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# Forecasting the U.S. Season-Average Farm Price of Upland Cotton: Derivation of a Futures Price Forecasting Model

Linwood Hoffman and Leslie Meyer

## Abstract

A forward-looking futures price-based model is developed that assists in forecasting upland cotton's season-average price (SAP) received by farmers. The SAP impacts resources devoted to cotton production, marketing, and manufacturing, and forecasts inform these decisions. A series of models are developed to generate alternative monthly SAP forecasts, derived from a different monthly basis (farm price minus nearby futures) and monthly marketing-weight expectations. As available, National Agricultural Statistics Service (NASS) monthly farm prices are also incorporated. As a measure of utility, root mean squared errors (RMSEs) from the best performing futures-adjusted model compare favorably to the *World Agricultural Supply and Demand Estimates* (*WASDE)* projections, a benchmark for industry comparisons. Furthermore, both forecast methods have a similar balance in over/under-forecasting errors during most months of the forecast cycle. The model's cotton futures-adjusted forecasts are timely, reasonably accurate, and can assist in forecasting the U.S. upland cotton season-average farm price.

**Keywords**: Upland cotton, season-average farm price forecasts, futures-adjusted forecast model, futures prices, basis, marketing weights

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# Contents

# Forecasting the U.S. Season-Average Farm Price of Upland Cotton: Derivation of a Futures Price Forecasting Model

## Introduction

The U.S. Department of Agriculture (USDA) analyzes agricultural commodity markets and provides year-to-date market information, including season-average price (SAP) projections for a number of crops. Information regarding commodity prices is crucial to a variety of market participants, including producers who make production and marketing decisions, market analysts who assess the impacts of domestic and international developments, and policymakers who administer commodity programs. USDA publishes official SAP forecasts in the monthly *World Agricultural Supply and Demand Estimates* (*WASDE*) report (USDA, OCE, WAOB, various issues). The SAP, sometimes known as the marketing year average price, represents the average price received by U.S. producers throughout the marketing year for all grades and qualities of the crop.[1]

For many years, however, cotton was an exception as USDA was prohibited by law from publishing cotton price forecasts between 1929 and 2008 (Townsend, 1989).[2] After a ban of nearly eight decades, the prohibition was eliminated with the passage of the Food, Conservation, and Energy Act of 2008. The USDA began publication of cotton price forecasts with the June 2008 *WASDE* report. Thus, a renewed interest in cotton SAP forecasting began.

The upland cotton's SAP, a key parameter in assessing the U.S. cotton sector's financial health, was also used until recently in determining commodity program payments. However, under the Agricultural Act of 2014, Title I's Price Loss Coverage (PLC) and Agriculture Risk Coverage (ARC) programs for upland cotton requiring an SAP were replaced by a stacked income protection plan (STAX), which depended instead on selected futures prices (Effland et al., 2014; USDA, Risk Management Agency, 2016).[3] On February 9, 2018, a new seed cotton program was added to Title I of the farm bill (National Cotton Council, 2018). This new program combines lint and cottonseed into one program and provides cotton producers the choice between a PLC or ARC program for the 2018 crop. Thus, an SAP is again needed in calculating payments for the PLC or ARC programs.[4]

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[1]A marketing year is a period of 1 year, designated for reporting and/or analysis of production, marketing, and disposition of a commodity. For cotton, the marketing year begins August 1 and concludes July 31.

[2]The longstanding prohibition began following congressional hearings that investigated a September 1927 USDA cotton price forecast. Members of Congress believed that the forecast triggered a market selloff, and legislation ensued. Season-average price forecasts, "internal use only," were produced, along with the supply and demand estimates to estimate commodity program costs during the prohibition.

[3]Under the 2008 Farm Bill the season-average price (SAP) received by cotton producers was a key policy parameter needed in calculating Counter Cyclical Payment rates or Average Crop Revenue Election (ACRE) program payments. In the 2014 Farm Act, the STAX program uses a futures price for the projected and actual upland cotton price to determine policy payments.

[4]This report focuses only on forecasting the lint cotton SAP, the same SAP that the *WASDE* currently reports, not the seed cotton SAP from the new seed cotton program that begins with the 2018/19 marketing year.

Cash and futures markets have long been followed as indicators of farm price expectations. Econometric and futures-based price forecasting models have been developed to aid in the forecasting of season-average farm prices. Econometric price forecasting models based on reported farm prices have been estimated for corn and wheat (Westcott and Hoffman, 1999), rice (Childs and Westcott, 1997) and cotton (Meyer, 1998; Isengildina-Massa and MacDonald, 2009). Meyer's model included market components and Government program parameters that explained 92 percent of the variation in annual upland cotton prices between the 1978/79 and 1996/97 marketing years. His model allowed for sensitivity analysis under various market supply and demand conditions that develop within a year, or between years, and an updated model has been used in USDA's short-term market analysis and long-term baseline projections.

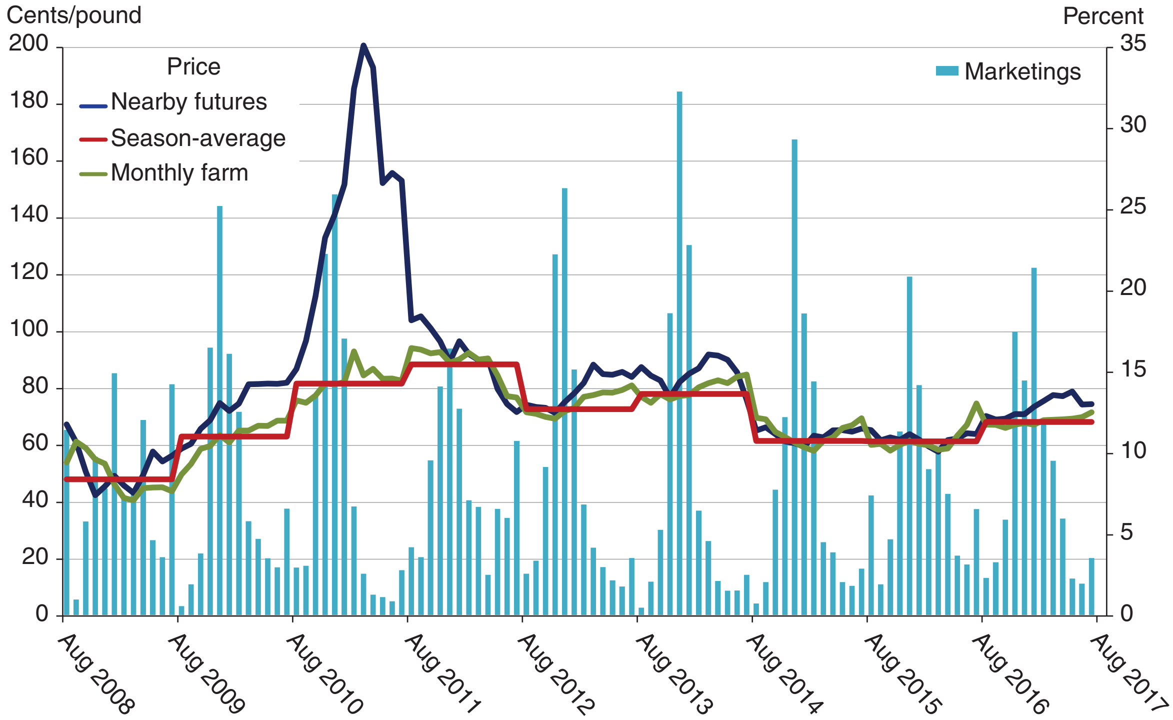
Econometric models built for cotton have a low forecast error, but their evaluation was based on historical (i.e., backward-looking) information. Price forecasting models using forward-looking futures prices were developed for corn, soybeans, and wheat to provide input for *WASDE* SAP forecasts, to forecast the annual counter cyclical payment rate for corn, soybeans, and wheat, and with the 2014 Farm Act to forecast price loss coverage rates (Hoffman, 2005a; Hoffman, 2005b; Hoffman et al., 2007).[5] Such futures price models also provide information on the likelihood of a crop's price triggering marketing loan benefits, and they complement econometric models in the array of price forecasting tools.[6] While both types of models have their strengths, the futures-based model with its forward-looking focus has helped commodity analysts provide short-term monthly forecasts of the SAP.

