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.

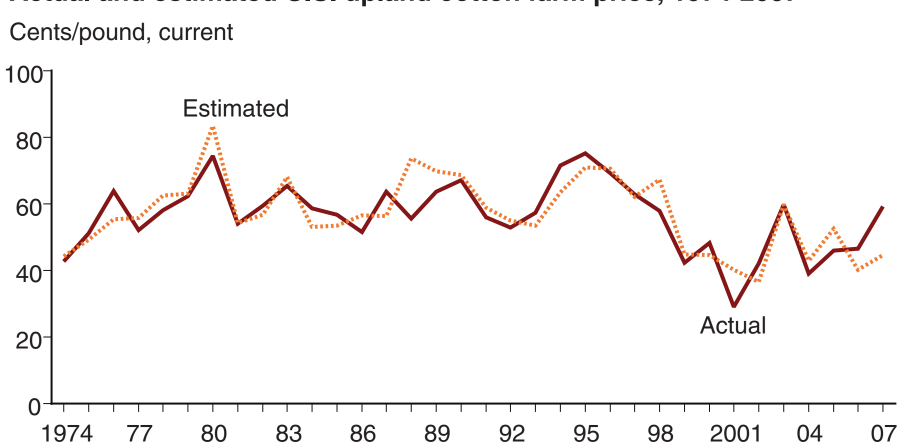
The goodness of fit of the model in nominal prices is illustrated in figure 6. Nominal prices are calculated by removing the inflation adjustment from the real prices predicted by the model and adjusting them for Step 2 payments. Converting real prices into nominal terms makes it easier to compare model 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:

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

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:

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

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

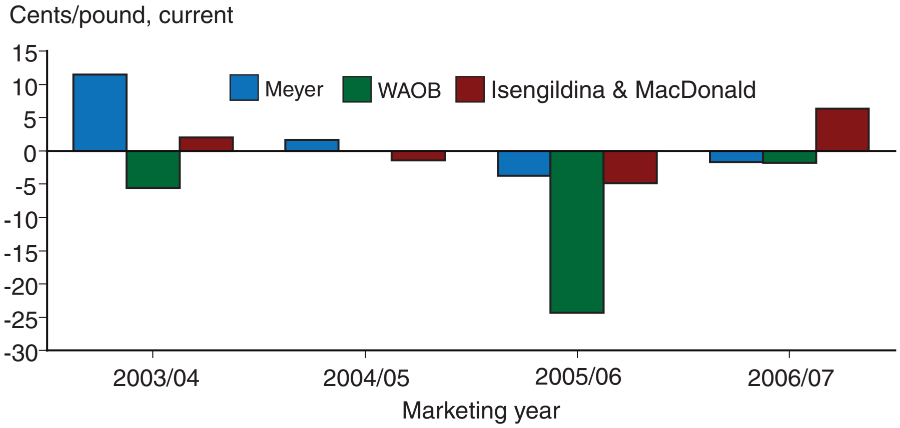
[1] Model parameters estimated with samples concluding in 2002/03.
[2] Meyer, 1998.
[3] Unpublished model developed by the World Agricultural Outlook Board.
[4] Information set used to estimate parameters. For each model, 2008 information is used to determine the values of the independent variables.
[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*.