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ABSTRACT. Expansion of the cotton industry depends on economic growth. Models

were specified to estimate U.S. domestic and export demand with and without structural

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KEYWORDS: Economic model, exchange rates, GDP, oil prices.

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INTRODUCTION

Cotton accounts for about one-half of the total fiber used in the world, making it the single most important textile fiber. Producing 20 percent of the world's supply, the United States ranks second only to China as the largest cotton producing country (Glade *et al.* 1996). Cotton is a major commodity for the United States generating about $4-5 billion in annual cash receipts (Dodson 1995). Furthermore, cotton is a major raw material for the textile and apparel industries creating heavy dependence by these industries on cotton production.

The demand for raw cotton fiber is derived from consumer demand for textile products where cotton is an important textile fiber. Total U.S. fiber consumption has risen dramatically over the past 35 years. Despite this increase, U.S. domestic consumption of cotton declined from a postwar peak of 5 billion pounds in 1966 to 3.1 billion pounds in 1982. Since 1982, domestic cotton consumption has rebounded achieving a new record of 9.3 billion pounds in 1998 (U.S. Department of Agriculture 1999).

Cotton export levels have also changed substantially over the past several decades. During the period 1945-1975, U.S. raw cotton exports accounted for nearly one-third of total cotton disappearance. From 1978-1984 cotton exports rose to more than half of the disappearance. In 1985-1986, however, U.S. prices were supported above those charged by competing exporters, and U.S. exports subsequently fell below 1.0 billion pounds. Between 1986 and 1991 exports averaged 3.3 billion pounds, which

was 45 percent of total use (Glade *et al.* 1996). Competitively priced foreign cotton limited U.S. exports once again in 1992, but exports in 1994 achieved a new record of 4.5 billion pounds to comprise more than 45 percent of total use. Exports fell once again in 1998 to 2.0 billion pounds, comprising just one-third of total use (U.S. Department of Agriculture 1999).

 The purpose of this study was to analyze the U.S. domestic and export demand for cotton as part of global economic conditions. Specific objectives were to determine the factors that influence the domestic and export demands for cotton.

The paper begins with background information and moves to a discussion of the data and empirical model, followed by results and discussion. Finally, conclusions and recommendations are drawn.

BACKGROUND

Cotton has been subject to wide swings in production, stocks, and prices over the last few decades. U.S. cotton acreage rose steadily from 7.7 million acres at the end of the Civil War until peaking at 46 million acres in 1925. Planted area declined from an average of 43.9 million acres between 1925 and 1929 to just 10.8 million acres between 1985 and 1989 (Glade *et al.* 1996). U.S. cotton acreage has since rebounded, averaging 14 million acres since 1990 (U.S. Department of Agriculture 1999). The decline in cotton acreage since the 1920s can be attributed to two important long-term forces: changes in cotton cultivation techniques and implementation of government policies (Glade *et al.* 1996). The adoption of new technology resulted in rising yields and increased production that, in turn, lowered prices and income. Consequently, acreage allotments, marketing quotas, price support programs, and other production control programs were prominent

features of U.S. government programs designed to limit supply from the 1930s to the 1970s. Since the early 1970s, however, strong demand and export sales combined with an effective government cotton program (marketing loan and market promotion programs) designed to keep U.S. cotton prices competitive in both the domestic and export markets have boosted cotton industry prospects (Smith 1993).

DATA AND EMPIRICAL MODEL

Domestic End-use Demand for Cotton

The term "end-use" for cotton, based on the Food and Agricultural Organization (FAO) definition, means apparent consumption of cotton derived from mill use plus net textile product trade balances (MacDonald 1997). Cotton data were collected from the Economic Research Service (U.S. Department of Agriculture 1999).

Assuming that consumers act rationally by maximizing utility, cotton demand is influenced mainly by income and prices. Prices include own price, price of major substitutes, and the price of energy. The price of energy is important because cotton is an input for textile production requiring considerable energy consumption.

The Gross Domestic Product (GDP) obtained from the Bureau of Economic Analysis (U.S. Department of Commerce, Bureau of Economic Analysis 2000) was used for the income variable. Since cotton competes with other fibers in the same market, the relative price of cotton to that of polyester (average mill price ratio) was used (Sukar 1991 and U.S. Department of Agriculture 1999). The price of energy was that for Saudi Arabian Light-34 crude oil (U.S. Department of Energy 2000).

Data covered the years 1975-99. Prices and income were deflated using the Consumer Price Index (CPI) 1995 = 100 (U.S. Department of Labor 2000). The model is

constructed on a per capita basis using historical national population estimates (U.S. Department of Commerce, Census Bureau 2000a). Based on goodness of fit, the model is in log-log form, thus the estimated parameters are also elasticities.

