United States
Department
of Agriculture

Economic
Research
Service

Economic
Research
Report
Number 80

September 2009

U.S. Cotton Prices and the World Cotton Market

Forecasting and Structural Change

Olga Isengildina-Massa
Stephen MacDonald

www.ers.usda.gov

Visit Our Website To Learn More!

Cotton
http://ers.usda.gov/Briefing/Cotton/

National Agricultural Library Cataloging Record:

Isengildina-Massa, Olga
U.S. cotton prices and the world cotton market: forecasting and structural change.

(Economic research report (United States. Dept. of Agriculture. Economic Research Service); no. 80)

1. Cotton trade—Econometric models.
2. Cotton—Prices—United States—Forecasting.
I. MacDonald, Stephen A.
II. United States. Dept. of Agriculture. Economic Research Service
III. Title.

HD9875

Photo credit: Shutterstock

USDA

United States
Department
of Agriculture

Economic
Research
Report
Number 80

September 2009

A Report from the Economic Research Service

www.ers.usda.gov

U.S. Cotton Prices and the World Cotton Market

Forecasting and Structural Change

Olga Isengildina-Massa

Stephen MacDonald, stephenm@ers.usda.gov

Abstract

This report analyzes recent structural changes in the world cotton industry and develops a statistical model that reflects current drivers of U.S. cotton prices. Legislative changes in 2008 authorized USDA to resume publishing cotton price forecasts for the first time in nearly 80 years. Systematic problems have become apparent in the forecasting models used by USDA and elsewhere, highlighting the need for an updated review of price relationships. A structural break in the U.S. cotton industry occurred in 1999, and world cotton supply has become an important determinant of U.S. cotton prices, along with China's trade and production policy. The model developed here forecasts changes in the U.S. upland cotton farm price based on changes in U.S. cotton supply, the U.S. stocks-to-use ratio (S/U), China's net imports as a share of world consumption, the foreign supply of cotton, and selected farm policy parameters.

Keywords: forecasting, cotton, price, demand, trade, structural change, farm programs.

Olga Isengildina-Massa is an Assistant Professor in the Department of Applied Economics and Statistics at Clemson University. Stephen MacDonald is a Senior Economist with the Economic Research Service's Market and Trade Economics Division.

Acknowledgments

The authors appreciate the support for this project from the Small Grants Program of the Market and Trade Economics Division of the Economic Research Service, and the assistance of Carol Skelly and Hunter Colby of the World Agricultural Outlook Board in acquiring valuable data and insight. The authors thank the reviewers Linwood Hoffman, Alejandro Plastina, John Robinson, Carol Skelly, and Russell Tronstad for their comments, which helped to improve the paper substantially. Finally we gratefully acknowledge Dale Simms for editorial assistance and Wynnice Pointer-Napper for layout and design.

Contents

Recommended citation format for this publication:

Isengildina-Massa, Olga, and Stephen MacDonald. *Cotton Prices and the World Cotton Market: Forecasting and Structural Change*. Economic Research Report 80, U.S. Dept. of Agriculture, Economic Research Service. Sept. 2009.

Summary

In 1929, Congress passed legislation forbidding the U.S. Department of Agriculture from publishing cotton price forecasts. That ban was removed in the Food, Conservation, and Energy Act of 2008. Recent changes in world cotton markets required that a model to forecast cotton prices be developed. This report develops a reduced-form specification for a U.S. cotton price forecasting model based on expected changes in U.S. and global supply and demand factors.

What Is the Issue?

Although cotton price forecasts were not published by USDA between 1929 and 2008, USDA's Interagency Commodity Estimates Committee for cotton calculated unpublished price forecasts each month. USDA's models have tended to overestimate cotton prices in recent years, however, because of rapid ongoing structural changes in the cotton industry. Other agencies making cotton price forecasts have encountered similar problems. Given the poor predictive capability of existing cotton price forecasting models and the renewed authority of USDA to publish cotton price forecasts, it is important to review and improve the existing models. An updated and improved cotton price forecasting model will more accurately account for the factors now determining U.S. upland cotton prices and illuminate the interaction of commodity markets with U.S. and global supply and demand, macroeconomic developments, and policy shifts.

What Did the Study Find?

Structural change has altered the market for U.S. cotton since the 1990s. Shifts in textile trade policy, combined with significant liberalization of China's cotton production policies, have overturned longstanding global consumption and trade patterns. The result has been to shift the United States into a nearly unprecedented dependence on global markets. While about 60 percent of U.S. cotton was consumed domestically for the last 60 years of the 20th century, exports have significantly surpassed the use of cotton within the United States since 2001/02. As a result, U.S. cotton prices are no longer determined solely by domestic supplies and stocks.

To reflect these recent structural changes, the model draws on a number of variables to forecast changes in the U.S. cotton price: U.S. cotton supply, U.S. stocks-to-use ratio, China's net imports as a share of world consumption, the proportion of U.S. cotton in the loan program, and the world supply of cotton. The model explains 68 percent of the variation in the U.S. upland cotton price from 1974/75 through 2006/07. The results suggest that a 1-percent increase in U.S. supply from the previous year will cause U.S. cotton prices to drop about 0.9 percent, in real terms. Changes in foreign supply affect U.S. prices on a nearly one-to-one basis: prices fall as foreign supply rises.

U.S. commodity policy helps support U.S. cotton prices: a 1-percent increase in the end-of-season stocks covered by the loan program (with stocks measured as a proportion of U.S. cotton use) raises prices by 0.4 percent. Import demand by China continues to play an important role in determining prices: a 1-million-bale increase in China's net imports raises prices by 3.1 percent.

Given China's recent imports, this is equivalent to a 1-percent increase in China's cotton imports, as a share of world consumption.

How Was the Study Conducted?

A review of the theoretical framework for commodity price forecasting revealed that forecasting price as a function of a stocks-to-use ratio and demand shifters, which is the standard methodology, is sufficient only when changes in supply are very small or when changes in stocks-to-use are much greater than changes in supply. Since these conditions were not satisfied in the cotton markets because of the rapid growth in supply due to the spread of genetically modified varieties and other technologies, changes in supply were included in a proposed model. Several demand shifters were also included. China's net trade as a proportion of world consumption was included to account for changes in export demand associated with China's commodity and trade policies. The impacts of U.S. farm policy were accounted for by including a variable representing the amount of cotton in the marketing loan program as a share of domestic consumption and by adjusting the dependent variable to reflect the impact of the User Marketing Certificate (Step 2) program.

The Quandt-Likelihood Ratio test indicated significant structural change in the 1999/2000 marketing year. This structural break was likely caused by a combination of factors, including the increased export orientation of the U.S. cotton industry following the U.S. textile industry's contraction as the Multifiber Arrangement was phased out. Thus, the proposed model was modified to include the foreign supply of cotton to reflect the increased export orientation and to correct for the observed structural change. The final model was subjected to extensive out-of-sample testing to ensure its appropriateness for forecasting.

Introduction

Agricultural prices are notoriously difficult to forecast due to shocks from weather events around the world, the influence of government policy in the marketplace, and changing tastes and technology. In addition, agricultural prices are affected by macroeconomic shocks and shifts in energy markets. Forecasts of agricultural prices are important to both private and public policymakers, as well as producers and consumers of agricultural products. Therefore, agricultural price forecasting is a widespread activity. USDA alone publishes updates of price forecasts for 24 commodities every month in its *World Agricultural Supply and Demand Estimates*. However, until recently USDA was legally prohibited from forecasting cotton prices.[1] Cotton price forecasts were available each month from the International Cotton Advisory Committee (ICAC) and—less frequently—from the Food and Agricultural Policy Research Institute (FAPRI), the Australian Bureau of Agricultural and Resource Economics (ABARE), and the World Bank. In addition, although USDA did not publish cotton price forecasts, its Interagency Commodity Estimates Committee (ICEC) for cotton calculated unpublished estimates of world and domestic cotton prices each month. In recent years, USDA and other agencies have observed systematic errors in their cotton price models, highlighting the need for a thorough review of price relationships. The removal of the ban on cotton price forecasting by USDA in the 2008 Farm Bill heightened the need to review existing cotton price forecasting procedures and to develop a new forecasting model.

[1]In 1929, Congress passed legislation forbidding USDA from publishing cotton price forecasts (see Townsend (1989) for a discussion of the circumstances surrounding this legislation).

This report develops a theoretically based reduced-form specification for a cotton price forecasting model. Like earlier models for cotton (Meyer, 1998; Valderrama, 1993; Goreux et al., 2007), wheat (Westcott and Hoffman, 1999), corn (Van Meir, 1983; Westcott and Hoffman, 1999), and soybeans (Plato and Chambers, 2004; Goodwin et al., 2005), the U.S. season-average farm price is a function of U.S. stocks/use. Other variables include U.S. and world cotton supply and a set of shift variables accommodating circumstances particular to cotton markets. The empirical version of the model includes a demand shifter for China's trade and another shifter for the impact of U.S. commodity policy. Testing indicates evidence of structural change, which is likely the result of the U.S. shift from domestic cotton consumption to exporting, and the model is adjusted to include impacts of foreign supply.[2]

[2] Foreign supply is an important factor for U.S. cotton prices because the United States, as one of the largest producers and exporters of cotton in the world, directly competes with cotton coming from other countries.

Data

This study concentrates on the marketing-year average U.S. farm price of upland cotton, over 1973-2007. Historical price data are from the USDA's National Agricultural Statistics Service (NASS) database and publications (USDA-NASS, 2008). One-year-ahead forecasts for U.S., world, and China supply and use variables are published in monthly *World Agricultural Supply and Demand Estimates* (WASDE) reports from the USDA's World Agricultural Outlook Board (USDA-WAOB, selected issues). These forecasts will provide the out-of-sample values for the independent variables in future years. Historical cotton supply and demand data are drawn from the "Production, Supply and Distribution Online" database maintained by USDA's Foreign Agricultural Service (USDA-FAS, 2008). Unlike wheat and feed grains, USDA does not publish forecasts and historical estimates of Commodity Credit Corporation (CCC) end-of-year stocks for cotton in the monthly WASDE. CCC cotton stocks are forecast twice a year in order to project budgetary outlays, and historical data for CCC cotton stocks were provided by USDA's Farm Service Agency (FSA). Data on expenditures for the U.S. User Market Certificate Program ("Step 2") were also provided by FSA.