The futures price forecast model developed here for cotton is similar to those developed by Hoffman et al. (2007) for corn, soybeans, and wheat. Data needed include the current and past year's futures prices for the nearby contract months, past monthly and season-average farm prices, and past monthly marketing weights (fig. 1). Such models are a useful tool for commodity and policy analysts within the U.S. cotton sector. A forward-looking, futures-based forecast model of upland cotton's SAP, following the design of Hoffman et al. (2015) and Hoffman and Meyer (2016), can provide insight for developing forecasts for the season-average price of upland cotton. The forecasts also provide an example of the impact additional information has on the accuracy of the futures model throughout the forecast cycle.

[5]Updated monthly forecasts of a futures price forecast model are currently provided for corn, soybeans, and wheat (Hoffman, 2005b).

[6]Futures prices are an unbiased predictor of the cash price for a given par delivery location and time period when the futures market is efficient (Fama, 1970 and 1991). Tomek (1997, p. 42), for instance, argues that it is often difficult for structural or econometric models to out-perform a futures price forecast.

Figure 1
**Overview of upland cotton prices and marketings**




Source: Intercontinental Exchange and USDA, National Agricultural Statistics Service

In this paper, a forward-looking futures price model is developed for monthly forecasts of the U.S. season-average farm price of upland cotton. The model's performance is assessed and an explanation of how futures-adjusted forecasts can be useful in creating SAP projections is discussed. Selected futures-adjusted model forecasts are then compared with *WASDE* projections. While *WASDE* projections are the official farm price forecast—a benchmark for industry comparisons—the futures-adjusted model provides information about what current futures prices imply for the season-average price.

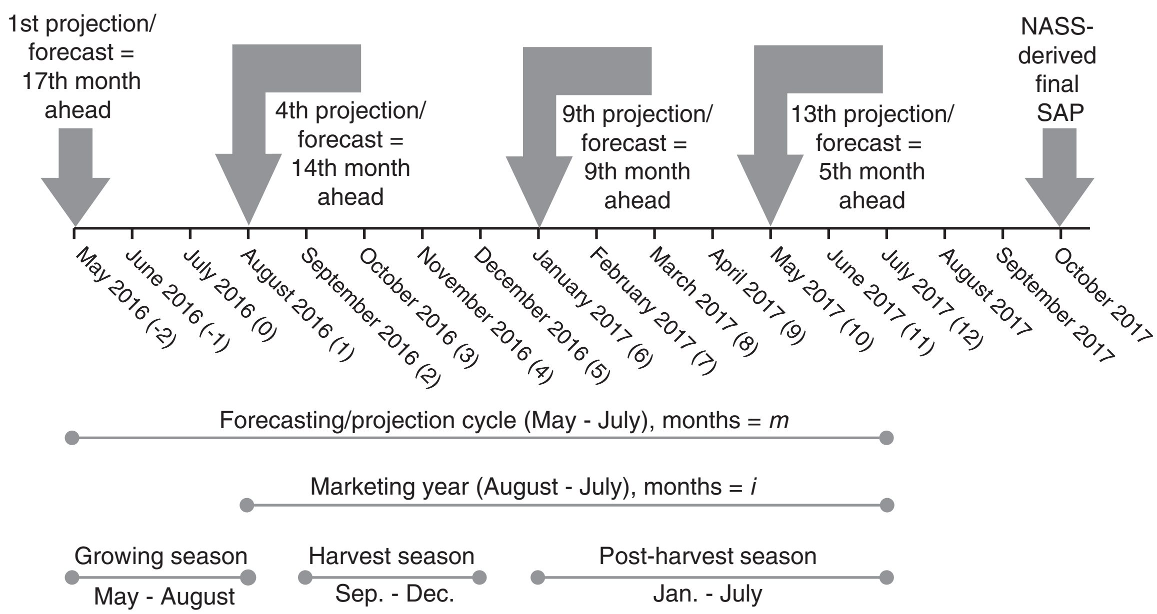
# Computing a Season-Average Farm Price

USDA's National Agricultural Statistics Service (NASS) publishes a monthly upland cotton price received by U.S. producers in *Agricultural Prices* (USDA, NASS, various issues), which is referred to as the monthly farm price in this report. A monthly survey of U.S. cotton buyers (merchandisers, mills, and others) provides information on the quantity and price of upland cotton purchased directly from U.S. farmers during a given month. The monthly farm price is derived by dividing the total cost (purchase price times quantity) by the total quantity purchased (farm sales) (USDA, NASS, 2011). Each year in October, 3 months after the conclusion of the marketing year, NASS publishes a cotton SAP received by farmers, which is an average of the final reported monthly prices weighted by monthly marketings.

While the NASS SAP (reported in October) represents the final marketing year (August-July) price, USDA projections of this price are made in each month of the forecast cycle (see figure 2). Forecasting begins in May (3 months prior to the start of the marketing year), includes most of the growing season (May through August), the harvest season (September through December), and the post-harvest season (January through July) (fig. 2).[7] A SAP projection is generated in each of these 15 months, and the entire period is considered a forecast cycle. Hence, May (first month of forecast cycle prior to the marketing year), August, January, and the second May (13th month of forecast cycle) are the 1st, 4th, 9th, and 13th forecasts/projections of the SAP during the forecast cycle, or the 17th, 14th, 9th, and 5th month-ahead forecasts/projections, respectively. The consecutive months within the forecast cycle are numbered -2 through 12 for purposes of model expression. (See figure 2 and equation (1) for further illustration and explanation.)

Figure 2

**Schematic of forecasting/projection cycle for upland cotton season-average price, including marketing year and crop seasons**




Source: USDA, Economic Research Service.

[7]Prior to May, USDA provides a cotton price forecast in November for the Long Term Projection activity and another for the Outlook Forum held in February. These forecasts are not evaluated in this study.

The monthly SAP updates to the annual marketing year price projection are included in the monthly *WASDE*. The process of generating the *WASDE* SAP projection is complex and involves the interaction of expert judgment, econometric price forecasting models, futures prices, market information, weather models, satellite imagery, and indepth research by USDA analysts (USDA, OCE, 2015).[8] Additional sources of private and public information are also considered. Since the *WASDE* price projection is usually reported as a range of the expected price, the midpoint of this range is used as the *WASDE* point forecast of the upland cotton SAP.

[8]Additionally, specific information relating to cotton price forecasts can be found in a conference paper by Carol Skelly and Stephen MacDonald (2009).