The equation to be estimated is as follows:

(1) $\ln USCD = b_0 + b_1 \ln GDPUS + b_2 \ln RCP + b_3 \ln OILP,$

where USCD is the U.S. per capita domestic demand (lbs end-use) of cotton, GDPUS is U.S. per capita GDP, RCP is the price of U.S. domestic cotton relative to the U.S. polyester price, and OILP is the price of oil, Table 1.

In order to gain greater predictive power, the model was modified to accommodate structural change according to the work of Valderrama (1991). The modified model, which allows the coefficients for income, relative price, and the price of oil to vary with respect to the business cycle, is as follows:

(2) $\ln USCD = b_0 + b_1 \ln GDPUS + b_2 \ln RCP + b_3 \ln OILP + b_4 \ln GDPUS * D$

$$+ b_5 \ln RCP * D + b_6 \ln OILP * D,$$

where $D = 1$ for the years when U.S. domestic cotton demand declined (1977, 1980-1982, 1988, 1990, 1995, and 1996) over the study period, 0 otherwise.

Export Demand for Cotton

In addition to the variables included in the domestic demand relationship for a U.S. commodity, other variables complicate the situation for a U.S. export commodity. The demand for U.S. exports can shift suddenly and substantially because of changes in exchange rates and highly variable weather patterns around the world (Collins *et al*. 1980; Manchester 1985). Weather patterns affect the production and availability of commodities in competing and importing countries. One way to account for these

phenomena is through the effects on beginning stocks (U.S. Department of Agriculture 1999).

The coincidence of the depreciation of the dollar against many foreign currencies with the attendant rapid expansion of U.S. agricultural exports in the 1970s has suggested to some economists that there is a strong relationship between the exchange rate and international agricultural trade (Collins *et al*. 1980). The exchange rate is thought to be an important factor impacting the export market and hence the U.S. share of the world market for cotton. An increase in the value of the dollar may induce a change in world trade patterns, especially if developing cotton-producing countries are willing to expand production and thus exports to capture hard currencies. The exchange rate is expected to have a negative effect on the U.S. export demand for cotton. In other words, a decrease in the value of the dollar is expected to foster an increase in U.S. cotton exports and vice versa.

The effect of cotton price on export demand for U.S. cotton was tested using the ratio of the world price of cotton in dollars (deflated A index, Liverpool Cotton Services (1975-2000), U.S. CPI, 1995=100) to the Taiwan polyester price, one of the lowest polyester prices in the world. A weighted average world price of polyester was not available. The Taiwan polyester price data (1975-1999) were converted to U.S. dollars (Yuan 1999) and then deflated using the U.S. CPI, 1995=100.

The estimated equation of U.S. export demand for cotton is as follows:

(3) $\ln \text{USEX} = b_0 + b_1 \ln \text{GDPW} + b_2 \ln \text{RCWP} + b_3 \ln \text{OILP} + b_4 \ln \text{EXR}$
$+ b_5 \ln \text{BSRW},$

where USEX is U.S. net exports of cotton in lbs per capita , GDPW is world per capita GDP (International Monetary Fund 1999b and U.S. Department of Commerce, Census bureau 2000b), RCWP is the world price of cotton relative to the Taiwan price of polyester, OILP is the price of oil, EXR is the Atlanta Fed Dollar Index (Federal Reserve Bank of Atlanta 2000), and BSRW is the beginning stock of cotton in the rest of the world (Table 1).

To account for structural change, the same logic used in the domestic demand model was applied to the export demand model. The estimated equation is as follows:

$$(4) \quad \ln \text{USEX} = b_0 + b_1 \ln \text{GDPW} + b_2 \ln \text{RCWP} + b_3 \ln \text{OILP} + b_4 \ln \text{EXR}$$
$$+ b_5 \ln \text{BSRW} + b_6 \ln \text{GDPW} * D + b_7 \ln \text{RCWP} * D + b_8 \ln \text{OILP} * D$$
$$+ b_9 \ln \text{EXR} * D + b_{10} \ln \text{BSRW} * D,$$

where $D = 1$ for the years when the export demand for U.S. cotton declined (1980, 1982,1984, 1985,1987-88,1990-92, 1995-96 and 1998) over the study period, 0 otherwise.

RESULTS AND DISCUSSION

The models were estimated with ordinary least squares (OLS). The Durbin-Watson test revealed autocorrelation of the first degree in the U.S. cotton demand model without structural change. Therefore, Yule-Walker estimates were used to correct for autocorrelation. Theoretical grounds for the autocorrelation t-test are in Brockwell and Davis (1996, p.274-329).

