FORECASTING WORLD COTTON PRICES

Stephen MacDonald, Economic Research Service, USDA

This paper presents a forecasting model used by the Economic Research Service (ERS) of USDA for its contribution to the unpublished forecasts of the Department's , interagency Cotton Estimates Committee. USDA does not publish any cotton price forecasts, and its unpublished price forecasts are not directly derived from this or any other single model.

Since 1929, Congress has forbidden USDA from publishing forecasts of cotton prices (see Townsend for a discussion of the circumstances surrounding this legislation). However, commodity price forecasting by USDA is not solely geared towards publication, and the Department's Interagency Cotton Estimates Committee calculates unpublished estimates of world and domestic cotton prices each month. This paper details a single equation forecasting model for world cotton prices used to assist ERS in its contribution to the USDA price forecasts. Several aspects of the model's specification are discussed in the context of developments in U.S. and foreign cotton markets over the last 25 years. The model is based on the relationship between price, consumption, and stocks, and also attempts to account for the wide variety of policies in the United States and overseas.

World Prices

There are a wide variety of prices available for any given major commodity, each associated with a specific location and function. Determining which price is "the" world price is occasionally difficult, and even widely accepted choices involve trade-offs between varying degrees of specificity and generality. At USDA, world prices for wheat, corn, and soybeans are generally accepted to be described by the Agricultural Marketing Services (AMS) prices at U.S. Gulf Ports (USDA). The drawbacks to this choice include the loss in generality stemming from fixing the price to a specific quality from a single origin. At times, world com markets may be influenced by different factors than those heavily weighing on number 3 com or U.S. corn.

An average per-unit value--like an import unit value or average price received by farmers--may generalize with respect to origin or quality, but has the disadvantage of potentially varying as the shares of origins or qualities vary.

For cotton, an average of price quotes for a specific quality of cotton (middling 1-3/32") grown in various regions, but quoted for delivery in Northern Europe, has become accepted as a measure of the world price. This average is published daily by Cotlook Limited, and is known as the A-index. Cotlook Limited has registered the Cotlook A-index as a trademark, and each issue of *Cotton Outlook* magazine details how the index is derived. U.S. legislation has led to the adoption of an index identical to the A-index to help trigger policy decisions for the U.S. cotton marketing loan program (MacDonald). Thus, forecasts of the A-index are useful to both public and private sector policy-makers.

The Model

Assuming production of cotton is fixed before the beginning of the marketing year, then the following equilibrium model of the cotton market can be specified:

supply, $S = Q$

Demand, $C = f(P)$

Stocks, $I = g(P)$

$$S - C - I = 0$$

where: Q is amount of crop production for that given year (plantings depend of previous year's price, and the size of the harvest is determined before the beginning of the marketing year, although it is not necessarily all immediately available at that time) and P is price. Prices can be determined from the inverse of either the consumption or stocks function. Taking the inverse of the consumption function yields a price determination equation with prices directly related to consumption,

$p = f'(c)$

Following Westcott, this consumption variable is measured relative to a "scale of availability" in the cotton sector, represented by the realized end of year stocks (I). Textile production is a capital-intensive process, and is most profitable when machinery operates continuously. A rate of consumption that suggested a depletion of the current year's cotton

supply before the availability of the following year's harvest would suggest a period during which textile producers would have no income to meet their fixed costs. Uncertainty regarding the size, timing, and transportation of the following year's crop suggests consumption should never be large enough to completely deplete the year's supply by, or even shortly after, the end of the year. Thus, we are left with a relationship stating prices are directly proportional to the ratio of consumption and ending stocks, and the implication that over a long time period this proportionality can shift as the risk of beginning the next marketing year with low supplies varies,

$$p = f^{1}(C / I, z)$$

where z is the set of exogenous factors that can shift the relationship between current year price and use/stocks. Figure 1 illustrates how trends in inflation-adjusted cotton prices and global use/stocks have varied since 1971. The growing divergence between these two variables suggests the relationship has not been constant.