# Futures-Adjusted Forecasting Model

A forward-looking, futures-adjusted price forecasting model provides valuable input to the development of cotton SAP forecasts. Season-average price forecasts from the futures-adjusted model are based on expectations reflected in the futures market and, as available, actual monthly farm prices. Input into the model includes historical data on monthly futures prices, monthly farm prices, monthly basis values (farm price less nearby futures), and monthly marketing weights. Using current futures prices, a futures-adjusted farm price forecast is generated for each month in the marketing year. Monthly farm price forecasts are derived from current prices from the futures contracts expiring during the marketing year projected (October, December, March, May, and July). Each monthly forecast begins with the nearby futures contract price except when the contract expires in that month, in which case the next nearby contract is used.[9] The current prices of each month's contract are adjusted by an expected basis and weighted by the expected marketings for that month (see equation 1 for clarification).[10] Thus, SAP forecasts are a summation of the monthly forecasts, weighted by projections of the monthly percentage of the total marketings for the marketing year.

An example of the model's timeline is provided in table 1. The SAP forecasts created in May through September are based on adjustments of the nearby futures prices with the expected basis. NASS-reported monthly farm prices are substituted for the futures-adjusted forecasts as they become available during the marketing year. Thus, SAP forecasts created in the subsequent months become a composite of actual monthly NASS farm prices and monthly futures-based forecasts. As the forecast cycle progresses, there are more months with reported farm prices and fewer months with futures-based forecast prices. Forecast error is expected to decline throughout the cycle as increased information is included and the forecast period moves closer to the end of the marketing year.

Table 2 provides an example of the forecast procedure, illustrating the steps needed to create forecasts in 2 months of the marketing year 2016/17 forecast cycle. The 2 months used for this illustration are May 2016 (1st month of forecast cycle, 17th month-ahead forecast, or month $m = -2$) and January 2017 (9th month of forecast cycle, 9th month-ahead forecast, or month $m = 6$) (fig. 2).

For illustration purposes, panel A in table 2 presents an example that computes a futures-adjusted forecast of the upland cotton SAP using data from May 9, 2016, the first month of the 2016/17 forecast cycle. Nine steps are involved in the forecast process:

1. Monthly prices are derived from the settlement prices of nearby futures contracts on May 9, 2016. Futures settlement prices from the day before *WASDE* release are used for forecast purposes.

2. The settlement price from the October 2016 futures contract, for example, is used for the monthly cotton prices in August and September. Subsequent monthly prices are similarly derived.

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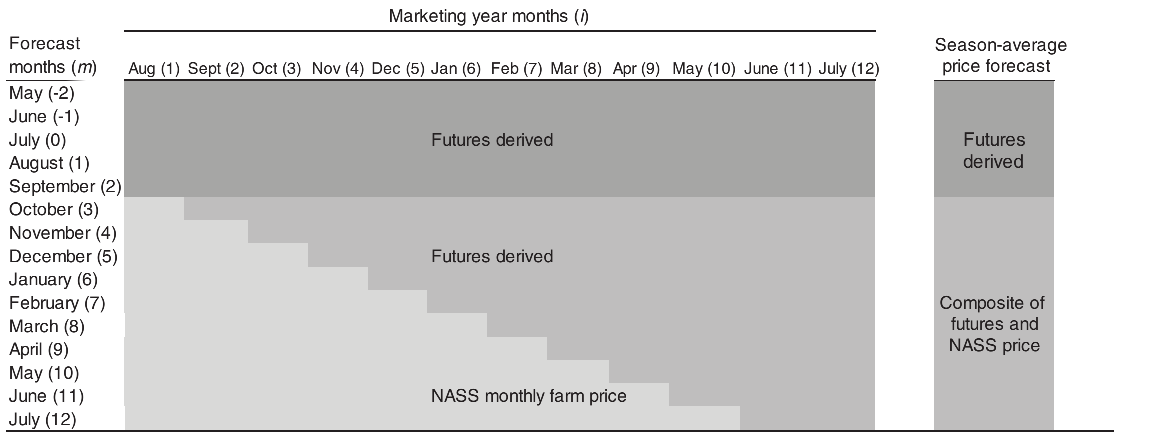
[9]One exception is for the July contract. Although its contract values are used for the months of May and June, the July contract values are also used for July. If the October contract values were used for July, they would represent next-marketing-year values rather than the current marketing year.

[10]Basis is computed by taking the farm price for each marketing year month and subtracting the nearby futures contract average daily settlement price for that month. The basis calculation reflects a composite of influencing factors since it represents an average of U.S. conditions rather than a specific geographic location. A number of factors affect the basis, including, in particular, local supply and demand conditions, transportation and handling charges, transportation bottlenecks, availability and costs of storage, and crop quality.

Table 1

**Futures model's season-average price forecasts by forecast months and marketing year months**




Source: USDA, Economic Research Service and National Agricultural Statistics Service.

3. The monthly expected basis is shown for its use in computing the monthly farm price forecast.

4. The U.S. monthly farm price forecast is computed by adding steps 2 and 3.

5. Available actual monthly prices received by farmers are obtained from NASS and used to replace the monthly price derived from futures contracts.

6. Actual monthly farm prices are not available on May 9, 2016, for marketing year 2016/17.

7. Monthly marketing weights are provided. Historical monthly marketing weights are computed from NASS data and used to project current-year weights.

8. A weighted monthly farm price is computed from step 6 multiplied by step 7.

9. The SAP forecast for 2016/17 is computed as the sum of the weighted monthly farm prices in step 8, or 57.11 cents per pound.

The second illustration of the futures-adjusted forecasting model is presented in table 2, panel B. The forecast is made with data from January 11, 2017, the 9th month of the 2016/17 forecast cycle. Since the actual monthly farm price is available for August through November 2016, the corresponding monthly forecasts obtained from futures prices are replaced with these actual prices in step 6. Thus, the forecast made on this date is derived from four actual monthly farm prices and eight futures prices. The forecast for 2016/17 as of January 11, 2017, is found in step 9, the sum of the weighted monthly forecasts, or 69.22 cents per pound. The final SAP was estimated to be 68.00 cents per pound. A mathematical representation of the futures-adjusted forecast model is presented in Box 1, "Mathematical Representation of Futures-Adjusted Forecast Model."

Table 2

**Examples of a futures-adjusted forecast of upland cotton's season-average price (SAP): marketing year 2016/17**

**Panel A. Forecasting date: 05/09/2016**

| | Aug 16 | Sep 16 | Oct 16 | Nov 16 | Dec 16 | Jan 17 | Feb 17 | Mar 17 | Apr 17 | May 17 | Jun 17 | Jul 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Futures price (settlement) by contract | | | 61.64 | | 61.04 | | | 61.42 | | 61.88 | | 62.22 |
| (2) Monthly price (cents/lb) | 61.64 | 61.64 | 61.04 | 61.04 | 61.42 | 61.42 | 61.42 | 61.88 | 61.88 | 62.22 | 62.22 | 62.22 |
| (3) Basis (7-yr Olympic average) | -7.88 | -5.56 | -4.57 | -1.88 | -2.80 | -5.97 | -5.98 | -7.90 | -5.59 | -6.31 | -4.13 | -1.51 |
| (4) Adjusted monthly futures price [(2)+(3)] | 53.76 | 56.08 | 56.47 | 59.16 | 58.62 | 55.45 | 55.44 | 53.98 | 56.29 | 55.91 | 58.09 | 60.71 |
| (5) Observed monthly farm price | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| (6) Spliced observed/ forecast farm price[1] | 53.76 | 56.08 | 56.47 | 59.16 | 58.62 | 55.45 | 55.44 | 53.98 | 56.29 | 55.91 | 58.09 | 60.71 |
| (7) Marketing weight (7-yr Olympic average) | 0.040 | 0.026 | 0.074 | 0.153 | 0.229 | 0.167 | 0.095 | 0.053 | 0.038 | 0.037 | 0.033 | 0.055 |
| (8) Weighted monthly farm prices [(6)*(7)] | 2.150 | 1.458 | 4.179 | 9.051 | 13.424 | 9.260 | 5.267 | 2.861 | 2.139 | 2.069 | 1.917 | 3.339 |
| (9) Futures-based SAP forecast [Sum of (8)] | | | | | | 57.11 | | | | | | |