Cotton Price Model

Theoretical Model

The general framework for the cotton price model is based on the theory of competitive markets, in which the market price results from allocating available supplies to alternative product uses (e.g., Tomek and Robinson, 2003, p. 406). For the U.S. cotton market, the identity between supply and demand can be written as:

$$I_t + Q_t + X_t = I_{t-1} + A_t + M_t \qquad (1)$$

where I_t = ending inventory,

I_{t-1} = beginning inventory,

Q_t = domestic consumption,

X_t = exports,

A_t = domestic production, and

M_t = imports.

At the beginning of the marketing year denoted by t, the variables on the right-hand side can be treated as predetermined.[3] Therefore, the above identity results in the demand for domestic uses, the demand for exports, and the demand for inventories at a given level of supply. To simplify, the demand for domestic uses and the demand for exports may be summed to represent current demand (D_t). Similarly, the sum of beginning inventory, domestic production, and imports reflects current supply (S_t). This allows the identity to be expressed as:

$$S_t - D_t - I_t = 0 \qquad (2)$$

Each variable in the identity is a function of a set of explanatory variables:

$$S_t = b(E_{t\text{-}1}(p_t), z_t)$$
$$D_t = g(p_t, y_t)$$
$$I_t = h(p_t, w_t)$$

where p_t is the inflation-adjusted price, $E_{t\text{-}1}(p_t)$ is the period t-1 expectation of p_t, and z_t, y_t, and w_t are exogenous variables affecting supply, demand, and stocks, respectively. All other variables are as defined previously. Supply is positively related to expected price while demand and stocks are negatively related to price. Assuming that supply is predetermined at the beginning of the marketing year, equation 2 can be expressed as:

$$S_t - g(p_t, y_t) - h(p_t, w_t) = 0. \qquad (3)$$

[3]Imports are not predetermined, but are trivially small compared with domestic production.

Traditionally, in forecasting models price is specified as a function of the stocks-to-use ratio (e.g., Westcott and Hoffman, 1999). Stocks-to-use ratio can be introduced in equation 3 by dividing through by $g(p_t, y_t)$:

$$\frac{S_t}{g(p_t, y_t)} - 1 = \frac{h(p_t, w_t)}{g(p_t, y_t)} = r(p_t, w_t, y_t), \tag{4}$$

where r denotes the ratio of stocks to use. Equation 4 is the implicit price equation. To find an explicit equation for price, we differentiate equation 4:[4]

[4]Since the time (t) indicator is identical for all variables, it is omitted from the following mathematical derivations.

$$dS = dr(g) + \frac{\partial g}{\partial p} dp + \frac{\partial g}{\partial y} dy + \left(\frac{\partial g}{\partial p} dp + \frac{\partial g}{\partial y} dy \right) r. \tag{5}$$

Solving dS for dp, we obtain the following equation for a change in price:

$$dp = \left((r+1) \frac{\partial g}{\partial p} \bigg|_y \right)^{-1} dS - g \left((r+1) \frac{\partial g}{\partial p} \bigg|_y \right)^{-1} dr - \left(\frac{\partial g}{\partial p} \right)^{-1} \frac{\partial g}{\partial y} dy \tag{6}$$

Equation 6 shows that change in price can be accurately approximated as a function of stocks-to-use ratio and demand shifters only when change in supply (dS) is very small or when change in stocks-to-use is much greater than change in supply ($dr >> dS$). Thus, equation 6 provides a more complete model of price changes when neither of these two conditions is satisfied. The result is a model that differs from the traditionally specified models (e.g., Meyer, 1998) since supply is now recognized as a variable distinct from stocks. Given the problems with forecasting cotton prices in recent years, pursuing alternatives to the traditional specification seems appropriate.

This specification models cotton price in first-difference terms, which has implications with respect to its time-series properties. For price levels, the hypothesis of a unit root cannot be rejected (with an Augmented Dickey-Fuller test statistic of -1.5). However, for the price series in percentage change form, the hypothesis that a unit root is present can be rejected at the 1-percent significance level (ADF = -8.4), and ordinary least squares estimation of the model will be efficient and unbiased.

Price enters this model in real rather than nominal terms. This bears discussion since commodity price forecasting models commonly omit any discussion of inflation, and specify their models in nominal terms. Van Meir (1983) specifies his model in real terms (deflating with U.S. the gross national product implicit deflator), but does not discuss the model's derivation. Goodwin et al. (2005) consider the role of inflation, and test specifications with inflation as an independent variable in their model, which forecasts nominal prices. Both including inflation as a variable and forecasting a deflated price when the ultimate goal is a nominal price forecast put the forecaster's results at the mercy of the available forecasts of inflation. However, if inflation should be accounted for, a model that completely omits it will see its usefulness diminished in other ways.

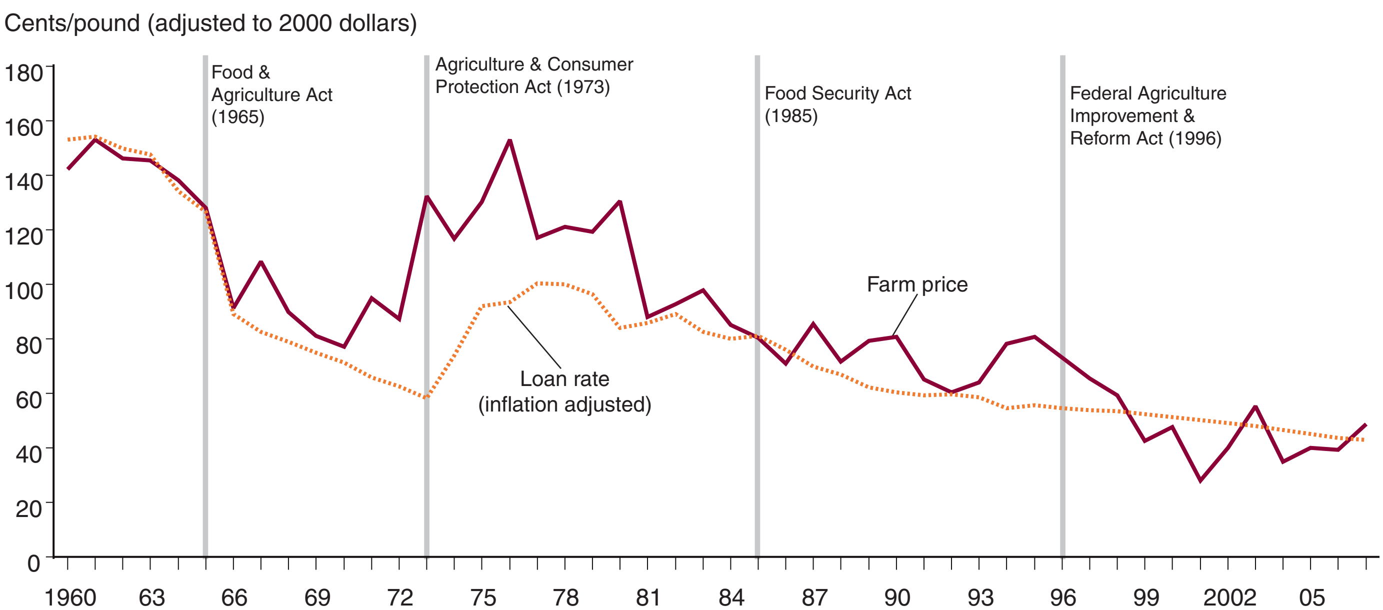
Given that this model's reduced form is based on a theoretical model with predetermined supply but demand as a function of price, real rather than nominal price is the appropriate dependent variable. Demand is almost invariably modeled as a function of real rather than nominal prices (Ferris, 2005), and a broad measure of inflation was chosen since cotton products will be competing with a broad range of products for consumer demand. Furthermore, given that the nominal loan rate is not an independent variable in this model, the use of real prices does not adversely affect the role of the independent variables as it would for some of the earlier models.

Empirical Analysis

The U.S. cotton price has been highly variable over time under the pressure of various economic and political factors (fig. 1). Equation 6 provides a reduced-form model for evaluating percent changes in U.S. average farm price (*dp*) based on changes in U.S. supply (*dS*), U.S. stocks-to-use ratio (*dr*), and a set of demand shifters. A significant demand shifter in U.S. and world cotton markets is export demand changes associated with China's trade policy. The strong correlation between world cotton prices and China's net trade was noted as early as 1988 by the ICAC, and the level of China's net trade was included in the International Cotton Advisory Committee's world price forecasting model for the 1974/75-1986/87 period (ICAC, 1988). Similarly, MacDonald (1997) adjusted the world (minus China) stocks-to-use variable by the amount of China's net trade in another world price model, estimated using 1971/72–1995/96 data. In 2001, researchers at USDA's Economic Research Service highlighted how China's domestic cotton policy drove its cotton trade, with significant impacts on world markets:

Figure 1

U.S. season-average farm price for upland cotton, 1960-2007



Source: ERS calcuations based on data from NASS and the U.S. Department of Commerce.

