.010	0.043	0.043	0.009	0.008	-0.013	0.013
$\bar{\psi}_T$	Cycle	0.089	0.010	0.0371	0.044	0.007	0.009	-0.011	0.014
				Explanatory Variables Parameters Estimation					
$CSTK_T \times 10^{-4}$	Change in Stock	0.597***	0.129	--	--	--	--	--	--
$LAindex_{T-1}$	Cotton Price	-0.506***	0.133	--	--	0.121**	0.061	-0.078	0.081
$LWool_{T-1}$	Wool Price	0.201**	0.089	0.331***	0.125	0.112***	0.043	--	--
$Lrayon_{T-1}$	Rayon Price	--	--	--	--	0.214***	0.081	--	--
$Lpoly_{T-1}$	Polyester Price	--	--	--	--	--	--	0.911***	0.045
$LWTI_T$	Oil Price	0.271***	0.085	0.169***	0.067	0.173***	0.039	0.078**	0.038
				Model Diagnostics					
R^2	Goodness of Fit	0.891		0.799		0.991		0.891	
Q(10, 6)	Autocorrelation	11.544		10.906		10.475		17.165	
H(13)	Heterokedasticity	1.369		0.604		0.721		0.785	

Notes: The steady state level, t=T, represents the point at which the relationship between unobserved component/explanatory variables and state dependent variables are evaluated. The signs ***, **, and * illustrate significance at the 1-, 5-, and 10-percent level. No t-statistics is provided for ψ_T and $\bar{\psi}_T$ because of the transitory nature of the cycle component making such statistics inappropriate (see Koopman et al., 2000). The values of Q(10,6) that are less than $\chi^2(6)$ at the 1-percent level =16.81indicate no autocorrelation, while the values of H(13) that are less than $F_{(13,13)\ 0.01}$=4.36 indicate no heterokeasticity.