The equations were estimated in log-log form, thus coefficients are also elasticities. Results for the estimated equations are presented in Tables 2 through 5.

U.S. Domestic Demand for Cotton

The results for the estimated demand equation for cotton in the Unites States are summarized in Tables 2 and 3. The factors influencing U.S. cotton demand are GDP and the price of oil. Income positively affects the demand for cotton, with income elasticity equal to 2.28 and 2.30 for the initial and modified models, respectively. These results are consistent with the fact that textile products are readily consumed in response to rising income. Oil prices had the expected negative effect on cotton demand with an estimated elasticity equal to -0.11 and -0.15 for the initial and modified models, respectively. The decrease in demand for domestic U.S. cotton due to an increase in the price of petroleum may be explained in two ways. First, oil is an input in cotton production and consumption. Second, rising oil prices tend to reduce real income where income has been found to have a positive effect on demand for U.S. cotton.

The results did not show a significant effect of the relative price of cotton to the price of non-cotton fiber on the domestic consumption of cotton in either model. These results may be explained by the International Cotton Advisory Committee's findings concerning the varying "non-price competitiveness" of cotton. The U.S. Department of Agriculture has invested heavily in research and promotion to increase the recognition and use of cotton products by industry and consumers. As a result, the behavior of consumers has shifted in response to these promotion efforts (MacDonald 1997).

Figures 1 and 2 show the actual and predicted values for U.S. cotton consumption using the two models. The second model, which accounts for structural change, estimates U.S. cotton demand slightly better during periods of slow economic growth (early 80s). For the 90s, both models underestimate cotton consumption which may be explained by a

shift in consumer demand because of promotion efforts as described previously. The correlation between fitted and actual cotton consumption further indicates that the model with structural change (correlation coefficient of 0.968) predicts slightly better than the model without structural change (correlation coefficient of 0.962).

Export Demand for U.S. Cotton

The results show that the export demand for U.S. cotton is dominated by the influence of beginning stocks in the rest of the world (BSRW) with and without structural change. The elasticity of export demand with respect to BSRW indicates that a 1 percent increase in BSRW decreases the export demand for cotton by 1.02 and 0.77 percent, respectively, for the initial and modified models (Tables 4 and 5). Beginning stocks of cotton in the rest of the world are directly related to cotton production and demand in the rest of the world in the previous year.

Cotton production in the rest of the world, which is a function of unpredictable climate forces, varying production technologies, and producer responses to market prices, is outside the purview of U.S. control. Thus, the logical approach is to take advantage of rising world per capita income, shifting the U.S. export demand for cotton through import loan and export promotion programs for U.S. cotton (Smith 1993).

Although the effect of world income on U.S. export demand for cotton is not highly significant, it is worthwhile to point out the positive relationship that exists between the two variables. The elasticity of export demand with respect to world gross domestic product (GDPW) indicates that a 1 percent increase in GDPW increases the export demand for cotton by 2.26 and 2.13 percent, respectively, for the initial and modified models (Tables 4 and 5)

Figures 3 and 4 show the actual and predicted U.S. export demand for cotton without and with structural change, respectively. The correlation between fitted and actual U.S. cotton exports indicates that the model with structural change (correlation coefficient of 0.846) predicts better than the model without structural change (correlation coefficient of 0.763).

CONCLUSIONS AND RECOMMENDATIONS

The analysis of U.S. domestic demand for cotton revealed that rising income increases the total consumption of cotton, domestic as well as that in imported textile products. The price of energy, i.e., the price of oil, is also a determining factor for U.S. cotton demand as an increase in the price of oil reduces the demand for cotton.

The analysis of U.S. export demand for cotton revealed that beginning stocks of cotton in the rest of the world is the paramount factor affecting export demand, impacting negatively. Thus, this strong inverse relationship can serve as one possible indicator of profitability at planting time by U.S. producers. Though not the dominant factor, per capita world income was found to be positively related to U.S. cotton exports.

Finally, given the importance of the export market to the viability of the U.S. cotton industry, continued emphasis should be placed on means to increase the U.S. export demand for cotton. Such means should include, but not be limited to, creative and flexible import loan and export promotion programs to meet competition at every avenue.

In the end, the demand for cotton depends heavily on favorable economic conditions in the United States and abroad. In such an environment, U.S. competitive advantage will depend on the resolve for excellence in technological development, the

resolve to fight trade barriers in whatever form they may take, and the resolve to develop

and use state-of-the-art marketing tools.