"Stocks rose after 1994/95 as China raised its farm prices while maintaining an open trade regime. China's government-mandated farm prices proved difficult to reduce as world prices fell, and restricting imports seemed inconsistent with ensuring the profitability of its huge textile industry. Also, government policy locked older cotton in stocks in order to prevent bookkeeping losses as the market value of procured cotton tumbled below the cost of purchasing, processing, and storage. Stocks reached a staggering 106 percent of use in 1998/99, and China accounted for 47 percent of the entire world's cotton ending stocks. Then, starting in 1998/99, the government began applying quantitative restrictions to cotton imports and subsidizing exports. In 1999/2000 the government effectively cut farm prices by refusing to guarantee procurement, and in 2000/01 a program to allow the central government to absorb the cost of marketing losses for stockpiled cotton went into high gear, opening the floodgates for enormous government stocks to flow into the market. By 2000/01, China had cut its ending stocks by nearly 10 million bales, mostly from government stocks (USDA/ERS, 2001)."

This demand shifter is measured in this report as an absolute change[5] from the previous 2-year average of China's net imports as a share of world consumption:

$$CN_t = \frac{M_t^{China} - X_t^{China}}{Q_t^{World}}. \tag{7}$$

Thus, the empirical price model is specified as:

$$\frac{(p_t - p_{t-1})}{p_{t-1}} = \alpha_0 + \alpha_1 \frac{(S_t - S_{t-1})}{S_{t-1}} + \alpha_2 \frac{(r_t - r_{t-1})}{r_{t-1}} + \alpha_3 \left(CN_t - average(CN_{t-1}, CN_{t-2})\right), \tag{8}$$

where all variables refer to U.S. values unless otherwise stated.[6] Since supply is predetermined, changes in supply have an inverse effect on price. Changes in stocks-to-use ratio are also negatively related to price. Increases in China's net cotton imports represent a greater export demand for U.S. cotton and thus have a positive relationship with price changes.

Another factor affecting the relationship between U.S. ending stocks and prices is government policy. The two most relevant policies to cotton prices are the loan program and the User Marketing Certificate Program (generally referred to as "Step 2" of the marketing loan program) (see Meyer et al., 2007, for a summary of U.S. farm programs affecting cotton). Since the relationship between how the loan program affects prices and how stocks affect prices in this model is relatively straightforward, a simple demand shifter can be created to account for the loan program. Step 2's effects were accounted for by adjusting the dependent variable for its impacts.

Before 1986, U.S. commodity programs sometimes served to establish a price floor for U.S. crops. USDA's Commodity Credit Corporation (CCC) acquired large stocks of cotton (and other commodities) during the early 1980s as market prices in the United States fell toward U.S. loan rates (table 1). Stocks owned by CCC were not available to the market, and prices were higher than if the stocks

[5]Absolute changes from the previous 2-year average are used instead of percent change relative to the previous year because of the sporadic changes in this variable, which cause small absolute changes to appear very large in percentage form.

[6]The choice of percentage change as the functional form followed from the theoretical model's derivation in differences. Alternatives—such as using the variables in levels or logs—also resulted in less accurate out-of-sample forecasts.

could have been drawn upon to satisfy demand. Furthermore, even cotton that had not yet been acquired by CCC, but was still being used as collateral in the loan program, was also not freely available for spinning, export, or private stockholding. The shift of U.S. cotton policy to a marketing loan program meant that CCC acquisition of cotton was significantly reduced, and in 2006 CCC instituted a policy of immediately selling any forfeited cotton, ensuring negligible CCC stocks at the end of the marketing year. However, the ability of producers to place their cotton in the loan program affected prices after 1986, and the volume of cotton remaining as collateral in the loan program at the end of the marketing year was often significant, even in recent years. While current legislation dictates that the maximum duration of a loan is 9 months, before 1996 cotton was permitted to remain under loan as long as 18 months. Given that cotton continues to enter the loan in the beginning months of each calendar year, cotton can remain under loan for several months after the end of the marketing year (July 31), even under current rules. Storage costs are, unlike with grains, covered by the CCC when the redemption price applicable to the loan is below the loan rate. This further encourages producers to delay marketing their cotton when the loan program is a sound alternative.

Table 1

Season-ending U.S. commodity program cotton stocks, 1974/75-2007/08

Marketing year	CCC inventory	Collateral on outstanding loans	Inventory as share of use
	1,000 bales	*1,000 bales*	*Percent*
1974/75	0	901	9
1975/76	0	110	1
1976/77	0	309	3
1977/78	0	1,209	10
1978/79	1	614	5
1979/80	0	501	3
1980/81	0	626	5
1981/82	1	3,643	31
1982/83	396	4,267	43
1983/84	158	444	5
1984/85	124	1,597	15
1985/86	775	5,965	80
1986/87	69	2,914	21
1987/88	5	3,164	22
1988/89	92	4,119	30
1989/90	27	430	3
1990/91	1	215	1
1991/92	3	297	2
1992/93	13	558	4
1993/94	13	179	1
1994/95	0	165	1
1995/96	0	312	2
1996/97	0	311	2
1997/98	0	61	0
1998/99	6	326	2
1999/2000	2	68	0
2000/01	5	1,460	9
2001/02	108	665	4
2002/03	97	668	4
2003/04	0	1,371	7
2004/05	2	301	1
2005/06	5	1,185	5
2006/07	51	857	5
2007/08	0	3,819	21

Sources: Stultz et al., Farm Service Agency (FSA), and ERS calcuations based on data from FSA and World Agricultural Supply and Demand Estimates..

Therefore, a variable was created representing the sum of both cotton owned by CCC and of cotton with CCC loans still outstanding at the end of the marketing year. This was divided by cotton use for that year to create an additional demand shifter:

$$CCC_t = \frac{h_t^{CCC} + h_t^{loan}}{Q_t + X_t} \qquad (9)$$

where h_t^{CCC} is the cotton owned by CCC at the end of the marketing year and h_t^{loan} is the volume of cotton remaining as collateral in the loan program at that time. By capturing all of the cotton involved in the loan program instead of just the cotton owned by CCC, the variable more accurately captures how the loan program supports prices. The loan rate appears to have functioned as a price floor in 1981, 1982, and 1984, but stocks from cotton produced in those marketing years were not acquired by CCC until the next marketing year. To correctly attribute the impact of the loan program to those years rather than to the subsequent years, the actual loan rate or another variable would have to be added (as in Westcott and Hoffman, 1999). Equation 9 allows the impact of the loan program to be accounted for with one variable.

Another government policy that affected cotton markets is the U.S. Step 2 program, which was introduced in 1990 and continued until 2006. The Step 2 program offered payments to U.S. textile mills and U.S. exporters when the price of U.S. cotton in Northern Europe exceeded the world price of cotton, as measured in Northern Europe. A World Trade Organization (WTO) panel in 2005 found the program in violation of the General Agreement on Tariffs and Trade (GATT), in large part because the payments to U.S. mills were exclusively for the consumption of U.S. cotton rather than either U.S. or imported cotton (see Schnepf, 2007, for a summary of the dispute). In the program's early years, the seasonality of the price spread that determined Step 2 payments and the seasonality of U.S. export sales coincided. Therefore, exports accounted for a disproportionate share of the payments in those years. The ability of exporters to lock in payments for much of the year's exports within a relatively small window of time was also a factor. As a result, Step 2 was often perceived to be primarily an export subsidy. However, regulatory changes in the program were frequent, and domestic U.S. payments exceeded payments to exporters in later years.

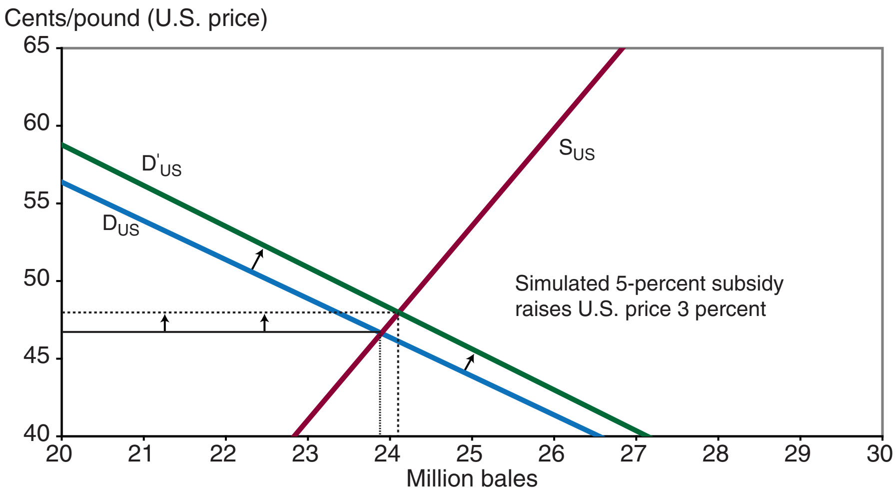
During much of the program's tenure, payments to exporters were made at the time of shipment rather than sale. Sales for exports typically occur 9-10 weeks before shipment, and sometimes much further in advance. Since the magnitude of Step 2 payments fluctuated weekly, this added uncertainty to the relationship between the price of export sales and the subsidy associated with the shipment. This, and the fact that payments were made to the firms exporting the cotton rather than those actually purchasing it, made the link between Step 2 payment and subsidization of export demand indirect. However, the subsidies averaged 5 percent of the value of U.S. cotton use during 1991-2006. Since U.S. cotton accounted for about 20 percent of global cotton use during this time, the program likely had an impact on the world price as well as the U.S. price. The Step 2 program was terminated in August 2006 as part of the United States' efforts to comply with the WTO panel's findings. Step 2 therefore is no longer a factor in the determination of prices, but must be accounted for when analyzing historical price data.

The simplest way to understand the impact of the Step 2 program is to abstract from the differing effects on U.S. export and domestic demand and simply consider it as a subsidy for consumption of U.S. cotton anywhere in the world (figures 2 and 3).[7] The introduction of the subsidy would shift the demand for U.S. cotton upward from D_{US} to D'_{US} (fig. 2), and the demand for the rest of the world's (ROW) cotton downward from D_{ROW} to D'_{ROW} (fig. 3). The new equilibrium would have production and consumption of U.S. cotton slightly higher than in the absence of a subsidy, and slightly lower for ROW. Similarly, the price of cotton in the United States would be higher, and would rise to a greater degree than the decline in the ROW's price. Simulations by FAPRI (2005) and Mohanty et al. (2005) found similar impacts, with the removal of Step 2 leading to a U.S. price that was 2.9 percent lower, on average, and a world price that was slightly higher (less than 1 percent).