**Panel B. Forecasting date: 01/11/2017**

| | Aug 16 | Sep 16 | Oct 16 | Nov 16 | Dec 16 | Jan 17 | Feb 17 | Mar 17 | Apr 17 | May 17 | Jun 17 | Jul 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Futures price (settlement) by contract | | | | | | | | 73.14 | | 73.66 | | 74.17 |
| (2) Monthly price (cents/lb) | | | | | 73.14 | 73.14 | 73.14 | 73.66 | 73.66 | 74.17 | 74.17 | 74.17 |
| (3) Basis (7-yr Olympic average) | -7.47 | -4.01 | -3.79 | -1.32 | -2.10 | -4.73 | -4.20 | -4.89 | -5.01 | -5.09 | -2.40 | 0.44 |
| (4) Adjusted monthly futures price [(2)+(3)] | | | | | 71.04 | 68.41 | 68.94 | 68.77 | 68.65 | 69.08 | 71.77 | 74.61 |
| (5) Observed monthly farm price | 67.30 | 67.00 | 66.00 | 67.20 | | | | | | | | |
| (6) Spliced observed/ forecast farm price[1] | 67.30 | 67.00 | 66.00 | 67.20 | 71.04 | 68.41 | 69.94 | 68.77 | 68.65 | 69.08 | 71.77 | 74.61 |
| (7) Marketing weight (7-yr Olympic average) | 0.032 | 0.023 | 0.068 | 0.151 | 0.245 | 0.164 | 0.089 | 0.060 | 0.045 | 0.033 | 0.027 | 0.063 |
| (8) Weighted monthly farm prices [(6)*(7)] | 2.154 | 1.541 | 4.488 | 10.147 | 17.405 | 11.219 | 6.136 | 4.126 | 3.089 | 2.280 | 1.938 | 4.700 |
| (9) Futures-based SAP forecast [sum of (8)] | | | | | | 69.22 | | | | | | |
| Actual season-average price | | | | | | 68.00 | | | | | | |

Note: N/A = Not available.

[1]If observed farm price is available, use it, otherwise use adjusted monthly average futures price from step (4).

Source: Intercontinental Exchange and USDA, National Agricultural Statistics Service and Economic Research Service.

## Mathematical Representation of Futures-Adjusted Forecast Model

### *Model*

$FM_m^t$ is the futures basis-adjusted forecast for the upland cotton season-average farm price for any marketing year *t* made in month *m* and is computed as follows:

$$FM_m^t = \begin{cases} \sum_{i=1}^{12} W_i^t (F_{i,m}^t + B_i^t) & \text{for } -2 \le m \le 2 \\ \sum_{i=1}^{m=-2} W_i^t P_i^t + \sum_{i=m-1}^{12} W_i^t (F_{i,m}^t + B_i^t) & \text{for } 3 \le m \le 12 \end{cases} \quad (1)$$

Where:

$FM_m^t$= forecasts of the SAP made monthly, $m$ = -2, -1, 0, 1, 2, 3, ……. 12 (table 1),
$-2 \le m \le 2$ are the first 5 months of the forecast cycle (May through September), $3 \le m \le 12$ are the next 10 months of the forecast cycle (October through July) (table 1),[11]
$i$ = upland cotton marketing year has 12 months, August through July, $i$ = 1, 2, 3, …12, in August both $m$ and $i$ are equal to 1 (table 1),
$F_{i,m}$ = nearby futures price of cotton No. 2 traded on the Intercontinental Exchange (ICE) for the contract expiring in month $i$ observed on a given day in month $m$,
$P_i$ = actual farm price in month $i$,[12]
$W_i$ = expected marketing weight for month $i$,
$B_i$ = expected basis (farm price less futures price) in month $i$,
$t$ = represents marketing years, 2008/09 through 2016/17.

### *Data and Sources*

Data for marketing years 2001/02 through 2015/16 are used to construct alternative average monthly basis and monthly marketing weights, both of which are updated when new information becomes available. The forecast evaluation period covers the marketing years 2008/09 through 2016/17. The futures settlement price for the day before the *WASDE* release is used to capture the market information available at that time. Additionally, the futures settlement price for 3 days before *WASDE* release was also examined to assist in forecasting the season-average farm price. During the sample period, the *WASDE* release time underwent one change, but no change was required in the choice of day for the settlement price.[13]

<u>Nearby futures prices</u> **–** Cotton # 2 contract traded on the Intercontinental Exchange (ICE, 2017).

<u>Average farm prices</u> – Upland cotton prices received by producers (monthly and annual) (USDA, National Agricultural Statistics Service, various issues).

<u>Basis</u> – Monthly average farm price minus nearby monthly average futures price, calculated by the authors.

<u>Marketing weights</u> – Upland cotton marketing weights computed from reported monthly marketings in *Agricultural Prices* (USDA, National Agricultural Statistics Service, various issues).

<u>*WASDE* SAP projections</u> **–** Midpoint of monthly *WASDE* projections of the season-average price range (USDA, Office of Chief Economist, various issues).

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[11]The 15 forecasting months are given identifying numbers of -2,-1, 0, 1, 2…… 12 so that equation (1) notations can be made. See table 1 for further clarifications.

[12]As of January 2015, an actual December monthly farm price was not available until February, the 10th month of the forecast cycle. NASS discontinued providing all midmonth price estimates. Previously the December mid-month price estimate would have been used in January as a farm price. Thus, this change requires the use of an additional month of an adjusted futures price.

[13]For example, the futures closing is at 1:15 pm Central Time, and as of May 1994, the *WASDE* release occurred at 8:30 a.m. Eastern Time. In January 2013, the *WASDE* release was moved to 12 noon, Eastern Time. Regardless of the change in *WASDE* release time, this analysis uses the futures settlement price from the day before the *WASDE* release.

# Derivation of Alternative Futures-Adjusted Forecast Models

Since the goal of the futures-adjusted model is to provide market participants with a tool for translating futures market prices into consistent estimates of the U.S. season-average price for upland cotton, a model is needed that can perform this task with a reasonable degree of accuracy. A basis is needed to adjust the futures price to the farm level. Similarly, there is a need to know the marketing weight for a particular month. Various models are examined that use different projections of monthly basis and marketing weights, and the best performing model is selected for use. A futures-based forecasting model for corn worked well, using a moving 5-year average to compute both the monthly basis and monthly marketing weight, particularly during periods of low price volatility (Hoffman et al., 2007). However, since cotton experienced extreme futures price volatility in 2010/11, which impacted the basis and marketing weights, a need arose to explore alternative mechanisms that could lessen the impacts of price volatility upon the monthly basis and marketing weight and consequently SAP forecasts.

Four different futures-adjusted models are evaluated for upland cotton.