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TABLE 1. Description of the Variables Included in the Models and Data Sources

Variable	Description	Source
USCD	U.S. domestic demand (end-use) for cotton (lbs/capita).	U.S. Department of Agriculture 1999
GDPUS	U.S. Gross Domestic Product ($/capita) deflated by U.S. CPI, 1995 = 100.	U.S. Department of Commerce 2000
CP	Average mill price of cotton (cents/lb) deflated by U.S. CPI, 1995 = 100.	U.S. Department of Agriculture 1999
RCP	Ratio of CP to the price of polyester.	U.S. Department of Agriculture 1999
CWP	Cotton world price, "A" Index (cents/lb) deflated by U.S. CPI, 1995 = 100.	Liverpool Cotton Service 1975-2000
TPP	Taiwan polyester price ($NT/Kg), converted to U.S. $. (cents/lb) deflated by U.S. CPI, 1995 = 100.	Liverpool Cotton Service 1975-2000
RCWP	Ratio of CWP to the TPP.	
USEX	U.S. per capita net export of cotton (exports-imports), expressed in lbs.	U.S. Department of Agriculture 1999
BSRW	Beginning stocks in the rest of the world (lbs/capita).	U.S. Department of Agriculture 1999
EXR	Atlanta Fed Dollar Index.	Federal Reserve Bank of Atlanta 1973-1999
OILP	Oil Price, Saudi Arabian Light-34 in $/barrel, deflated by U.S. CPI, 1995 = 100.	U.S. Department of Energy 1999
GDPW	World Gross Domestic Product deflated by U.S. CPI (1995 = 100) in ($/capita).	International Monetary Fund 1999b

TABLE 2. Estimated U.S. Cotton Demand without Structural Change, 1975-99

Explanatory Variable	Parameter Estimate	t-value
Intercept	-19.720	-5.359***
GDPUS	2.280	6.585***
RCP	0.160	1.212
OILP	-0.114	-1.690*

$R^2 = 0.876$

F-value = 98.998

Root MSE = 0.0742

Degrees of Freedom = 24

Autoregressive Parameter Estimation

Lag	Coefficient	Std Error	t-value
1	-0.4547	0.1991	-2.284

*** Denotes statistically significant at 99 percent confidence level

*   Denotes statistically significant at 90 percent confidence level

TABLE 3. Estimated US Cotton Demand with Structural Change, 1975-99

Explanatory Variable	Parameter Estimate	t-value
Intercept	-19.801	-5.530***
GDPUS	2.303	6.889***
RCP	-0.064	-0.371
OILP	-0.159	-2.147**
DGDP	-0.004	-0.154
DRCP	0.290	0.871
DOILP	0.003	0.039

$R^2 = 0.98$

F-value = 45.137

Root MSE = 0.0917

Degrees of Freedom = 24

*** Denotes statistically significant at 99 percent confidence level

** Denotes statistically significant at 95 percent confidence level

TABLE 4. Estimated U.S. Cotton Export Demand without Structural Change, 1975-99

Explanatory Variable	Parameter Estimate	t-value
Intercept	-23.067	-1.396
BSRW	-1.027	-3.755***
RCWP	-0.390	-1.370
GDPW	2.261	1.672
EXR	0.887	0.772
OILP	0.109	0.687

$R^2 = 0.620$

F-value = 6.216

Root MSE = 0.225

Degrees of Freedom = 24

*** Denotes statistically significant at 99 percent confidence level

TABLE 5. Estimated U.S. Cotton Export Demand with Structural Change, 1975-99

Explanatory Variable	Parameter Estimate	t-value
Intercept	-23.090	-1.459
BSRW	-0.779	-2.479**
RCWP	-0.294	-0.949
GDPW	2.131	1.563
EXR	1.066	0.901
OILP	0.149	0.933
DBSRW	-0.645	-1.219
DRCWP	-0.324	-0.624
DGDPW	0.134	0.313
DEXR	-0.036	-0.040
DOILP	-0.150	-0.645