[7]While the core of Step 2 was to convey payments to consumers of U.S. cotton either directly or indirectly, the details and history of the program are complex (Meyer and MacDonald, 2001).

Figure 2

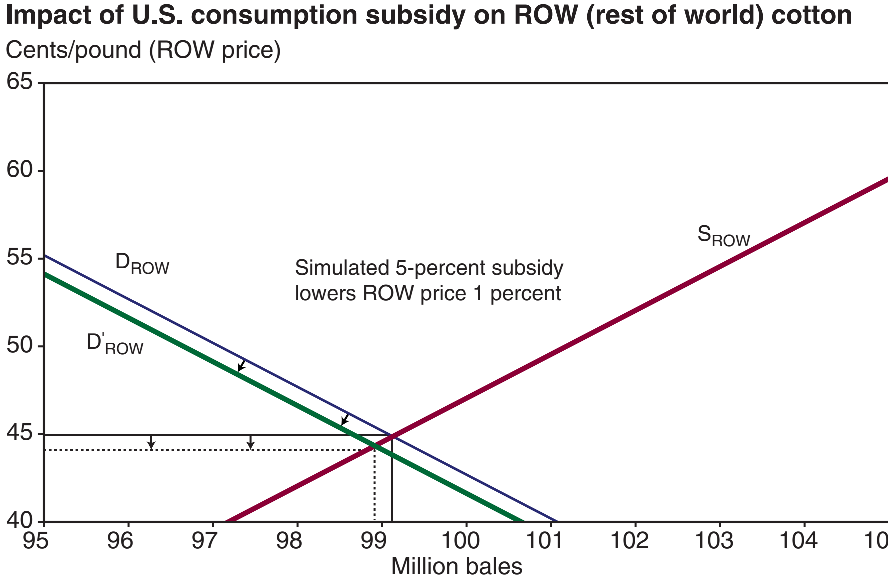
Impact of U.S. consumption subsidy on U.S. cotton



Source: Simulation of model with linear supply and demand for U.S. and rest of world, substitution between U.S. and ROW cotton, and calibrated to approximate recent realizations of the variables.

Figure 3

Impact of U.S. consumption subsidy on ROW (rest of world) cotton



Source: Simulation of model with linear supply and demand for U.S. and rest of world, substitution between U.S. and ROW cotton, and calibrated to approximate recent realizations of the variables.

Since Step 2 will no longer be a factor in U.S. prices, and since it influenced past prices, the forecasting model was estimated with data for the dependent variable adjusted to remove the past impact of Step 2. Data on spending for Step 2 payments in each year were divided by the value of U.S. cotton use to determine the relative subsidy provided each year (table 2). An adjustment variable (λ_t) was constructed so that each year's price adjustment was proportional to that year's subsidy; the average for the adjustment variable over 1991-2006 is 2.9 percent. Thus, if S_t equals a given year's subsidy, then $\lambda_t = 0.029 * S_t / (\Sigma S_t / T)$, where T = number of years between 1991 and 2006. This variable was used to adjust the U.S. season-average upland farm price to remove the impact of Step 2:

$$p_t = \frac{p_t^{NASS}}{GDPDEF_t} \text{ and } p_t^* = \frac{(1-\lambda_t)p_t^{NASS}}{GDPDEF_t}. \quad (10)$$

Here we define p_t more explicitly as the season-average price reported by USDA's National Agricultural Statistics Service (p_t^{NASS}), deflated by the U.S. Department of Commerce's gross domestic product price index ($GDPDEF_t$).[8]

Thus, the cotton price model adjusted for the impact of the government programs is:

$$\frac{(p_t^* - p_{t-1}^*)}{p_{t-1}^*} = \alpha_0 + \alpha_1 \frac{(S_t - S_{t-1})}{S_{t-1}} + \alpha_2 \frac{(r_t - r_{t-1})}{r_{t-1}} + \alpha_3 \left(CN_t - average\ (CN_{t-1},\ CN_{t-2})\right) + \alpha_4 CCC_t. \quad (11)$$

[8]An alternative to this procedure would be to continue to define price as p_t rather than p_t*, and instead include Step 2 payments or subsidy levels as an independent variable. We chose to adjust the dependent variable, as described, due to higher out-of-sample forecasting accuracy of the model using this approach.

Table 2
Step 2 expenditures and price adjustment variable

Marketing year	Payments[1]	Payments/cotton use	Subsidy (S_t)	Adjustment (λ_t)[2]
	$ Million	*$/pound*	*Percent*	*Percent*
1991/92	140	0.02	2.9	1.6
1992/93	114	0.02	2.7	1.5
1993/94	149	0.02	2.5	1.5
1994/95	88	0.01	1.0	0.6
1995/96	34	0.00	0.5	0.3
1996/97	6	0.00	0.1	0.1
1997/98	416	0.05	6.4	3.7
1998/99	280	0.04	6.7	3.9
1999/2000	445	0.05	10.4	6.0
2000/01	236	0.03	5.5	3.2
2001/02	182	0.02	4.9	2.8
2002/03	455	0.05	8.9	5.1
2003/04	363	0.04	5.5	3.1
2004/05	582	0.06	10.7	6.2
2005/06	397	0.04	6.2	3.6
Average	259	0.03	5.0	2.9

[1]Fiscal year.

[2]Derived from annual subsidy so that the 1991-2005 average adjustment is 2.9 percent, and each year is proportional to that year's subsidy: $\lambda_t = 0.029 * S_t / (\Sigma S_t / T)$.

Sources: USDA's Farm Service Agency (FSA), and ERS calculations based on data from the FSA, *World Agricultural Supply and Demand Estimates,* and *Cotlook*.

Another factor that may have an important effect on cotton prices is energy prices. Previous work (e.g., Barsky and Kilian, 2002) has indicated how oil price shocks can affect prices in general. More recently, policy changes—like those regarding ethanol—have linked energy and grain prices (Westcott, 2007). Energy market shocks occurred in the 1970s and again after 2004. In an effort to develop a model that is robust to both high and low energy prices, and to a variety of policy environments, this study concentrates on cotton price movements starting from the 1974/75 marketing year and extending to 2007/08. Since the proposed model is estimated in reduced form, the impact of energy prices is included implicitly through the supply variable. A similar argument can be made about other supply-inducing variables, such as the price of cotton seed.

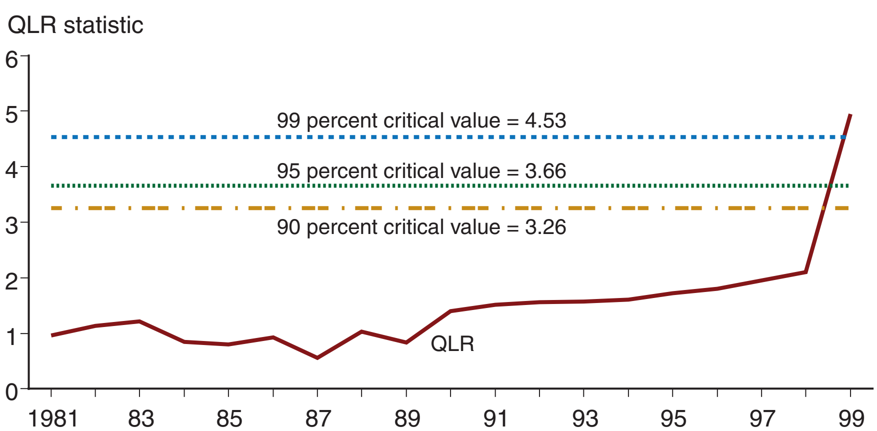
Structural Change Test

Following Wang and Tomek (2007), it is important to ensure that a correctly specified model is used to test for structural change. Therefore, equation 11 is used to test for structural change. A traditional approach would be to pick an arbitrary sample breakpoint, often the midpoint of the sample, and use a Chow test for structural change. This could be further refined by associating breakpoints with major events relevant to the data series. Either of these approaches suffers from the arbitrary nature of the selected breakpoints. Recent literature suggests that the Quandt-Likelihood Ratio (QLR) test is superior for detecting structural change of unknown timing (e.g., Hansen, 2001). The QLR test consists of calculating Chow breakpoint tests at every observation, while ensuring that subsample points are not too near the end points of the sample. The QLR test was applied to the pooled data in this study with 20-percent trimming. The highest value of the QLR statistic was 5.0 (fig. 4). The probabilities for these statistics were calculated using Hansen's (1997) method. The critical value of the QLR statistic at the 99-percent significance level with five restrictions is 4.53 (Stock and Watson, 2003, p. 471), which indicates that the null hypothesis of no structural change is rejected. The maximum statistic of 5.0 was observed in 1999/00, which indicates the breakpoint location.

This structural break was likely caused by a combination of factors. Besides significant changes in international trade, which have been transitory, this period coincided with some permanent regime changes in China's supply due to the end of guaranteed procurement prices. Some permanent changes also took place in China's consumption sector due to its growing textile industry. These regime changes in China's cotton sector are likely associated with China's accession to the WTO at the end of 2001. China joined the WTO just as the textile trade liberalization provisions of the Uruguay Round Agreement were having an impact. The phasing out of developed country textile trade protection (commonly referred to as the Multifiber Arrangement, or MFA) was an important factor behind the rapid

Figure 4

Quandt Likelihood Ratio test results for cotton price model, 1974/75-2006/07[1]



[1]The Quandt Likelihood Ratio (QLR) test excludes subsamples too close to the end-points of the overall sample. QLR statistics for the 1974-2006 sample are only available for 1981-1999.

increased export orientation of the U.S. cotton industry. As the export share of U.S. cotton use surpassed domestic use in the early 2000s (fig. 5), the importance of world supply and demand to U.S. cotton prices increased. In addition to policy changes in China, 1999 marked the first year that foreign cotton supplies (excluding China) surpassed 75 million bales. As a liberalizing global economy began an accelerated expansion in 1999, foreign cotton supplies began rising to meet this demand.

