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STRUCTURAL TIME SERIES ANALYSIS OF U.S. COTTON EXPORTS

Mohamadou Fadiga
Department of Agricultural and Applied Economics
Texas Tech University
Lubbock, TX

Abstract

This study employs a structural time series method to model and estimate U.S. cotton exports. The results show that the fluctuations observed in U.S. cotton exports have transitory (cycle), secular (trend), and seasonal characteristics. The estimated structural relationships after accounting for the impact of the unobserved components indicate that U.S. cotton exports volume responds positively to higher international price relative to domestic price of cotton and negatively to real exchange rate volatility. The study also confirms that the U.S. government export-marketing loan program has a significant and direct effect on U.S. cotton exports.

Introduction

A difficult competitive environment has led the U.S. textile industry to shift from the production of high-valued end-use products and to focus more on production and exports of low-valued products such as yarns and fabrics (Hudson and Ethridge, 2000). This new strategy has contributed to the vitality of textile industries in the developing world, especially in Asia, the Caribbean basin, and Mexico leading to increased demand for cotton in these areas. The volume of shipment was evaluated at 11.9 million bales for the 2002-2003 marketing year, which represents 38.7% of the world cotton exports (USDA, 2003). Most of the exports are directed to countries where the U.S. has a sizable share of the cotton markets with Mexico (96.3%), China (60.7%), Turkey (72.3%), Pakistan (56.0%), India (32.3%), Canada (100%), South Korea (31.7%), Thailand (29.3%), Indonesia (37.6%), and Taiwan (44.4%). As textile industries in these countries are increasingly searching for high quality cotton fibers and reliable supply sources, the U.S. shares are expected to remain high in the foreseeable future.

While cotton exports volume is generally determined by a favorable parity between international price and domestic price of cotton, i.e. exports flow is expected to increase when international price of cotton is above domestic price, economic fluctuations such as downturns in foreign textile manufacturing activities and currency realignments remain determining factors. For instance, a relative appreciation of the dollar with respect to the currencies of the U.S. textile trading partners, 13% since the 90's according to MacDonald (2002), and the Asian financial crisis have been identified as the main reason for the decline in U.S. cotton exports between the 1996/97 and 2000/01 marketing years.

Though it is widely accepted that robust industrial activities have positive effects on exports, empirical evidence about the effects of exchange rate and exchange rate volatility on trade flows, including commodity exports, is not unequivocally established. Studies conducted in this area have led to contradictory conclusions despite hypothesizing that exchange rate volatility hinders exports (Bini-Smaghi, 1991), Chowdhury (1993), and Arize (1995, 1996), among others.

The conflicting empirical results from previous studies are due to specification problems. For instance, while volatility is perceived as a risk, in many studies, it is derived as a moving average of the growth rate of real exchange rate. The moving average process only accounts for the expected volatility and thereby does not fully measure risk (Bini-Smaghi, 1991). Chowdhury (1993) also pointed out other procedural flaws in earlier studies stemming from a failure to account for the possible integration and long run relationship between exports volume and most of its determinants, including exchange rate and world price. When two variables integrated of order one establish a long-run relationship, either an error correction model (ECM) or first-order autoregressive distributed lag model (ADL(1)) can be used to assess the short and long run dynamics between the variables. However, these methods provide little to no information with respect to the trend, cyclical, and seasonal components of the series.

To circumvent the procedural limitations as previously outlined, this study proposes a structural time series approach that uses the Kalman filtering procedure in a state-space form to model the components (trend, seasonal, and cycle) and the structural relationships between exports and its determinants. Modeling the unobserved components along with the economic variables affecting exports volume provides the possibility to isolate the different sources of fluctuations and thereby better assess the contribution of each set of variables to exports flow.

Procedures and Data Consideration

This study proposes a structural time series approach to model and estimate the relationship between cotton exports and its determinants. The particularity of this procedure compared to ECM and ADL(1) is that the independent variables, including intervention variables are modeled simultaneously with the unobserved components (trend, cyclical, and seasonal). As Kasa (1992) noted, the decomposition of economic series in terms of their respective components helps to understand how these components relate to the underlying economic forces that shape their evolution. Thus, a structural time series approach provides a unique framework to model the unobserved components and the explanatory variables. The stochastic component formulation is as follows

$$XP_t = \mu_t + \psi_t + \gamma_t + \varepsilon_t$$
$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t$$
$$\beta_t = \beta_{t-1} + \xi_t \qquad (1)$$