- Futures (1) uses a 5-year average monthly basis and marketing weight to demonstrate the effects that price volatility has on SAP forecasts.
- Futures (2) uses a 5-year Olympic average that removes large and small numbers with a resulting 3-year average.
- Futures (3) uses a 7-year Olympic average, again deleting the high and low number from the computation, resulting in a 5-year average. Both Futures (2) and (3) smooth the impact of volatile prices and marketings from any single year, but do not necessarily anticipate the year when these aberrations occur.
- Futures (4) removes the 2010/11 marketing year to illustrate the effects this year had on the model's performance and uses the best performing model from Futures (1, 2, 3).[14]

[14]Marketing year 2010/11 was deleted because of its extreme price volatility and accompanying forecast errors. Without removal from the model these errors would be carried forward into the following marketing years (Hoffman and Meyer, 2016).

# Evaluation of Alternative Futures-Adjusted Models

To compare performance of the four models, several criteria are considered that evaluate the performance of the monthly futures-adjusted forecasts relative to the NASS final SAP.[15] Evaluation requires assessment of 15 monthly forecasts for 1 forecast cycle. This also allows examination of how projections respond to new information available in the market as the cotton season develops.

The error for a given SAP forecast made in month *m* for marketing year *t* is defined as,

$$E_m^t = \left(FM_m^t - SAP^t\right) \qquad (2)$$

Where: $FM_m^t$ is the forecast of the SAP made in month *m* of the forecasting cycle for marketing year *t* by the futures forecast method. The squared error (SE) can be computed as $\left(e_m^t\right)^2$, or $(FM_m^t - SAP^t)^2$. The mean error (ME) and root mean squared error (RMSE) are computed and defined for each forecast as follows:

$$ME_m = \frac{1}{T}\sum_{t=1}^{T}\left(FM_m^t - SAP^t\right) \qquad \text{(Mean Error)} \qquad (3)$$

$$RMSE_m = \left[\frac{1}{T}\sum_{t=1}^{T}\left(FM_m^t - SAP^t\right)^2\right]^{1/2} \qquad \text{(Root Mean Squared Error),} \qquad (4)$$

Where: $t$ = 1,2, ..., T for marketing year 2008/09 through 2016/17.

A negative mean error implies an underestimation of the SAP, while a positive mean error implies overestimation. Although the mean error represents forecast bias, this statistic could be misleading due to a few very large over- or underestimation errors. Over time, knowing whether the forecasts are constantly over or under forecasting could suggest needed modifications to the model. For this reason, the number of times the forecast was above or below the actual SAP was also examined. The root mean squared error measures the direction-free magnitude of forecast error but places greater weights on larger errors.

[15]The forecast performance of *WASDE* projections relative to the SAP are computed in the same way as for the futures-adjusted forecasts. Instead of using $FM_m^t$ in the above equations, one would use values for *WASDE* projections.

## Selecting the Preferred Futures-Adjusted Model

The Futures (1) model (5-year average basis and marketing weight) had the largest RMSEs and also had the most underforecasting of all three models (table 3). RMSEs for Futures (2) and (3) models (5-year Olympic average and 7-year Olympic average basis and marketing weight, respectively) declined compared to Futures (1), and the balance between over- and under-forecasting also improved compared to Futures (1). Overall, the Futures (3) model had lower RMSEs and a better forecasting balance than Futures (2). However, the forecast balance from Futures (3) could still be improved as its RMSEs tended to increase during the forecast cycle rather than decline.

The three models, Futures (1), (2), and (3), were not able to accurately forecast the SAP for many of the months (October through May) in the 2010/11 marketing year. Futures prices rose significantly in that year, creating a large negative basis (appendix 1, 2010/11 marketing year).[16] The Futures (1) model not only had large forecast errors for many of the months (October through May) in the 2010/11 forecast cycle, but the large basis values for that year were averaged forward with the rolling 5-year average, thus contributing to larger (under-) forecast errors in the future years. While Futures (2) and (3) models also had large forecast errors for many of the months (October through May) in the 2010/11 forecast cycle, the large basis values for that year were dropped from the average basis computation, thus contributing to smaller RMSEs in future years. Futures (2) and (3) models, like the Futures (1) model, also experienced some under-forecasting, but that improved somewhat with a more balanced forecast and lower RMSEs in each of the forecasting months, and Futures (3) was the most accurate of this group.

In an effort to improve performance of the Futures (3) model, marketing year 2010/11 was removed from the database, thus excluding it from the forecasts and from the monthly basis and marketing weight computations (table 3).[17] The resulting model, Futures (4), exhibited the best forecast balance of all four models, and the pattern of monthly RMSEs followed expectations, declining over the forecast cycle. Forecasts based on futures prices prior to the start of the marketing year had large RMSEs due to lack of information on the crop size/condition and demand prospects. However, after the June NASS *Acreage* report was published and reflected in the July forecast, and August crop yields became known and published in the August forecast, the RMSEs began to decline. Further declines were observed during the harvest season as more information became known about the actual crop size, the crop's demand prospects, and actual prices.

[16]In 2010/11, cotton prices rose significantly as a result of a combination of factors that drove stocks to unexpectedly low levels and also limited global production increases that year; in addition, the introduction of export limitations by India—the world's second largest exporter—raised demand for cotton stocks elsewhere in the world, driving prices even higher.

[17]Deletion of the 2010/11 marketing year will no longer be needed for marketing year 2018/19 forecasts because the 7-year data range runs from 2011/12 through 2017/18.

Table 3
### Selection of preferred cotton futures-adjusted model from four alternatives, marketing year average, 2008/09-2015/16

| | Futures (1) = 5-yr. avg. basis & mkt. wt. | | | Futures (2) = 5-yr. oly. avg. basis & mkt. wt. | | | Futures (3) = 7-yr. oly. avg. basis & mkt. wt. | | | **Preferred model** - Futures (4) = 7-yr. oly. avg. basis & mkt. wt., excluding 2010/11 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ME | Over/ Under | RMSE | ME | Over/ Under | RMSE | ME | Over/ Under | RMSE | ME | Over/ Under | RMSE |
| Forecast months | *Cents/ lb* | *Num- ber* | *Cents/ lb* | *Cents/ lb* | *Num- ber* | *Cents/ lb* | *Cents/ lb* | *Num- ber* | *Cents/ lb* | *Cents/ lb* | *Num- ber* | *Cents/lb* |
| **Growing season (17th month to 14th month-ahead forecasts)** | | | | | | | | | | | | |
| May (-2) | 2.5 | 3/5 | 15.3 | 7.1 | 5/3 | 15.1 | 7.4 | 5/3 | 15.2 | 10.5 | 5/2 | 16.1 |
| June (-1) | -0.2 | 3/5 | 16.5 | 4.3 | 3/5 | 14.9 | 4.6 | 4/4 | 14.8 | 7.2 | 4/3 | 15.7 |
| July (0) | -3.8 | 2/6 | 13.5 | 0.7 | 3/4 | 10.7 | 1.0 | 4/4 | 10.6 | 3.5 | 4/3 | 10.4 |
| August (1) | -4.7 | 2/6 | 11.5 | -0.1 | 3/5 | 7.8 | 0.1 | 3/5 | 7.6 | 1.7 | 3/4 | 7.6 |
| **Harvest season (13th month to 10th month-ahead forecasts)** | | | | | | | | | | | | |
| September (2) | -4.6 | 2/6 | 10.1 | 1.2 | 2/6 | 6.8 | 1.4 | 2/6 | 7.0 | 2.3 | 4/3 | 7.5 |
| October (3) | -5.8 | 2/6 | 10.8 | 0.1 | 3/5 | 5.7 | 0.3 | 3/5 | 5.6 | -0.6 | 3/4 | 3.9 |
| November (4) | -3.1 | 2/6 | 18.5 | 2.5 | 2/6 | 15.3 | 2.7 | 2/5 | 15.4 | -2.3 | 1/5 | 3.8 |
| **Post-Harvest season (9th month to 3rd month-ahead forecasts)** | | | | | | | | | | | | |
| December (5) | -4.1 | 2/6 | 14.0 | 1.1 | 2/6 | 10.6 | 1.2 | 2/6 | 10.6 | -2.3 | 1/6 | 3.1 |
| January (6) | -1.9 | 2/6 | 12.7 | 2.2 | 3/5 | 10.4 | 2.3 | 3/5 | 10.4 | -1.1 | 2/5 | 2.4 |
| February (7) | -0.2 | 2/6 | 12.7 | 2.8 | 3/5 | 10.9 | 2.9 | 3/5 | 10.9 | -0.7 | 3/3 | 2.0 |
| March (8) | 1.1 | 1/7 | 12.4 | 3.1 | 1/7 | 11.0 | 2.9 | 3/4 | 10.6 | -0.6 | 3/4 | 1.9 |
| April (9) | 1.5 | 2/6 | 9.6 | 2.6 | 3/3 | 8.4 | 2.4 | 6/2 | 7.7 | 0.0 | 4/3 | 1.5 |
| May (10) | 0.4 | 2/6 | 4.5 | 1.1 | 4/3 | 3.8 | 1.1 | 5/3 | 3.6 | 0.1 | 4/3 | 1.6 |
| June (11) | -0.1 | 2/6 | 3.1 | 0.5 | 4/4 | 2.6 | 0.4 | 4/4 | 2.4 | -0.2 | 3/4 | 1.2 |
| July (12) | -0.5 | 2/6 | 2.2 | -0.1 | 3/5 | 1.8 | -0.1 | 3/5 | 1.7 | -0.4 | 4/3 | 1.4 |
| Total | | 31/89 | | | 44/72 | | | 52/66 | | | 48/55 | |