To correct for the structural change detected in the estimated model (equation 11), an additional shift variable was added to reflect the increased export orientation of the U.S. cotton industry. World market signals are assumed to be transmitted to the U.S. market through foreign supply, which was constructed excluding China's supply but including China's net contribution to the global availability of cotton (net exports):[9]

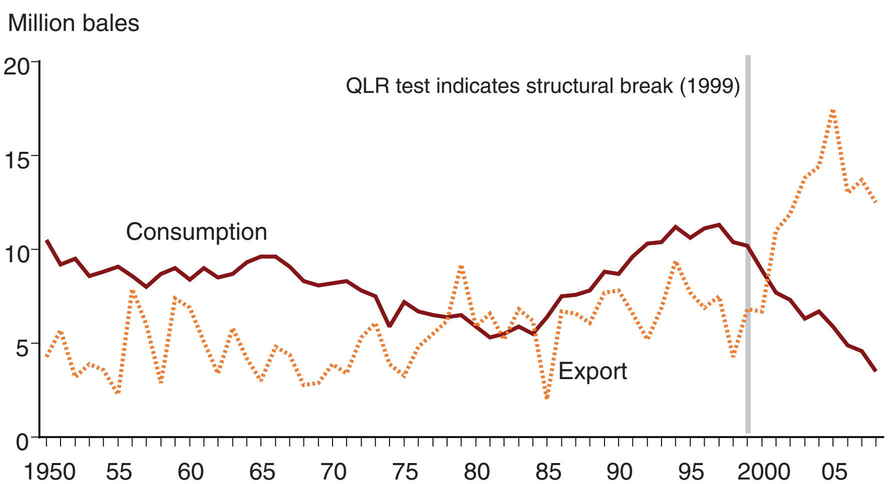
$$S_t^{Foreign} = S_t^{Foreign} - S_t^{China} + X_t^{China} - M_t^{China}. \qquad (12)$$

Foreign supply is an important factor for U.S. cotton prices. The United States is one of the largest producers and exporters of cotton and directly competes with cotton coming from other countries. With this variable included, no structural break was detected and the specification of the model was complete. Thus, the final model specification is:

$$\frac{(p_t^* - p_{t-1}^*)}{p_{t-1}^*} = \alpha_0 + \alpha_1 \frac{(S_t - S_{t-1})}{S_{t-1}} + \alpha_2 \frac{(r_t - r_{t-1})}{r_{t-1}} + \alpha_3 \left(CN_t - average\ (CN_{t-1},\ CN_{t-2})\right) + \alpha_4 CCC_t + \alpha_5 \frac{(S_t^{Foreign} - S_{t-1}^{Foreign})}{S_{t-1}^{Foreign}}. \qquad (13)$$

Figure 5

U.S. cotton exports and consumption, 1950-2008



Source: *World Agricultural Supply and Demand Estimates* (WASDE), various issues.

[9]China's stocks and production were excluded from this shift variable since the cotton stocks data are particularly unreliable (MacDonald, 2007). Stocks were regarded as a state secret in China for many years, and although the degree of secrecy has diminished profoundly, even current stock estimates for China are highly conjectural. Production data in China are also considered less reliable than elsewhere, so China's impact on world supply comes through its net trade position. With such problems in the data for the world's largest cotton consumer and stockholder, neither a world stocks-to-use (r_w) nor foreign stocks-to-use (r_f) ratio would be an appropriate variable.

All data used for the empirical estimation of this equation are presented in table 3. The model is estimated using the most recently available revisions of supply and demand categories.

Table 3
Model data, 1974/75 through 2006/07

Marketing year	Price	Supply	S/U	China net imports	CCC	Foreign supply
			Percent			
1974/75	-12.0	-10.8	114.1	-2.1	9.2	8.5
1975/76	11.6	-8.5	-41.6	-0.8	1.0	-4.3
1976/77	17.6	1.6	-26.4	-0.2	2.7	-6.3
1977/78	-23.5	21.2	82.2	1.6	10.1	2.6
1978/79	3.5	-6.5	-34.8	1.7	4.9	0.9
1979/80	-1.4	14.9	-37.6	3.3	3.2	-2.6
1980/81	9.3	-24.0	7.9	0.7	5.3	-0.1
1981/82	-32.4	29.9	179.9	-2.4	30.8	-0.6
1982/83	5.1	1.3	34.0	-3.0	43.5	2.1
1983/84	5.7	-15.8	-68.3	-2.6	4.7	-4.3
1984/85	-13.0	0.2	46.5	-1.9	14.6	18.8
1985/86	-5.6	11.4	227.0	-3.0	80.5	13.6
1986/87	-11.6	8.6	-68.7	-1.4	21.1	-1.3
1987/88	19.9	3.2	13.7	1.1	22.3	0.3
1988/89	-15.8	7.1	33.8	3.0	30.2	0.1
1989/90	10.2	-10.9	-69.2	2.6	2.8	-1.9
1990/91	1.8	-3.1	-24.2	1.0	1.3	0.5
1991/92	-19.0	8.6	82.5	-0.1	1.8	2.6
1992/93	-7.5	-1.0	24.3	-1.9	3.7	-3.4
1993/94	5.9	4.8	-30.0	-0.3	1.1	-5.1
1994/95	22.5	12.0	-35.3	4.8	0.8	-4.6
1995/96	3.0	-9.4	14.3	1.0	1.7	14.2
1996/97	-9.5	4.1	55.4	0.0	1.7	-0.6
1997/98	-10.5	3.8	-6.1	-1.7	0.3	3.3
1998/99	-9.1	-20.1	14.3	-3.4	2.3	2.3
1999/2000	-28.2	13.9	-3.6	-2.5	0.4	5.8
2000/01	11.4	1.4	54.4	0.8	9.4	0.4
2001/02	-41.1	24.5	11.0	1.1	4.1	0.5
2002/03	43.0	-7.2	-29.3	2.5	4.0	-3.8
2003/04	38.2	-2.9	-35.6	7.6	6.8	-5.2
2004/05	-36.7	12.8	52.1	0.2	1.4	23.3
2005/06	14.1	11.0	-6.9	9.2	5.1	-6.2
2006/07	-1.7	-6.7	115.4	-2.7	5.1	7.4

Note: Price is percent change in the real U.S. season-average upland cotton farm price from year *t-1* to year *t*. Supply is percent change in U.S. supply from year *t-1* to year *t*. S/U is percent change in U.S. stocks-use-ratio from year *t-1* to year *t*. China net imports is the absolute change in China's net imports as a proportion of world demand from their average over the preceding 2 years. CCC is end-of-season stocks for year *t* of cotton either owned by USDA's Commodity Credit Corporation or remaining as collateral for the cotton loan program as proportion of demand for U.S. cotton that year. Foreign supply is the percent change in global cotton supply (minus China's supply and plus China's net exports) from year *t-1* to year *t*.

Source: USDA National Agricultural Statistics Service, and *World Agricultural Supply and Demand Estimates* (various issues).

Estimation Results

Table 4 presents the results of cotton price model estimation (equation 13) over the 1974/75-2006/07 period. The estimated model explains over 68 percent of the variation in U.S. upland cotton price. All coefficients except that for the *stocks/use* variable are significant at the conventional levels and have the expected signs. Since most variables are measured in percent changes, their coefficients are interpreted as elasticities. Thus, a 1-percent increase in U.S. *supply* from the previous year will cause prices to drop by about 0.9 percent. The impact of the *stocks/use* variable is not statistically different from zero at the 10-percent level. An increase of 1 million bales in *China NI* (net imports) from the average of the previous 2 years will cause the U.S. average farm price of upland cotton to increase by 3.1 percent relative to the previous year's level. An increase in *CCC* stocks equal to 1 percent of U.S. use would raise price by 0.4 percent. *Foreign supply* changes have approximately a one-to-one inverse effect on price.

According to Pearson correlation coefficients (table 5), significant correlation exists between *stocks/use* and several other variables in the model. Multicollinearity caused by this variable may inflate standard errors and the R-squared statistic of the model. This issue was investigated by dropping the *stocks/use* variable, which resulted in very minor changes (in the second decimal) in the standard errors and the R-squared and no changes in the signs of the coefficients. Thus, it was determined that multicollinearity did not cause significant problems in our model.

The low significance of the *stocks/use* variable highlights some differences of this model from past models, and the changes in world cotton markets.

Table 4

Estimation results for cotton price model, 1974/75-2006/07

Variable or statistic	Coefficient	Std. error	t-Statistic	Prob.
Constant	-0.026	0.026	-1.022	0.316
Supply	-0.949	0.190	-4.989	0.000
Stocks/use	-0.028	0.046	-0.597	0.556
China NI (net imports)	3.060	0.828	3.697	0.001
CCC	0.372	0.162	2.299	0.030
Foreign supply	-0.867	0.356	-2.436	0.022
R-squared	0.688	--	--	--
Adjusted R-squared	0.630	--	--	--
Regression	--	0.118	--	--
Sum squared residual	0.376	--	--	--
Log likelihood	26.991	--	--	--
F-statistic	11.916	--	--	0.000
Mean dependent variable	-0.017	0.194	--	--
Akaike info criterion	-1.272	--	--	--
Schwarz criterion	-1.000	--	--	--
Hannan-Quinn criterion	-1.181	--	--	--
Durbin-Watson statistic	2.362	--	--	--

Note: Price is percent change in the real U.S. season-average upland cotton farm price from year *t–1* to year *t*. Supply is percent change in U.S. supply from year *t–1* to year *t*. S/U is percent change in U.S. stocks-use-ratio from year *t–1* to year *t*. China net imports is the absolute change in China's net imports as a proportion of world demand from their average over the preceding 2 years. CCC is end-of-season stocks for year *t* of cotton either owned by USDA's Commodity Credit Corporation or remaining as collateral for the cotton loan program as proportion of demand for U.S. cotton that year. Foreign supply is the percent change in world minus U.S. cotton supply (minus China's supply and plus China's net exports) from year *t–1* to year *t*.