$R^2 = 0.780$

F-value = 4.981

Root MSE = 0.199

Degrees of Freedom = 24

** Denotes statistically significant at 95 percent confidence level
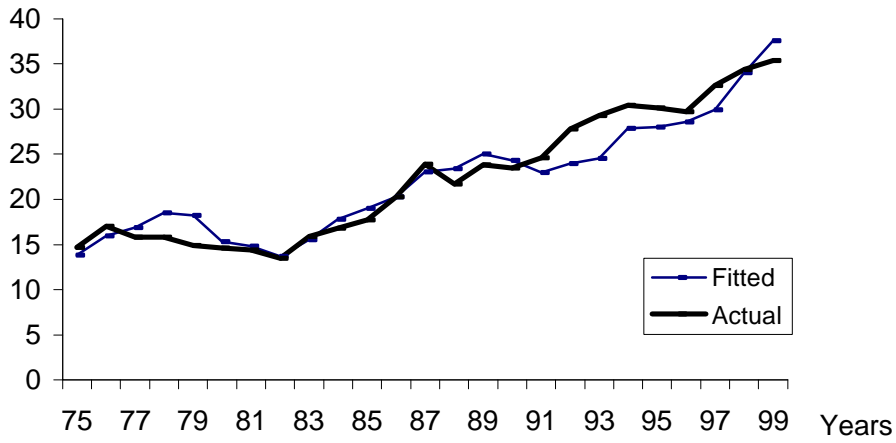
Pounds per capita

FIGURE 1. U.S. Cotton Demand without Structural Change (correlation of 0.962)
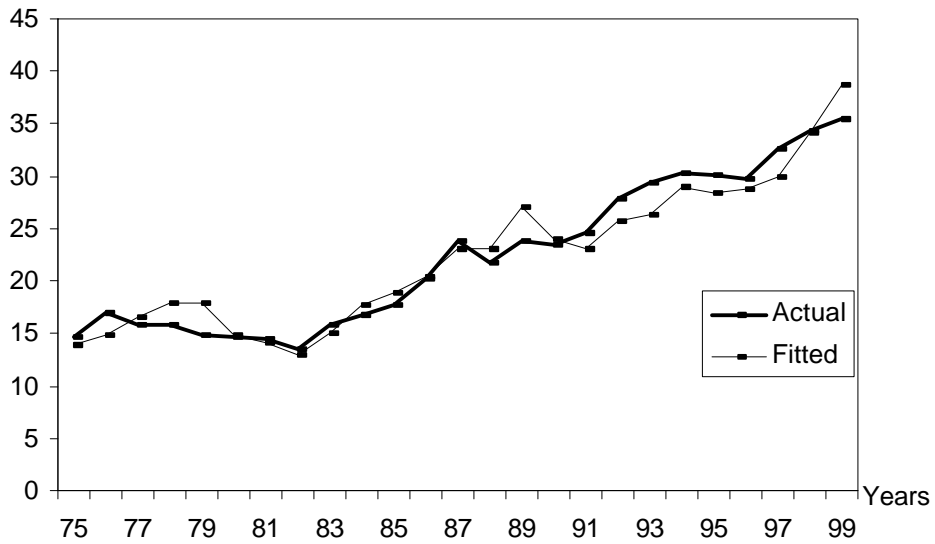
Pounds per capita

FIGURE 2. U.S. Cotton Demand with Structural Change (correlation of 0.968)

FIGURE 3. Export Demand for U.S. Cotton without Structural Change
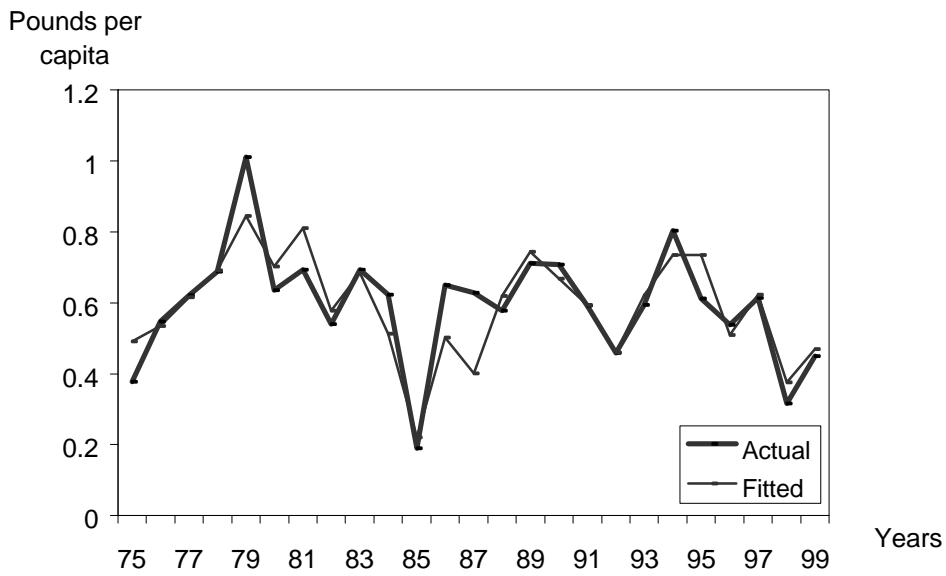
(correlation of 0.763)

FIGURE 4. Export Demand for U.S. Cotton with Structural Change

(correlation of 0.846)