| **Balance of forecasts (over/under) summary** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* | *Number* | *Percent* |
| Over | 31 | 26 | 44 | 37 | 52 | 43 | 48 | 46 |
| Under | 89 | 74 | 72 | 60 | 66 | 55 | 55 | 52 |
| Equal | 0 | 0 | 4 | 3 | 2 | 2 | 2 | 2 |
| Total | 120 | 100 | 120 | 100 | 120 | 100 | 105 | 100 |

Note: ME = mean error; RMSE = root mean squared error.
Source: USDA, Economic Research Service.

## Potential for Contribution to USDA Projections

Further assessment is needed to evaluate the potential of the Futures (4) model to contribute to forecasts of the SAP. Thus, in addition to knowing how the futures-adjusted forecasts perform in forecasting the upland cotton SAP, it is important to compare them with *WASDE* SAP projections, the official USDA projection. If futures-adjusted forecasts compare well with *WASDE* projections, this strengthens the case for using the futures-adjusted model as one tool to assist in forecasting of the upland cotton SAP.

Forecasts from the Futures (4) model and *WASDE* projections indicate that they had fairly similar errors during most of the forecast cycle, and these errors declined over the forecast cycle (table 4). One difference was the first 2 months of the forecast cycle, May and June. The futures-adjusted RMSEs and MEs were noticeably larger than those for *WASDE* projections, which may be due to differences between the futures market and *WASDE* evaluation strategies of the unknown supply and demand situation prior to the actual crop year. However, a similar balance in forecasting was exhibited by both methods. Overall, both Futures (4) forecasts and *WASDE* projections provided forecasts/projections that overestimated the actual SAP 45-46 percent of the time and underestimated 52-55 percent of the time (table 4).[18] During the growing season and first month of the harvest season both methods tended to over-forecast, but for the remainder of the harvest season and post-harvest season both tended to under-forecast.

As expected, the RMSEs declined throughout the forecast cycle for both forecasting methods, Futures (4) and *WASDE,* but started at a higher level for Futures (4) (table 4). Inferences may be made regarding the role of information on forecasting accuracy.[19,20] For instance, together there was a reduction of 1.4 cents per pound to 5.7 cents per pound for the *WASDE* projections and Futures (4) forecasts, respectively, between May (17th month-ahead forecast or month $m$ = -2) and July (15th month-ahead forecast or month $m$ = 0), reflecting new crop information in sources such as the June *Acreage* report and *Crop Progress* reports available during these months. Continued improvement in forecasting accuracy from July to August (15th to 14th month-ahead forecasts or months $m$ = 0 to 1) reflects, in part, the availability of information on the new crop's estimated yield and crop progress. Improvement in forecasting performance between August and October (14th and 12th month-ahead forecasts or months m = 1 and 3) may, in part, be attributed to information concerning production of the new crop, and the NASS monthly farm price for August that was available to Futures (4) forecasts and *WASDE* projections in October.[21] Additional information—such as the global supply and demand outlook—could also contribute to the continued decline in forecast errors for the remainder of the forecast cycle. Further error reduction in the post-harvest period was minimal after January's adjustments to crop production by NASS as reflected in the January RMSEs.

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[18]The U.S. Government pays for cotton storage when the price is below the loan rate, and when this occurred it appeared to change the pattern of monthly marketings for marketing year 2008/09 (fig. 1). Additional analysis is required to determine whether this program has an impact on the monthly marketing patterns.

[19]Each forecasting method has access to market information such as crop progress, planting intentions, acreage reports, agricultural prices, crop production, weekly export sales reports, and actual monthly exports. Thus, we may not expect to find large differences between the *WASDE* projections and futures-adjusted forecasts.

[20]The study objectives do not include testing the statistical significance of the decline in forecast errors between forecast periods. However, conducting these tests would provide logical followup work to this study. For work on estimating the effect of information on prices, see Adjemian (2012).

[21]Prior to January 2015, there also would have been information about the midmonth price for September. However, as of January 2015, NASS no longer reports midmonth prices.

Table 4
**Comparison of the preferred cotton futures-adjusted model forecasts with *WASDE* projections, marketing year average, 2008/09-2015/16, excluding 2010/11**

| | Futures (4) = 7-yr. oly. avg. basis & mkt. wt., excluding 2010/11 | | | *WASDE*, excluding 2010/11 | | |
|---|---|---|---|---|---|---|
| | ME | Over/under | RMSE | ME | Over/under | RMSE |
| Forecast months | *Cents/lb* | *Number* | *Cents/lb* | *Cents/lb* | *Number* | *Cents/lb* |
| **Growing season (17th month to 14th month-ahead forecasts)** | | | | | | |
| May (-2) | 10.5 | 5/2 | 16.1 | 5.4 | 5/2 | 10.7 |
| June (-1) | 7.2 | 4/3 | 15.7 | 5.0 | 4/3 | 10.4 |
| July (0) | 3.5 | 4/3 | 10.4 | 4.0 | 5/2 | 9.3 |
| August (1) | 1.7 | 3/4 | 7.6 | 3.3 | 5/2 | 8.4 |
| **Harvest season (13th month to 10th month-ahead forecasts)** | | | | | | |
| September (2) | 2.3 | 4/3 | 7.5 | 1.9 | 4/3 | 7.3 |
| October (3) | -0.6 | 3/4 | 3.9 | -0.5 | 2/5 | 5.9 |
| November (4) | -2.3 | 1/5 | 3.8 | -2.1 | 2/5 | 3.7 |
| **Post-Harvest season (9th month to 3rd month-ahead forecasts)** | | | | | | |
| December (5) | -2.3 | 1/6 | 3.1 | -1.9 | 2/5 | 2.8 |
| January (6) | -1.1 | 2/5 | 2.4 | -1.4 | 3/4 | 2.4 |
| February (7) | -0.7 | 3/3 | 2.0 | -0.3 | 2/5 | 1.7 |
| March (8) | -0.6 | 3/4 | 1.9 | -0.3 | 3/4 | 1.5 |
| April (9) | -0.0 | 4/3 | 1.5 | -0.1 | 3/4 | 1.6 |
| May (10) | 0.1 | 4/3 | 1.6 | -0.2 | 3/4 | 1.7 |
| June (11) | -0.2 | 3/4 | 1.2 | -0.2 | 2/5 | 1.7 |
| July (12) | -0.4 | 4/3 | 1.4 | -0.2 | 2/5 | 1.7 |
| Total | | 48/55 | | | 47/58 | |
| **Balance of forecasts (over/under) summary** | | | | | | |
| | *Number* | | *Percent* | *Number* | | *Percent* |
| Over | 48 | | 46 | 47 | | 45 |
| Under | 55 | | 52 | 58 | | 55 |
| Equal | 2 | | 2 | 0 | | 0 |
| Total | 105 | | 100 | 105 | | 100 |