Before adjusting for the structural change (i.e., estimating equation 11), the parameter for *stocks/use* was significant at the 12-percent level with the full sample, but is significant at the 3-percent level if equation 11 is estimated with data through 1999 only. This is despite the presence of significant collinearity with the *CCC* variable in this truncated sample (65-percent correlation). In the full data set, the *stocks/use* variable is not statistically significant, possibly because the United States now accounts for its smallest share of world production since the early 1800s and prices are increasingly set by supply and demand forces outside the United States.

The goodness of fit of the model in nominal prices is illustrated in figure 6. Nominal prices are calculated by removing the inflation adjustment from the real prices predicted by the model and adjusting them for Step 2 payments. Converting real prices into nominal terms makes it easier to compare model predictions against observed prices. The largest in-sample forecast error of 17.1 cents/pound occurred in 1988 (fig. 6). The average forecast error for the entire sample is 0.2 cent/pound, suggesting that the model is unbiased. However, the importance of in-sample properties diminishes if the model does not forecast well.

Table 5

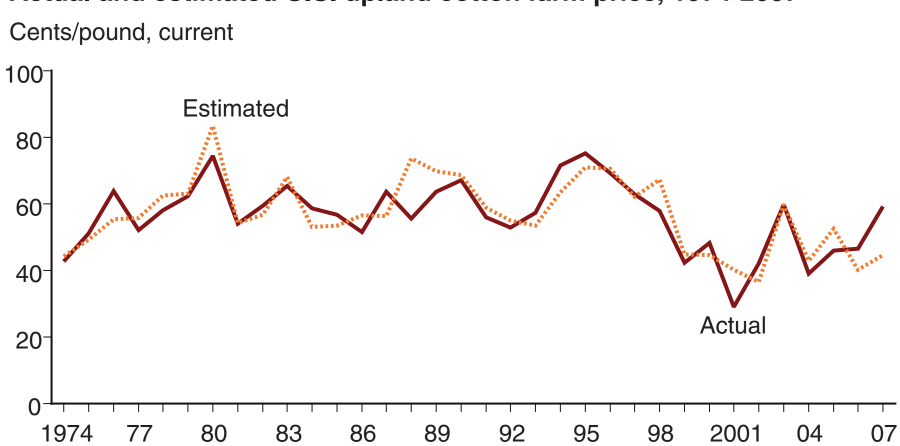
Pearson correlation coefficients for cotton price model, 1974/75 - 2006/07

	Supply	Stocks/use	China NI	CCC	Foreign supply
Supply	1.00	0.33	0.13	0.25	0.05
Stocks/use	0.33	1.00	-0.39*	0.60**	0.51**
China net imports	0.13	-0.39*	1.00	-0.26	-0.39*
CCC	0.25	0.60**	-0.26	1.00	0.24
Foreign supply	0.05	0.51**	-0.39*	0.24	1.00

Note: Supply is percent change in U.S. supply from year *t–1* to year t. S/U is percent change in U.S. stocks-use-ratio from year *t–1* to year *t*. China net imports is the absolute change in China's net imports as a proportion of world demand from their average over the preceding 2 years. CCC is end-of-season stocks for year *t* of cotton either owned by USDA's Commodity Credit Corporation or remaining as collateral for the cotton loan program as proportion of demand for U.S. cotton that year. Foreign supply is the percent change in world minus U.S. cotton supply (minus China's supply and plus China's net exports) from year *t–1* to year *t*. Number of observations is 33. One asterisk indicates significance at the 5% level (two-tailed), two asterisks indicate significance at the 1% level (two-tailed).

Figure 6

Actual and estimated U.S. upland cotton farm price, 1974-2007



Source: *World Agricultural Supply and Demand Estimates* (WASDE), various issues, and authors' calculations.

Granger (2005) highlighted that the construction of a model's evaluation should be motivated by the model's purpose. While one purpose of this model is to discern the impact of supply/demand and policy variables on cotton prices to improve the understanding of these processes, the primary purpose of the model is to assist forecasting. Jumah and Kunst (2008) recently demonstrated with a set of grain price forecasting models that statistics assessing in-sample fit and those evaluating out-of-sample performance can give distinctly different rankings of model preference.

For this cotton model, a set of out-of-sample forecasts was calculated by reestimating the model with a truncated historical sample (ending in 2002/03) and using the parameters from this truncated sample to estimate subsequent out-of-sample forecasts. Four years of price forecasts (2003/04 to 2006/07) were calculated using data available in August 2008. Forecast performance was assessed relative to alternative forecasts.

The first alternative is the cotton forecasting model developed by Meyer in 1998. Meyer's specification is:

$$\ln(P) = f\,(\ln(S/U), CHFSTKS, Index, DUM_{SU}, \ln(LDP) * DUM_{SU}, \ln(1+CCC/Use)), \quad (14)$$

where *CHFSTKS* = change in foreign (excluding China) stocks, *Index* = product of the September average of the price of the December futures contract and AMS's September estimate of the share of expected planted area already forward contracted, DUM_{SU} = dummy valued at 1 when stocks/use is less than or equal to 22.5 percent, *LDP* = the difference between the loan rate and effective loan repayment rate, and *CCC* = CCC inventory.

Thus, the main difference between the proposed model and Meyer's model is that the latter model does not take into account changes in domestic and world supply (which was less relevant during the time that model was developed) but accounts for the impact of additional information through the index variable connected to futures prices.

The second alternative is the reduced-form model developed by USDA's World Agricultural Outlook Board (WAOB) in 2006 in an attempt to reflect the increased export orientation of the U.S. cotton industry (U.S. Department of Agriculture, WAOB, 2006). This model's specification is:

$$P_t = f\,(WxC\ S/U_t, WxC\ S/U_{t-1}, \text{China net exports}_t), \quad (15)$$

where *WxC S/U* = world, excluding China, *stocks/use*.

The forecast from this model was used as one of the inputs in the USDA's cotton ICEC forecast. The difference between the proposed model and the WAOB model is that the WAOB model focuses on international forces, while the proposed model includes both international and domestic components.

Alternative models were estimated with samples ending in 2002/03. For each model, 2008 data for independent variables were used to estimate parameters. Estimated parameters were used to construct out-of-sample forecasts for 2003/04-2006/07. Alternative forecasts have been compared based on their individual mean error to test for bias, root mean squared error (RMSE), and mean absolute percent error to evaluate the size of the error, as well as Theil's U, with comparisons between forecasts based on the Morgan-Granger-Newbold (MGN) and Diebold-Mariano (DM) statistics (e.g., Diron, 2008).

Table 6 summarizes the proposed and alternative models' out-of-sample performance over 2003/04-2006/07. The first accuracy statistic presented for all forecasts is mean error, which measures forecast bias. This statistic demonstrates the tendency of the WAOB model forecasts to overestimate cotton prices in recent years, which was one of the motivations for developing the new model. The mean error for the proposed model is one of the smallest, suggesting that this model has been successful in reducing the bias in cotton price forecasts. The next two statistics, root mean squared error and mean absolute percent error, evaluate the variance of the alternative forecasts. The proposed model's RMSE of 4.1 cents/pound and MAPE of 7 percent are both lower than those of the alternative models. Theil's U statistics indicate that all three forecasts are distinctly better than those of the naive model, but the proposed model has the lowest (best) Theil's U of 0.31. Finally, the alternative forecasts were compared to a benchmark of the proposed model, using a the DM and MGN tests. The negative sign of the GNM statistic indicates lower accuracy of the alternatives relative to the benchmark. This test indicates that even with as little as four observations, the proposed model is significantly more accurate than the WAOB model (at the 10-percent significance level).[10]

Additional detail on out-of-sample performance is shown in figure 7, which plots specific errors of the alternative forecasts over 2003/04-2006/07. The proposed model had the smallest error in 2003/04, the largest error in 2006/07, and an about average performance in 2004/05. Unfortunately,

[10]Accuracy of this model deteriorates significantly if the dependent variable is switched from real to nominal prices. MAPE doubles in the out-of-sample test, while RMSE and bias also grow. Theil's U-statistic rises to above Meyer's and the GNM statistic falls so that this model is no longer more accurate than WAOB. Thus, adjusting for inflation improves the accuracy of the model.