In this model the exogenous shift variables include: dummies representing different U.S. agricultural policy regimes, dummies for a few years of specific economic or policy shocks, variables capturing the impact of U.S. payments to cotton exporters (under a program that has made payments to both domestic users and exporters of cotton), and variables capturing consumers' expectations of changes in the cost of consuming cotton. A real U.S. exchange rate is also included as a separate variable since much of the world's consumption occurs in economies where neither costs nor returns are calculated in U.S. dollars. This could be specified by adjusting the A-index (which is reported in terms of U.S. currency) by the exchange rate. However, exchange rate changes are not exactly the same as changes in product prices (Goldstein and Khan), so the exchange rate was used as an explanatory variable, and the price remained in U.S. currency.

Given the somewhat ad-hoc nature of the exogenous shift variables introduced into the model, hypothesis testing of parameter values is not reliable, However, the model is still suitable for forecasting purposes since the large number of explanatory variables (11) suggests the danger is greater that the model includes irrelevant variables than is the danger that it omits relevant variables. Omitting relevant variables introduces bias and inconsistency into the parameter estimates for the included variables, in most cases (Pindyck and Rubinfeld). Irrelevant variables reduce efficiency but do not introduce bias or inconsistency, and, when the concern is with forecasting rather than hypothesis testing, the cost of mistakenly excluding a relevant variable is greater than the cost of including one that is irrelevant. Therefore, some variables for which theory suggests inclusion, but test statistics suggest omission, remain in the model.

Data

The dependent variable (P) was an unweighed marketing year average of the daily A-index in U.S. currency, adjusted by the U.S. GDP deflator. This is the deflator used for all the real prices in USDA's baseline forecasts. The stocks variable (I) is world ending stocks according to USDA's official database, minus China's ending stocks. Similarly, the consumption variable (C) is world consumption minus China's consumption, plus an additional factor. The additional factor added to consumption is net imports by China. These data are published in USDA's *Cotton and Wool Situation and Outlook Yearbook. These* adjustments largely reflect the uncertainty regarding the actual amount of cotton produced, consumed, and stored in China. One source of this uncertainty is the lack of a clear relationship between China's apparent domestic cotton supplies and its trade volume. Regardless of whether or not China's consumption and stocks have been correctly estimated, China's government prevents the rest of the world from accessing China's stocks at will, and prevents consumers in China from accessing world stocks at will. In a given year, China's most important effect on world prices comes from its trade, which either adds to cotton consumption when China is a net importer, or effectively reduces world consumption when China is a net exporter. These adjustments are similar to those followed by the International Cotton Advisory Committee (ICAC) in its world price forecasting model. One difference is that the ICAC includes China's trade as a separate variable rather than adding it to consumption or stocks.

Results

The model was estimated over 1971-95, since 1971 is initial year of the macroeconomic database developed for ERS'S long-range baseline forecasting for the President's Budget (USDA). A semi-logarithmic functional form is used since the non-linear relationship captured turning points slightly better.

The estimated equation is (t-statistics in parentheses):

Ln(P) = 7.70-0.47 Dum8695 -0.22 Dum9195
(23.8) (5.1) (3.0)

-0.29 Dum8485 + 0.54 Dum73 + 0.15 Dum7476
(3.9) (6.8) (2.8)

-0.74 Step2 -0.44 Step2d + 2.87 Infl -0.45 Prodd
(0.5) (1.0) (1.97) (2.6)

-0.004 Xr + 0.18 C/I
(1.97) (3.9)

R^2= .98 D.W .= 2.54

Figure 2 illustrates the performance of the estimated model.

Dum8695 is a variable with the value of 1 during 1986-1995 and zero otherwise. Dum9 195 is a variable with the value 1 during 1991-1995 and zero otherwise. These dummies correspond to shifts in U.S. agricultural policy which significantly changed the relationship between prices and stockholding for all commodities in the United States, the world's largest cotton stockholder throughout much of the period analyzed. The United States has held as much as 35 percent of the world's non-Chinese stocks before 1986, but has remained below 20 percent every year since 1988.

Recall the divergence in trends in prices and the world use/stock ratio illustrated in Figure 1. While some of this divergence represents improvements in global communication, transportation, and trade that reduce the risk of not holding stocks, a large part of the divergence represents progressive changes in U.S. government efforts to keep U.S. cotton stocks off the market.