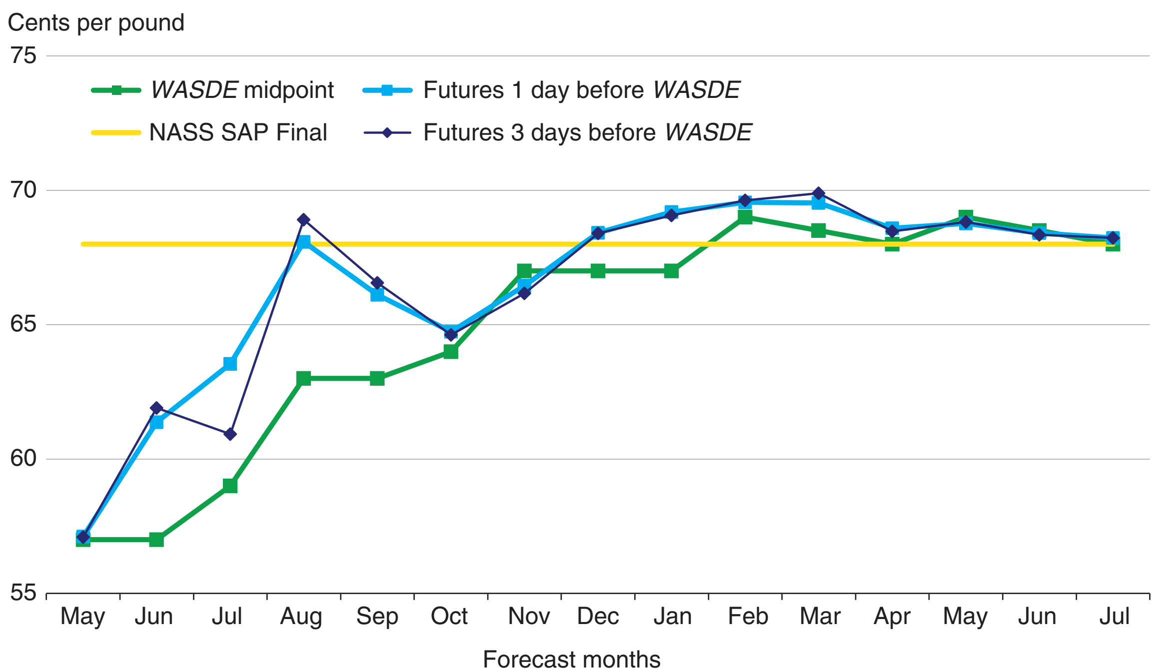
Note: ME = mean error; RMSE = root mean squared error.
Source: USDA, Economic Research Service and Office of Chief Economist.

## Results for 2016/17

The Futures (4) model provides valuable input to the forecasting process of the cotton SAP. Futures (4) forecasts are based on a futures price from the day before the *WASDE* release; the most up-to-date market information is included. However, analysts may also want to evaluate the forecast from 3 days before the *WASDE* release to allow time for additional input prior to the release. Figure 3 illustrates the use of the day before and 3 days before futures-adjusted forecast. Based on this example, both forecasts appear to provide similar but valuable information for forecasts of the cotton SAP.

Results for 2016/17, the latest completed forecast cycle, are used for comparison. The May 2016 estimate of the upland cotton SAP, the first for the forecast cycle, was similar for all three methods; the 3-day-ahead futures-adjusted forecast was 57.09 cents per pound, the 1-day-ahead futures-adjusted forecast was 57.11 cents per pound, and the *WASDE* projection was 57.00 cents per pound (fig. 3). *WASDE* projections released in May 2016 indicated that the 2016 production was going to expand above 2015, due to increased acreage and yield. Since the increased supply was greater than the anticipated demand, stocks were projected to rise along with the stock-to-use ratio. Thus, a *WASDE* SAP projection for 2016/17 of about 57 cents per pound, which was lower than the SAP for 2015/16 (61.2 cents per pound), seemed reasonable at that time.

Figure 3
**2016/17 Season-average price forecasts for U.S. upland cotton**




Source: USDA, Office of Chief Economist, National Agricultural Statistics Service, and Economic Research Service

Between May and August 2016, both futures-adjusted and *WASDE* SAP forecasts/projections rose on expectations of increased global demand and lower global stocks. While the U.S. production forecast rose during this period based on increased acres, the export projection also rose, contributing to strengthening price expectations. In addition, the futures-adjusted forecasts were noticeably above the *WASDE* projections for the months of June through September. For the early months of the forecast cycle, the futures market appears to question whether the crop will achieve yields assumed in *WASDE* projections, thereby leading to a higher forecast SAP than *WASDE*-derived projections. Later, July through September, the difference could have been caused by the market anticipating a larger U.S. price increase than the *WASDE* projections. Regardless, the futures-adjusted forecasts provided guidance for the direction of *WASDE* SAP projections during this period. By October, the SAP was forecast at about 65.00 cents per pound for both the futures-adjusted forecasts of 3 days and 1 day ahead of the *WASDE* release, while the *WASDE* projection was 64.00 cents per pound.

Between November and March, both futures-adjusted forecasts and *WASDE* projections increased further, with the futures-adjusted forecasts slightly above the *WASDE* projections. Again it appears that the futures-adjusted forecasts provided direction for the *WASDE* projections. Both futures-adjusted SAP forecasts and *WASDE* projections merged in April and remained together through July. Thus, for 2016/17, both futures-adjusted forecasts and *WASDE* projections started in May 2016 with 57 cents per pound and settled at 68.00 cents per pound in July 2017. As of July 2017, U.S. production and consumption were larger than originally estimated in May 2016 and stocks declined, as did the stocks-to-use ratio, supporting a higher SAP. The official NASS SAP for 2016/17 marketing year was 68 cents per pound, as released in the October 2017 *Agricultural Prices* report.