Table 6

Evaluation of price forecasting models, 2003/04-2006/07[1]

Model	Isengildina and MacDonald	Meyer[2]	WAOB[3]
Information set[4]	2008	2008	2008
Sample	1974-2002	1978-2002	1989-2002
		Cents/lb	
Mean error (bias)[5]	2.1	2.0	-7.8
Root mean squared error (RMSE)[6]	4.2	6.2	12.4
		Percent	
Mean absolute percent error (MAPE)	8	9	16
Theil's U statistic	0.33	0.39	0.97
Morgan-Granger-Newbold statistic[7]	--	-0.97	-2.79
Diebold-Mariano statistic[8]	--	1.01	0.86

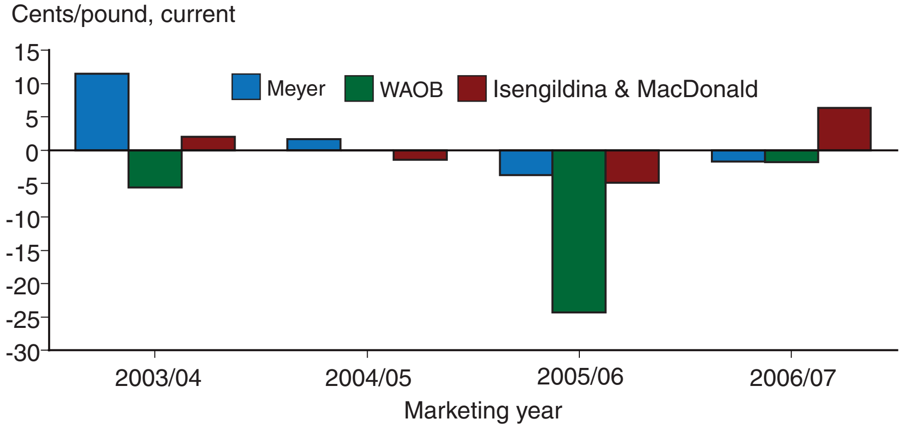
[1] Model parameters estimated with samples concluding in 2002/03.
[2] Meyer, 1998.
[3] Unpublished model developed by the World Agricultural Outlook Board.
[4] Information set used to estimate parameters. For each model, 2008 information is used to determine the values of the independent variables.
[5] For each year, $e_t = Y_t - F_t$, where Y_t is the actual realization of the price and F_t is the forecast. Therefore, $e_t < 0$ is an indication of upward bias. None of the models evaluated here had average forecast means that were significantly different from zero at either the 1-percent, 5-percent, or 10-percent level.
[6] The RMSE shown here are calculated only for the out-of-sample forecasts over 2003/04-2006/07.
[7] GNM statistic testing difference between forecast accuracy of Isengildina and MacDonald forecast. None of the differences were significant at either the 1-percent or 5-percent levels. WAOB was significant at the 10-percent level.
[8] DM statistic testing difference between forecast accuracy of Isengildina and MacDonald forecast. None of the differences were significant at the 1-percent, 5-percent, or 10-percent level.

the necessary tradeoff between the need to estimate models relevant to a dynamic economic environment and the already limited universe of annual observations available limits the number of observations available for evaluating annual forecasting models, but these tests indicate that the model is an improvement over earlier efforts.

Another important characteristic for a forecasting model is parameter stability. If estimated parameters change significantly as new observations are added, the out-of-sample forecasts may become highly volatile and less accurate, and the model may be misspecified. Parameter estimates are relatively unchanged when estimated using a 1974/75-2002/03 sample versus a 1974/75-2006/07 sample (table 7). Furthermore, the out-of-sample forecasts of the model estimated with the 1974/75-2002/03 subsample are only slightly less accurate than the in-sample estimated prices of the model using the full dataset. This stability bodes well for the model's usefulness in future forecasting.

Figure 7

Out-of-sample performance of proposed model relative to alternative models



Source: Authors' calculations.

Table 7

Parameter stability between samples and out-of-sample performance

Variable or statistic	1974/75-2006/07 Coefficient	1974/75-2002/03 Coefficient	Percent difference
Constant	-0.026	-0.032	20
Supply	-0.949	-0.893	-6
Stocks/use	-0.028	-0.041	48
China NI (net imports)	3.060	3.407	11
CCC	0.372	0.408	10
Foreign supply	-0.867	-0.830	-4
Accuracy: 2003/04-2007/08			
RMSE	3.492	4.173	21
MAPE	0.066	0.079	--
Theil's U statistic	0.333	0.398	--

Note: Price is percent change in the real U.S. season-average upland cotton farm price from year *t–1* to year t. Supply is percent change in U.S. supply from year *t–1* to year t. S/U is percent in U.S. stocks-use ratio from year *t–1* to year *t*. China net imports is the absolute change in China's net imports as a proportion of world demand from their average over the preceding 2 years. CCC is end-of-season stocks for year *t* of cotton either owned by USDA's Commodity Credit Corporation or remaining as collateral for the cotton loan program as proportion of demand for U.S. cotton that year. Foreign supply is the percent change in global cotton supply (minus China's supply and plus China's next exports) from year *t–1* to year *t.*

Conclusions and Implications

This report developed a statistical model that reflects current drivers of U.S. upland cotton prices in response to renewed authority for USDA to publish cotton prices and the growing challenges to accurate cotton price forecasting in recent years. A review of the theoretical framework for commodity price forecasting suggested that changes in supply should be included in a cotton price model because of the rapid growth in supply due to the spread of genetically modified varieties and other technologies. Several demand shifters were also included in the model. China's net trade as a proportion of world consumption was included to account for changes in export demand associated with China's commodity and trade policies. The impacts of U.S. farm policy were accounted for by including a variable representing the amount of cotton in the marketing loan program as a share of domestic consumption and by adjusting the dependent variable to reflect the historical impact of the User Marketing Certificate (Step 2) program, now discontinued.

Analysis of the cotton price forecasting model identified a structural break that occurred in the U.S. cotton industry in 1999. This structural break was likely caused by a combination of factors, including an increased export orientation of the U.S. cotton industry as the domestic textile industry contracted following the phasing out of the Multifiber Arrangement (for more information on the end of the MFA, see MacDonald and Vollrath, 2005). Thus, the proposed model was modified to include the world supply of cotton, to reflect the increased export orientation, and to correct for the observed structural change. The final model was subjected to extensive out-of-sample testing to ensure its appropriateness for forecasting.

The out-of-sample performance measures of the proposed cotton price model suggest that it is a considerable improvement over the naive forecast. Parameter estimates and forecast errors do not change much between a full sample and reduced sample used for out-of-sample forecasting, indicating the stability of the model. This stability is an improvement over past forecasting models that have been challenged by changing market conditions. Specifically, the out-of-sample forecasts from the proposed model are characterized by a lack of bias and relatively low variance. However, the in-sample root mean squared error of the nominal price predictions projected by this model is 6.0 cents/pound, which is about 10 percent of the 1974/75–2006/07 average for U.S. upland cotton farm prices. These errors suggest that there may be some variables omitted from the model that can be pursued in future research.

Omitted variables could include cotton quality characteristics, the role of polyester (cotton's primary substitute in textile spinning), and lower transmission of grain price shocks to significant non-U.S. cotton producers. For example, Olmstead and Rhode (2003) demonstrate that the average staple length of U.S. cotton rose during the historical sample used to estimate this model. The U.S. season-average price is equivalent to the value of the crop of upland cotton divided by its volume, and staple length is a key determinant of the price of a particular bale, or lot, of cotton. Olmstead and Rhode's data started in 1957, when the U.S. upland crop averaged 32.75 sixteenths of an inch long. In 2006/07 and 2007/08, it averaged 35.3 sixteenths, an increase since 1957 that in 2007/08 would be worth about 2 cents per pound (USDA/

AMS, 2008). However, the impact of these quality characteristics on the price of cotton was not included in this study as it is very difficult to quantify.

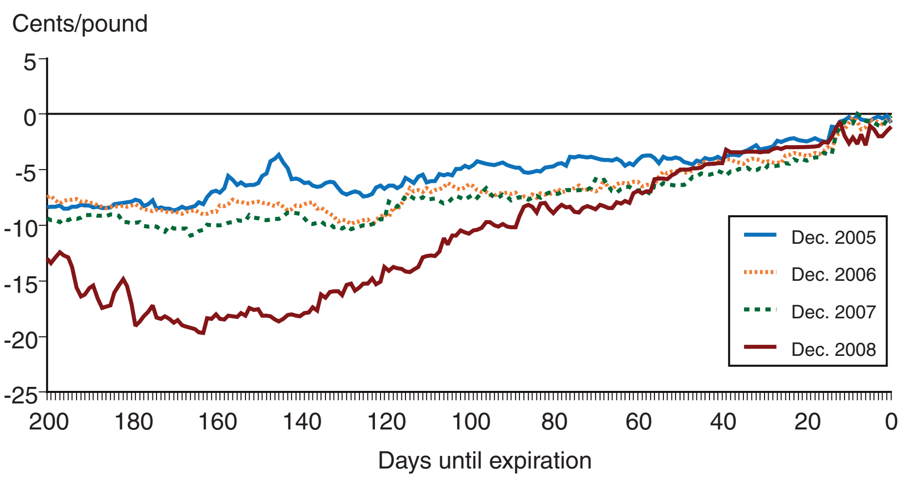
The proposed model is particularly informative in an environment of volatile commodity prices and the increased role of new players in futures markets. These developments and changing market institutions, such as the rise of electronic trading, have raised questions about the relationships among cash prices, futures prices, and supply/demand fundamentals. Specifically, there has been growing concern about changes in the relationship between futures prices and cash prices in the United States (Irwin et al., 2007). In March 2008, U.S. cotton futures demonstrated nearly unprecedented volatility. The basis between nearby futures and spot prices remained historically wide for several months afterward (fig. 8).

As a result, a cotton price forecast based on futures prices in 2008 would have been biased substantially upward. This is illustrated by the surge in the futures-based forecasts of farm prices for corn, wheat, and soybeans published by USDA's Economic Research Service during 2008 (U.S. Department of Agriculture, Economic Research Service, 2008). Therefore, while it would be irrational to ignore the information provided by futures markets when forecasting the U.S. farm price of cotton, it is also important to have forecasts that are independent of that information.

The out-of-sample performance of the proposed model was superior to that of alternative models. This comparison, however, does not include the consensus-based forecasts of USDA's Interagency Commodity Estimates Committee (ICEC) for cotton that became publicly available in the WASDE reports as of June 2008. The consensus forecasts were about as accurate as the proposed model, despite the handicap of preliminary supply and demand estimates. The advantage that the ICEC had in making its forecasts was the ability to incorporate additional information in its forecasting procedure that is hard to quantify within the framework of a statistical model. However, consensus forecasts are very specific to current events and difficult to replicate or adjust to changing circumstances. As such, they are of limited use when presenting policymakers

Figure 8

December ICE cotton contracts' basis, 2005-08



Source: Thompson Reuters Datastream.

with alternative scenarios. A further advantage of this report's model is the opportunity for checking consistency. USDA's ICEC sometimes adjusts its supply and demand outlook in response to prices, and this model provides an additional tool to aid in that process.