Dum8485 is a variable with the value 1 in 1984-1985 and O otherwise. It represents the combined effect of anticipation of the 1985 U.S. farm legislation and a shift in China's trade policy. The 1985 U.S. farm legislation lowered the high loan rates of the 1981 legislation and opened U.S. stocks to world markets for a variety of commodities. World prices fell in marketing year 1984 as the legislation took shape, partly in anticipation of lower prices in the subsequent year, and continued falling as lower priced production and pent-up stocks from the United States subsequently became available. These years also mark the initiation of large exports by China, only a few years after China had culminated 19 years of continuous net imports by becoming the world's largest importer. Between 1980 and 1985, China went from the world's largest importer to the world's largest exporter. China has generally been a net importer since then. Thus, it is not altogether clear if Dum8485 is capturing just the effect of U.S. policy, Chinese policy, or both.

Dum73 and Dum7476 are variables with the value 1 in, respectively, 1973 and 1974-76. The first oil shock and the USSR's "great grain robbery" (Morgan) of the early 1970's introduced significant volatility into commodity prices. Efforts to capture the volatility in expectations associated with this price volatility through other variables such as inflation and exchange rates were not completely successful. Simple specification testing (Durbin-Watson statistics) indicated that a model that included the years 1971-76 with two associated dummies was superior to one that excluded these years. In general, a modeler must use judgement to distinguish between outliers that are so extreme that they suggest measurement error or sim i lar flaws and events that contain valuable information about the process being modeled (Pindyck and Rubinfeld).

U.S. Marketing Loan Program

Step2 is expenditure on exported cotton in a given year by the U.S. government under Step 2 of the cotton marketing loan program, divided by the value of all U.S. cotton exports that year. Export values are from USDA's ***Outlook for U.S. Agricultural Exports*** and data on the spending for Step 2 are from USDA's Farm Service Agency. Direct expenditures to support exports are thereby converted into percent equivalents. Both the export and expenditure data are on a fiscal year, but the difference between fiscal and marketing year is only 2 months, and the two months are those typically with the lowest export activity.

Step 2 of the marketing loan program was introduced in the 1990 U.S. farm legislation (MacDonald), so the variable is zero before 1991. Note that this program is also available to domestic consumers of cotton, and was therefore unaffected by the Uruguay Round Agreement. However, the United States unilaterally modified the program in 1996 to shift the expenditures even further in favor of domestic cotton consumers. This suggests that the relationship between expenditures under Step 2 and prices will be different in the future than what has been estimated here.

The expected sign of this variable is negative, as is the expected sign of the other variable associated with the Step 2 program, Step2d. Step2d is the first difference of the Step2 variable. Since the expenditures on

exported cotton under the Step 2 program acted like an export subsidy by a large exporter when they occurred during 1991-1995, they would be expected to lower the world price of the commodity (Tweeten). The Step2d variable is intended to capture the additional effect of changes in the expenditures. The Step 2 program is not in effect continuously, and if market participants assumed the previous year's expenditures were a guide to the current year, Step2d is the adjustment in their expectations.

Step 2 payments to exporters were equivalent to 2-3 percent of the value of global raw cotton trade in 1992 and 1993, and the relationship between U.S. and world prices appears to have shifted since the step 2 program began. During 1972-90, the average premium Memphis 1-3/32" cotton received in Northern Europe to the A-index was 3.4 percent (excluding the policy transition period just before the 1985 farm legislation took effect). During 1990-96 the average premium was 6.8 percent. The shift from 3.4 percent to 6.8 percent may stem from the introduction of a price wedge between U.S. and world cotton prices through the Step 2 program. Some of this price wedge would derive from higher U.S. prices, but some would derive from lower world prices (Tweeten). The t-statistics for these parameters do not support the hypothesis that either is significantly different from O. But, as noted earlier, the specification of this model does not lend itself to hypothesis testing. Both variables remain in the model due to their ability to improve short-run forecasts when recent years of data are dropped from the sample, and out of sample forecasts derived for those years.