## Results from Earlier Years

As with 2016/17, upland cotton price projections from the Futures (4) forecast model and *WASDE* midpoint projections generally moved in a similar fashion during earlier years. Results from the 8 previous years (2008/09-2015/16) are illustrated in Appendix 1, showing the monthly forecasts/projections and the NASS final SAP for each marketing year. As expected, the overall SAP forecasts/projections from both Futures (4) and *WASDE* improved as the season progressed, with forecasts stabilizing near the final SAP about midway through the marketing year. Two notable exceptions occurred, one in 2010/11 and another in 2015/16. Significant increases in futures prices led to the exclusion of the 2010/11 marketing year as explained earlier. The second exception occurred in 2015/16, when both the Futures (4) forecasts and the *WASDE* projections are shown below the final SAP for upland cotton for most of the forecasting period. However, the results for 2015/16 proved to be an anomaly. In the October 2016 *Agricultural Prices* report—3 months after the end of the 2015/16 marketing year—NASS revised upward many of that season's monthly prices and marketings, which pushed the SAP considerably higher than earlier data indicated and accounted for the discrepancy.

# Summary and Conclusions

The U.S. Department of Agriculture (USDA) analyzes agricultural commodity markets and generates year-to-date market information, including season-average price (SAP) projections for a number of crops. In response to a renewed interest in cotton's SAP forecasting, a forward-looking futures-based forecast model is developed. The cotton futures-adjusted model provides easy access for monthly updating and useful information to analysts forecasting cotton's SAP. Sequential monthly price forecasts generated from the model provide an example of the impact additional information has on the accuracy of forecasts, an issue deserving future analysis. Furthermore, as a means to improve the futures-adjusted forecasts, monthly marketing weights and basis can be adjusted by the analyst to reflect current market conditions.

Forecasts generated from the best-performing futures-adjusted model, Futures (4), provide useful information. The performance of Futures (4) and *WASDE* projections are fairly similar for most of the forecast cycle, which supports using the futures-adjusted model as a source of input to generate USDA's cotton SAP. RMSEs and MEs were similar, with one exception: *WASDE* projections had noticeably lower RMSEs and MEs in the first 2 forecasting months, May and June, which occur early in the growing season. For both forecast methods, RMSEs decline throughout the forecast cycle, in line with increased information. Furthermore, both forecast methods have a similar balance in over/under forecasting errors, over-forecasting 45-46 percent of the time and under-forecasting 52-55 percent of the time.

Due to the extreme run-up in cotton futures prices in 2010/11, effects of that marketing year were removed from this analysis. Additional analyses of the cotton futures-adjusted model are warranted. More analysis of the basis and monthly marketing weights is needed but was beyond the scope of this study. One suggestion is to simply bypass basis forecasting and forecast the monthly farm price. Furthermore, one could add the prior month's actual price-received to this monthly cash price forecasting equation. Regarding marketing weights, more information is needed about the Government's storage subsidy: when is it made, what is its duration, and what information is needed to incorporate it in marketing-weight forecasts? Also, does this storage subsidy have any impact on the monthly basis? Information on cotton contracting exists, but whether this information can be incorporated into the futures forecasting methodology needs further exploration.

Lastly, the structure of this model could be applied to the recently enacted Seed Cotton Program (National Cotton Council, 2018). Once set up, this model could forecast the seed cotton season-average price, which would be a key parameter in computing the PLC payment rate and ARC payments. This would require additional analysis, however. Since there is a futures price for lint cotton, which can be used to provide a lint SAP, a proxy futures price would be needed for cottonseed. Once this issue is resolved, a marketing year seed cotton price could be derived using the weights specified in the legislation.

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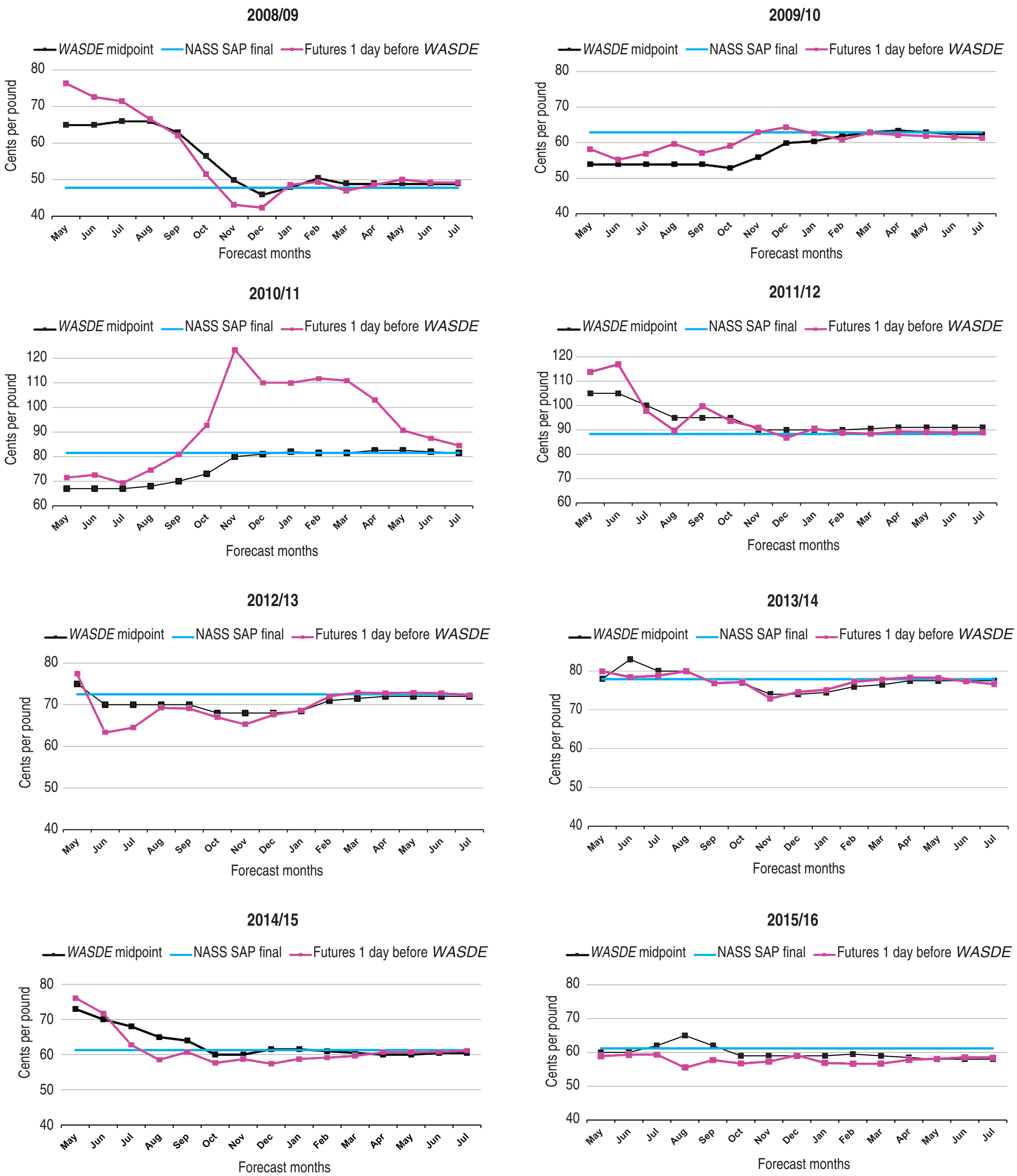
# Appendix 1—Comparison of the Futures (4) Model Results With *WASDE* Projections and the Final Season-Average Farm Price, 2008/09-2015/16

Appendix figure 1

**Season-average price forecasts for U.S. upland cotton by year**




Note: *WASDE* = *World Agricultural Supply and Demand Estimates*. SAP = season-average price.

Source: USDA, Office of Chief Economist, National Agricultural Statistics Service (NASS), and Economic Research Service.