where XP_t represents the export volume of upland cotton (1000 480-lbs bales), μ_t is a stochastic level, β_t is a slope of the trend, ψ_t is a stochastic cyclical component, γ_t is a vector of seasonal dummies, while ε_t represents a white noise irregular disturbance. The stochastic property of the level and slope are driven by η_t and ξ_t, which are uncorrelated random errors. Each of the unobserved components in equation (1) is assumed to be normally distributed with mean 0 and variances σ_ε^2, σ_η^2, and σ_ξ^2. If any of these variances converges to zero, the stochastic component becomes purely deterministic. If all variances governing the trend converge to zero, then the stochastic model collapses into a purely deterministic model that can be estimated using OLS estimation technique. The above stochastic specification is extended to include explanatory variables and intervention dummies to account for the effect of government policies in the cotton export sector. The structural time series model of the U.S. cotton exports is therefore specified as

$$XP_t = \mu_t + \psi_t + \gamma_t + aXP_{t-1} + bPR_t + cSVX_t + dD85 + \varepsilon_t \qquad (2)$$

where $D85$ is a dummy intervention indicating the beginning of the export-marketing assistance for cotton equal to zero before 1985 and one thereafter, PR is an indicator of competitiveness and is defined as the ratio of international price of cotton measured by the Cotlook A-index (cents/lb) and the U.S. domestic mill price (cents/lb), and SVX is the stochastic volatility of exchange rate. The stochastic volatility series is constructed following a transformation based on a Taylor series of real cotton trade-weighted exchange rate index (base year 2000). The above specification is put into a state space form and estimated by maximum likelihood procedure using the Kalman filtering technique. Detailed explanations of the procedure are provided in Harvey (1989, 1990), de Jong (1991) and Koopman et al. (2000).

The data used in this study are monthly data between 1980:01 and 2002:12 compiled from various sources, which include USDA 2002 Cotton and Wool Situations for cotton export volume, USDA-ERS (2003) for the real trade-weighted exchange rate for cotton, and the National Cotton Council of America (2003) for the domestic and A-index prices. Stationarity test based on the Augmented Dickey-Fuller method indicates that XP is integrated of order 1, while a plot of the series (not provided) does not show any noticeable slope. Most of the changes in patterns of the series can be attributed to the embedded seasonal components. Thus, the stochastic component in equation (2) reduces to a stochastic trend with a fixed slope, stochastic cycle, seasonal dummies, and an irregular component.

Empirical Results

The estimation results confirm the stochastic characteristics of cotton exports. The stochastic characteristics of U.S. cotton export are governed by two stochastic cycles with standard deviations evaluated at 0.053 and 0.0708. The standard deviation of the irregular disturbance is estimated at 0.217. The results also show the seasonal and trend components are purely deterministic as the estimated variances of the seasonal and trend disturbances converge to zero. Thus, there is a clear indication that the observed variations in U.S. cotton exports are primarily the results of cyclical innovations.

The estimated parameters of the cycle show that U.S. cotton exports follow two cyclical patterns, one with period of approximately 12 months with a damping factor estimated at 0.90, and a variance of 0.016 and the other with a period of 22 months, a dumping factor estimated at 0.93, and a variance of 0.364. A damping factor less than 1 is indicative of a stationary cycle.

The results on the estimation of the final state vector indicate that the level and slope of the trend are significant at the 1% level. The results are summarized in Table 1 and show a trend level estimated at 8.032 with a slope estimated at 0.0012. The estimated value of the slope parameter indicates that U.S. cotton exports increase at a rate of 1.45% a year. With respect to seasonality, the results show a significant difference between the month of December and all the remaining months except November. However, these parameters are only indicative of potential impacts of seasons on U.S. cotton exports. Further analysis of the effects of seasons on U.S. cotton exports is provided in Table 2. The results show that U.S. cotton exports, on average, are above the level of the trend from November through May with exports in March almost 43% above the level of the trend while cotton exports in September are 39% below.

Further, the estimation of the independent variables in the final state vector (Table 3) reveals that the coefficient of lag of export is between 0 and 1 and significantly different from 0, which confirms that U.S. cotton exports follows an adaptive expectation framework. The estimated coefficient of lagged of exports allows to explore long-run impacts of each independent variable in the model.

The ratio of A-index to the U.S. domestic price of cotton is significant and greater than one. Thus, U.S. cotton exports increase with international price relative to domestic price of cotton. A one-unit increase in the price ratio between international and domestic prices of cotton results in 2.622 units of cotton exports. The effect of exchange rate volatility was also estimated. The estimated parameter is negative as hypothesized and is significantly different from zero at the 10% level. Thus, U.S. cotton exporters seem to reduce their activities when facing exchange rate uncertainty. The results also indicate that the marketing loan assistance program has a significant impact on the U.S. cotton exports. This finding corroborates previous USDA's assessment that the program contributes significantly to annual exports of raw cotton (USDA, 1998).