One difficulty in determining the impact of the Step 2 on world prices is that Step 2 payments are correlated with the appearance of inexpensive Central Asian cotton on world markets. The ICAC, rather than including Step 2 data in their model, incorporates the bartered share of Central Asian exports (ICAC). While theory suggests that payments like Step 2 would put a price wedge between U.S. and world prices, the widening gap between the price of U.S. cotton and the A-index may also reflect changes in the A-index. Low production costs and falling domestic demand within the Former Soviet Union (FSU) meant increased quantities of Central Asian cotton were available at extraordinarily low cost in the early 1990's. Significant quantities of FSU cotton were held by former consumers which had acquired cotton under traditional barter arrangements, and marketing outside of the FSU was novel for Central Asian exporters. Thus much of the cotton left Central Asia under barter arrangements, resulting in its availability on world markets for low prices when sold for convertible currencies. Illustrative of the shift in costs to non-FSU markets is the shift in Central Asian cotton's rank among exporters: from a typical position of the third least expensive cotton in the world during the late 1980's, to consistently the least expensive during the early 1990's. More recently it has ranked closer to second least expensive.

Prices were particularly low during the 1992 marketing year when, in addition to the influx of Central Asian cotton, China was a net exporter for the only time between 1988-96, and India was exporting after an unusual decline in its cotton consumption. Much of the marketing year 1993/94 Step 2 export expenditures were based on commitments made during the 1992/93.

Other Variables

Expectations of exogenous changes in the future cost of procuring cotton are assumed to be encompassed by current year inflation and by an average change in production over the last 2 years.

Infl is the annual percent change in the U.S. GDP deflator. It has been assumed that consumers and stockholders believe the current year's inflation rate is the best guide to future inflation, which influences their willingness to accept a given price at a given use/stocks ratio. If inflation is higher, they will accept a higher price, since it reduces the likelihood they will be able to consummate postponed transactions later at a lower price. The estimated parameter has the expected positive sign.

Prodd is the average of the percent difference between the previous year's world production (excluding China) and each of the preceding 2 years. The preceding year is used because current year's actual production is generally not known until late in the year. While it is a safe assumption that the size of the crop is largely determined before the year begins, the poor communication and transportation infrastructure of the developing countries that account for much of the world's cotton production mean that early season estimates of production are unreliable.

Also, since developing countries heavily intervene in their economies, the price signals their producers receive are often at variance from those suggested by world prices. The best guide to the nature of the price signals many cotton producers receive, and to their ability to respond to them, is the resulting change in production. Since much of government economic policy, and the shifts in weather and insect pressures

that influence yields, are exogenous from world price signals, it is appropriate to incorporate the past performance information as an instrument representing these complex factors in a consumer's calculation of an appropriate price. As Prodd rises (declines) it is indicative of a rising (falling) exogenous trend in cotton availability, and price should fall (rise). Thus, the expected sign of the estimated parameter is negative. The estimated parameter's sign is in accordance with this expectation.

Finally, Xr is the International Monetary Fund's trade-weighted, real exchange rate index for the United States. Weighting exchange rates by some other measure than the value of U.S. merchandise trade might seem appropriate, but since a significant portion of cotton imports are for producing textiles whose ultimate consumption occurs in developing countries, the IMF's weights seemed generalizable.

As the index rises, the strength of the dollar increases, and the cost of cotton in other currencies rises. Thus, as the exchange rate index rises, foreign consumers are less willing to pay a given price in dollars, and the expected sign of the exchange rate variable parameter estimate is negative. The estimate's sign is in accordance with this expectation.

Conclusions

Forecasting a price open to as many changing influences as the A-index is difficult. Even after years of global economic liberalization, government intervention in world cotton markets is significant. The second largest consumer of cotton in the world, India, continues to regulate its exports through quotas, and the second largest exporter, Uzbekistan, seems impervious to changes in world prices.

This model has been built by step-wise regression over several years. The variables associated with the Step 2 program are the only variables in the model where t-statistics show a pronounced lack of significance. They remain in the model nonetheless since theory suggests a they will affect prices, and because out of sample testing with truncated data sets gives far more accurate estimates for 1994 and 1995. The change in the Step 2 program since 1996 also means that even correctly modeling the impact of the program on past prices will be insufficient for forecasting prices in the future.

The mean absolute percent error of the model is 4.4 percent over 1971-1995, and the error for its first out of sample estimate (1996) is 4.7 percent. While this is promising, the new U.S. Step 2 program, and the possible specification errors concerning some of the other variables, suggest that further stepwise revisions in this forecasting model will be needed.

References

Goldstein, Morris, and Moshin S. Khan. "Income and Price Effects in Foreign Trade." In ***Handbook of International Economics, Vol. II.*** R. W. Jones and P.B. Kenan (cd.). Elsevier Science Publishers. Amsterdam, Netherlands. 1985.