Future avenues for research relate to both world cotton markets and to the characteristics of USDA's supply and demand forecasts. While this study correctly identified some aspects of the structural change that has occurred in U.S. cotton markets since 1999, further examination of the sources of structural change and the channels through which it affects cotton prices is warranted. In addition, forecasts based on this model will depend not only on the parameters of the model, but will also be conditional on the forecasts of supply and demand used to derive any particular forecast of price. Intuitively, early-season forecasts are less reliable than late-season forecasts, but further research can inform these intuitions, and identify key points in the season with respect to dynamics of forecast performance within the forecasting season. Furthermore, the accuracy of specific supply and demand variables and their potential contribution to forecast errors should be examined with the goal of correcting for systematic errors in the cotton price forecasts.

References

Barsky, R.B., and L. Kilian. 2002. "Do We Really Know that Oil Caused the Great Stagflation? A Monetary Alternative." in *NBER Macroeconomics Annual 2001*, 16, B.S. Bernanke and K. Rogoff, eds., Cambridge, MA: MIT Press, pp. 137-183.

Diron, M. 2008. "Short-term forecasts of Euro area real GDP growth: an assessment of real-time performance based on vintage data," *Journal of Forecasting* 27: 371-390.

Ferris, J.N. 2005. *Agricultural Prices and Commodity Market Analysis*, Michigan State University Press.

Food and Agricultural Policy Research Institute. 2005. *Impacts of Commodity and Conservation Reserve Program Provisions in House and Senate Reconciliation Bills*, FAPRI-UMC Report #15-05.

Goodwin, B.K., R. Schnepf, and E. Dohlman. 2005. "Modelling soybean prices in a changing policy environment," *Applied Economics*, 37: 253-263.

Goreux, L., A. Plastina, A. Gruere, and Y. Cao. 2007. "The New ICAC Cotton Price Forecasting Model." *Cotton: Review of the World Situation*, ICAC, (July-August 2007).

Granger, C.W.J. 2005. "Modeling, evaluation, and methodology in the new century," *Economic Inquiry*, 43(1): 1-12.

Hansen, B.E. 2001. "The New Econometrics of Structural Change: Dating Breaks in U.S. Labor Productivity," *Journal of Economic Perspectives* 15:117-28.

Hansen, B.E. 1997. "Approximate Asymptotic P Values for Structural Change Tests." *Journal of Business and Economic Statistics* 15(1):60-61

International Cotton Advisory Committee. 1998. "Where will cotton prices go?" *Cotton Review of the International Situation* 41(3): 3-5.

Irwin, S.H., H.H. Garcia, and D.L. Good. 2007. "The Performance of Chicago Board of Trade Corn, Soybean, and Wheat Futures Contracts after Recent Changes in Speculative Limits," American Agricultural Economics Association, Annual Meeting, July 29-Aug. 1, 2007, Portland, OR.

Jumah, A., and R.M. Kunst. 2008. "Seasonal production of European cereal prices: good forecasts using bad models?" *Journal of Forecasting* 27: 391-406.

MacDonald, Stephen. 1997. "Forecasting World Cotton Prices." *The Ninth Federal Forecasters Conference—Papers and Proceedings,1997*. National Center for Educational Statistics, U.S. Department of Education.

MacDonald, Stephen. 2006."Cotton Price Forecasting and Structural Change," *The 15th Federal Forecasters Conference—Papers and Proceedings, 2006*, U.S. Department of Veterans Affairs, Veterans Health Administration.

MacDonald, S., and T. Vollrath. 2005. *The Forces Shaping World Cotton Consumption After the Multifiber Arrangement*, U.S. Department of Agriculture, Economic Research Service, CWS-05C-01. http://www.ers.usda.gov/publications/cws/apr05/cws05c01/cws05c01.pdf

Meyer, L., and S. MacDonald. 2001. *Cotton: Background and Issues for Farm Legislation*, Outlook Report No. CWS-0601-01, U.S. Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/publications/CWS-0601-01/cotton-policy.pdf

Meyer, L., S. MacDonald, and R. Skinner. 2008. *"Cotton and Wool Outlook,"* Outlook Report No. CWS-08a, U.S. Department of Agriculture, Economic Research Service. http://usda.mannlib.cornell.edu/usda/ers/CWS//2000s/2008/CWS-03-12-2008.pdf

Meyer, L., S. MacDonald, and L. Foreman. 2007. *Cotton Backgrounder*, Outlook Report No. CWS-07B01, U.S. Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/publications/CWS/2007/03Mar/CWS07B01/cws07B01.pdf

Meyer, L.A. 1998. "Factors Affecting the U.S. Farm Price of Upland Cotton," *Cotton and Wool Situation and Outlook*, CWS-1998, U.S. Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/briefing/cotton/pdf/cws1998CottonFarmPrice.pdf

Mohanty, S., S. Pan, M. Welch, and D. Ethridge, 2005. "The Impacts of Eliminating the Step 2 Program on the U.S. and World Cotton Market," Briefing Paper CER-BR05-01, Cotton Economics Research Institute, Texas Tech University.

Olmstead, A.L., and P.W. Rhode. 2003. "Hog Round Marketing, Seed Quality, and Government Policy: Institutional Change in U.S. Cotton Production, 1920-1960," Working Paper w9612, National Bureau of Economic Research.

Plato, G., and W. Chambers. 2004. *How Does Structural Change in the Global Soybean Market Affect the U.S. Price?* OCS-04D-01, U.S. Department of Agriculture, Economic Research Service.*http://www.ers.usda.gov/publications/OCS/APR04/OCS04D01/OCS04D01.pdf*

Skelly, Carol, ICEC Chair, World Agricultural Outlook Board, private communication, 03/30/2007.

Schnepf, R. 2007. "Brazil's WTO Case Against the U.S. Cotton Program," CRS Report for Congress, No. RL32571. http://ncseonline.org/NLE/CRSreports/07Oct/RL32571.pdf

Stock, J.H., and M.W. Watson. 2003. *Introduction to Econometrics*. Pearson Education, Inc., New York, 2003.

Stultz, H., E.H. Glade, S. Sanford, J.V. Lawler, and R.A. Skinner. 1990. *Fibers: Background for 1990 Farm Legislation*, Agriculture Information Bulletin No. 591, U.S. Department of Agriculture, Economic Research Service. *http://www.ers.usda.gov/Publications/aib591/aib591fm.pdf*

Tomek, W.G., and K.L. Robinson. 2003. *Agricultural Product Prices*. 4th edition. Cornell University Press.

Townsend, Terry P. 1989. "This Was a High-Powered Instrument That Sent Its Projectile to the Vitals of the Industry—Why USDA Does Not Forecast Cotton Prices," *Proceedings of the Cotton Beltwide Conferences*. National Cotton Council.

U.S. Department of Agriculture Agricultural Marketing Service, Cotton Program. 2008. *Cotton Quality Annual Report*, Vol. 81, No. 8.

U.S. Department of Agriculture, Agricultural Marketing Service, Cotton Program. 2008. *Cotton Price Statistics Annual Report*, Vol. 89, No. 13.

U.S. Department of Agriculture, Economic Research Service. 2008. S*eason-Average Price Forecasts*. *http://www.ers.usda.gov/Data/PriceForecast/*

U.S. Department of Agriculture, Economic Research Service. 2001. *Cotton and Wool Situation and Outlook,* CWS-2001, Nov.

U.S. Department of Agriculture, Foreign Agricultural Service, *Production, Supply, and Distribution Online*. http://www.fas.usda.gov/psdonline/

U.S. Department of Agriculture, National Agricultural Statistics Service. 2008. *Agricultural Prices*, Sept. 29.

U.S. Department of Agriculture, World Agricultural Outlook Board. Various years. *World Agricultural Supply and Demand Estimates*. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1194

U.S. Department of Agriculture, World Agricultural Outlook Board. 2006. Unpublished price model in ICEC current supply and demand summary.

Valderrama, C. 2000. "A Revision of the ICAC Price Model," *Cotton: Review of the World Situation* 53-6 (July-Aug.), International Cotton Advisory Committee.

Valderrama, C. 1993. "Modeling International Cotton Prices," *Proceedings of the Cotton Beltwide Conferences*. National Cotton Council.

Van Meir, L.W. 1983. *Relationships among Ending Stocks, Prices, and Loan Rates for Corn*. *Feed Outlook and Situation Report*, FdS-290, U.S. Department of Agriculture, Economic Research Service.

Wang, D., and W.G. Tomek. 2007. "Commodity Prices and Unit Root Tests," *American Journal of Agricultural Economics* 89(4): 873-889.

Westcott, P.C. 2007. *Ethanol Expansion in the United States: How Will the Agricultural Sector Adjust?* Outlook Report No. FDS-07D-01, U.S. Department of Agriculture, Economic Research Service. *http://www.ers.usda.gov/Publications/FDS/2007/05May/FDS07D01/fds07D01.pdf*

Westcott, P.C., and L.A. Hoffman. 1999. *Price Determination for Corn and Wheat: The Role of Market Factors and Government Programs*. Technical Bulletin No. 1878. U.S. Department of Agriculture, Economic Research Service. *http://www.ers.usda.gov/publications/tb1878/tb1878.pdf*

Westcott, P.C., and J.M. Price. 2001. *Analysis of the U.S. Commodity Loan Program with Marketing Loan Provisions*, Agricultural Economic Report No. 801, U.S. Department of Agriculture, Economic Research Service. *http://www.ers.usda.gov/publications/aer801/aer801.pdf*