The forecasting performance of the model is evaluated by comparing the actual values of the U.S. cotton exports with the forecasted values for the period between May 2001 and December 2002. The results as shown in Figure 1 indicate that in most cases this procedure adequately forecast monthly U.S. cotton exports.

Conclusion

This study modeled simultaneously U.S. cotton exports with its unobserved components determinants, including an intervention dummy in a state space format using the Kalman filter. A unit root test indicated that U.S. cotton exports could be specified as a stochastic trend with fixed slope and two stochastic cycles. The results of this study showed a presence of short run dynamics that are both stochastic (cycle) and deterministic (seasons). The estimated variances of the cycles and irregular disturbances were all non-zero confirming the presence of two stochastic cycles with periods of 11 and 22 months. There is a clear indication that the effects of seasons account for most of the short run dynamics of U.S. exports because of the fluctuations around the trend line as the seasonal analysis at end of period suggests. The degree of fluctuations is also high whether above the trend line (i.e., between November and May) or below the trend line (i.e., between June and August).

The estimated structural relationships between exports and its determinants indicate that U.S. cotton exports are responsive to favorable international to domestic prices of cotton ratio. Moreover, cotton exports are also sensitive to real exchange rate volatility. Finally, the government export-marketing loan program has a significant effect in U.S. cotton exports. All of these characteristics have to be taken into account to generate reliable forecasts useful to the industry and policymakers.

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Table 1. Estimated Coefficients of the Trend and Seasonal Components.

Variables	Parameters	Estimates	Standard Error
Level	$\bar{\mu}_t$	8.032[a]	1.912
Slope	β_t	0.0012[a]	0.0004
January	γ_1	0.148[b]	0.0645
February	γ_2	0.358[a]	0.0632
March	γ_3	0.229[a]	0.0622
April	γ_4	0.184[a]	0.0637
May	γ_5	0.316[a]	0.0617
June	γ_6	0.151[b]	0.0660
July	γ_7	-0.331[a]	0.0677
August	γ_8	-0.481[a]	0.0640
September	γ_9	-0.306[a]	0.0636
October	γ_{10}	-0.231[a]	0.0618
November	γ_{11}	-0.059	0.0621

Notes: (a) and (b) indicate significance at the 1 and 5% level.

Table 2. Seasonal Analysis at End of Period.

Seasons	Seasonal Factor at Log	Seasonal Factor at Level	Percentage
January	0.1844	1.2025	20.25
February	0.2299	1.2586	25.86
March	0.3587	1.4316	43.16
April	0.1481	1.1596	15.96
May	0.0268	1.0209	2.09
June	-0.0594	0.9422	-5.77
July	-0.2307	0.7939	-20.61
August	-0.3065	0.7360	-26.39
September	-0.4811	0.6118	-38.19
October	-0.3314	0.7179	-28.21
November	0.1509	1.1630	16.29
December	0.3163	1.3721	37.21

Note: Seasonal factor is a factor of proportionality by which to multiply other component to get the systematic part of the series. Percentage is the percentage of the observed seasonal value above or below the trend line.

Table 3. Estimated Coefficients of Explanatory Variables.

Variables	Parameters	Estimates	Standard Error
XP_{-1}	a	0.2093[a]	0.0525
PR	b	2.6228[a]	0.2559
SVX	c	-0.9704[c]	0.6044
$D85$	d	0.1414[c]	0.0841

Notes: (a) and (c) represent significance at the 1 and 10% levels.

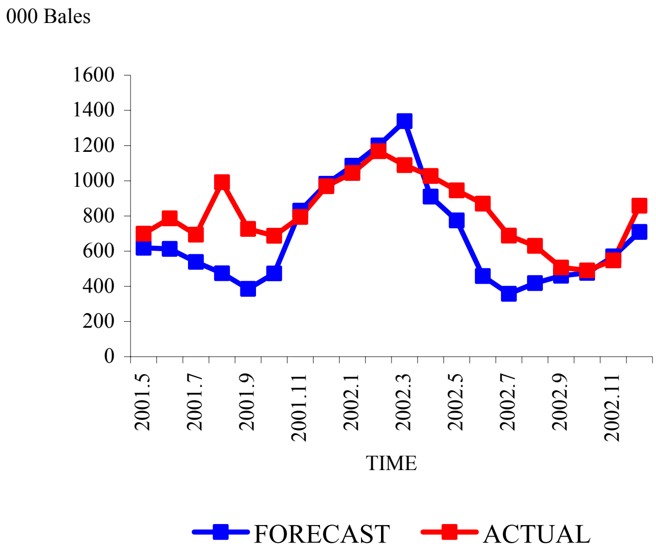

Figure 1. Forecast and Actual Values of Monthly U.S. Cotton Exports.