International Cotton Advisory Committee. ***Review of the World Cotton Situation.*** Various issues.

MacDonald, Stephen. "Cotton Marketing Loan Program Shifts Away from Imports." *Agricultural Outlook.* July 1997.

Morgan, Dan. *Merchants of Grain.* Penguin Books. Harmondsworth, England. 1980.

Pindyck, Robert S., and Daniel L. Rubinfeld. *Econometric Models & Economic Forecasts.* McGraw-Hill. New York. 1981.

U.S. Department of Agriculture. Economic Research Service. *Cotton and Wool Situation and Outlook Yearbook.* Various issues.

U.S. Department of Agriculture. Economic Research Service. *International Agricultural Baseline Projections to 2005.* Agricultural Economic Reports Number 750. Washington, DC. 1997.

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

Tweeten, Luther. *Agricultural Trade: Principles and Policies.* Westview Press. Boulder, CO. 1992.

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

Westcott, Paul C. "An Annual Model for Forecasting Corn Prices." Paper presented to Ninth Federal Forecasters Conference. Washington, DC. September 1997.

Figure 1--World Price and Use/Stocks

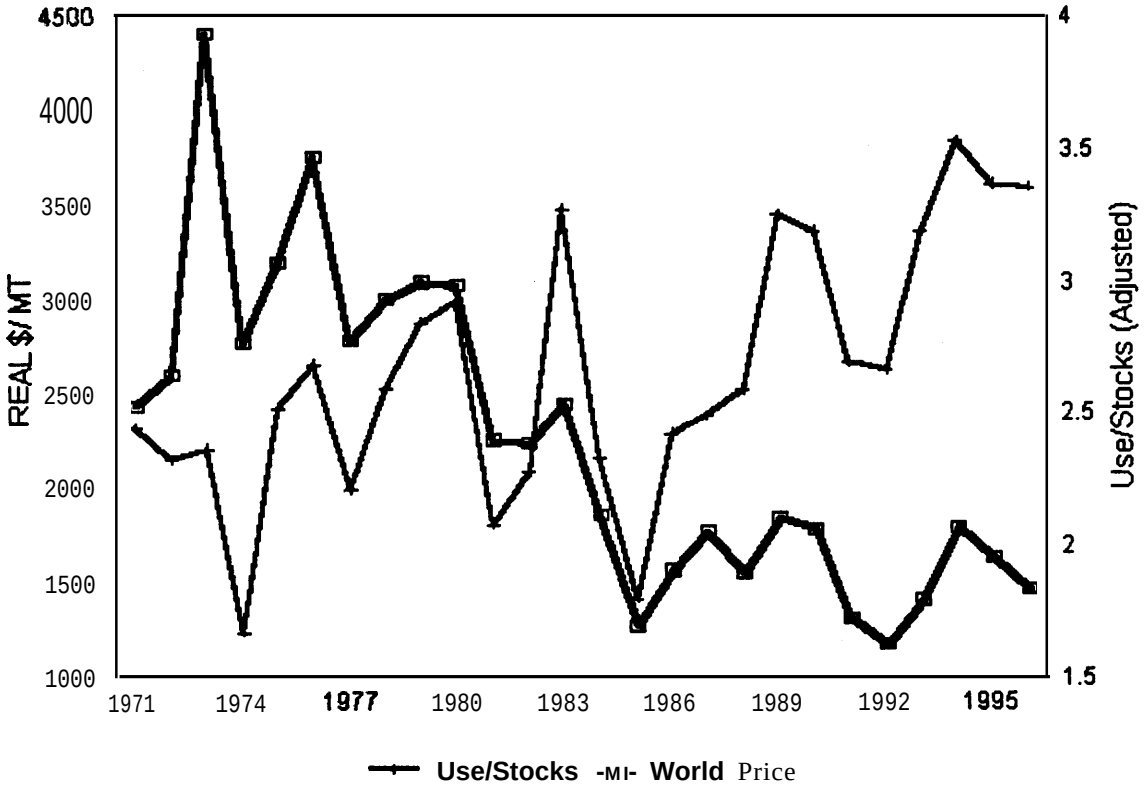

Figure 2--World Cotton Price