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by

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**Are New Crop Futures and Option Prices for Corn and Soybeans Biased?**
**An Updated Appraisal**

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## Are New Crop Futures and Option Prices for Corn and Soybeans Biased? An Updated Appraisal


### Practitioner's Abstract

*This study revisits the debate over whether a bias exists in new crop December corn and November soybean futures and option prices. Some evidence of bias is found in December corn futures and December corn puts, but the evidence is substantially muted when transaction costs are included. The study also examines if information contained in the widely-followed World Agriculture Supply and Demand Reports (WASDE) issued by the U.S. Department of Agriculture as well as the implied volatility from new crop corn and soybean options are incorporated efficiently into December corn and November soybean futures prices. Previous studies have examined the immediate incorporation of public information into futures prices. This study examines whether public information is incorporated efficiently from the perspective of the change in price between the first non-limit close following the release of a WASDE report and the first contract delivery day. The May WASDE is the first release of the calendar year to include estimates of the forthcoming new crop year's supply and demand. For both the December corn and November soybean regressions, the intercept, change in stocks-to-use ratio between the current and new crop year reported in the May WASDE, and option market implied volatility are significantly different than zero at the 95 percent confidence level. The current crop year's stocks-to-use ratio is not statistically significant. These results held in general for both the May and June WASDE releases, although some sensitivity occurred when the May WASDE observation period was divided in half and for the June WASDE. All variables were statistically insignificant at the July and August WASDEs. These results are not consistent with market efficiency until the July WASDE is released. However, because only 24 observations exist, these results fall more into the category of something that needs to be monitored in the future rather than as a direct confrontation to the theory of market efficiency.*



**Keywords:** price bias, market efficiency, new crop futures and options, corn, and soybeans


### Introduction

The existence of a bias in new crop (December) corn and new crop (November) soybean futures prices has been addressed by several studies over the last 40 years. Tomek and Gray, Kenyon *et al.*, and Zulauf and Irwin do not find a bias while Wisner *et al.* claim a bias can be found if you appropriately partition the data. Zulauf and Irwin is the only study to examine bias in new crop corn and soybean put option prices. They found no bias using data for the 1985-1997 crop years.

The efficient market hypothesis implies that no price bias should exist (Fama, 1970 and 1991). However, numerous studies have found that markets are not perfectly efficient (for example, Grossman and Stiglitz). Because information is costly, markets are slow to acquire and interpret new information. Thus price adjustments can lag, creating opportunities for biases.

Existence of a price bias in new crop futures has substantial importance not only for economic theory, but also for farmers, agribusiness managers, and government policy makers.

Considerable evidence exist that U.S. farmers use futures prices to allocate production resources among crops (for example, Eales *et al*.). In addition, new crop futures are used to set crop insurance coverage levels and premiums, which are subsidized by U.S. taxpayers.

Small data samples of variables with high variability, such as futures prices and options premiums, have limited statistical power in tests of biasness. Analysts tend to partition the data into pre-1973 and post-1973 periods due to the increase in price volatility that occurred in the early 1970s (Kenyon *et al.*) The longest post-1973 period studied is 1974-1997 by Zulauf and Irwin. In addition, the behavior of corn and soybeans prices since 2005 adds a new information dimension to the analysis. For these reasons, it is important to revisit the analysis to see if findings change with a longer data set.

This study also tests for efficient incorporation of public information into new crop corn and soybean futures prices. The efficient market hypothesis postulates that all information available to the public at the time a price is quoted should be incorporated into price (Fama, 1970 and 1991). If an item of information is fully incorporated into a product's price, then this item of information should not explain subsequent changes in the product's price. Previous studies generally find that publically-known information is incorporated efficiently.

This study specifically examines if information contained in the widely-followed *World Agriculture Supply and Demand Reports* (WASDE) issued by the U.S. Department of Agriculture is incorporated efficiently into the December corn and November soybean futures price. The analysis also examines if implied price volatility derived from the new crop options contract is incorporated efficiently. Previous studies have examined the immediate incorporation of public information into futures prices. In contrast, this study examines whether the public information is incorporated efficiently from the perspective of the change in price after the first non-limit close following the release of a WASDE report and the first delivery day of the December corn and November soybean futures contract.

The rest of the article is organized as follows. Existence of routine bias in the December corn and November soybean futures contracts is examined in the next section, followed by the examination of routine bias in the new crop option contracts. The method and materials used to analyze public information efficiency of the new crop December corn and November soybean futures prices are discussed next, followed by a discussion of the results of this analysis. The paper ends with a discussion of conclusions and implications.

## Test for Routine Price Bias: Futures

A routine price bias is the tendency for price on average to increase or decrease. It should not exist in an informationally efficient market because traders should recognize that the routine bias exists and thus take trading positions that eliminate the bias.

To test for a routine bias in December corn and November soybean futures prices, gross trading return was calculated to a long position using prices at the close of trading:

(1) $[\ln(\text{December corn futures price}_{\text{December 1}}) - \ln(\text{December corn futures price}_t)]$

(2) $[\ln(\text{November soybean futures price}_{\text{November 1}}) - \ln(\text{November soybean futures price}_t)]$,

where t is a trading day prior to December 1 (November 1). December 1 and November 1 are the first day of the contract expiration month. The futures prices used in this study are from the Chicago Mercantile Exchange and Barchart.com.

Gross trading returns were calculated for each of the 249 trading days prior to December 1 (November 1). Two hundred and forty nine days is the usual number of trading days in a calendar year. Thus, the observation period extends back to approximately December 1 (November 1) of the preceding calendar year. The date could be slightly earlier or later depending on the exact calendar pattern and the occurrence of unusual events, such as the September 11, 2001 terror attacks.

A mean percent return was calculated for each trading day. The mean return was tested to determine if it differed statistically from zero. A 95 percent confidence level was used for the test. Gross trading returns for a long futures position in the new crop contract are presented in Figure 1 for corn and soybeans, along with the 95 percent confidence band. The years included in the observation period are 1974 through 2009. Despite the increase in price level since 2005 and the high price variability during the 2008 crop year, the evidence suggests that the first difference of prices has remained stationary. However, the transition phase may still be in progress. Thus, additional data may lead to a conclusion that the first difference in price change of new crop corn and soybean futures prices is no longer stationary post 1974.

For December corn futures, 19 percent of the individual trading days had a gross trading return that was significant at the 95 percent confidence level (Panel A). Forty five of the forty seven significant trading days occurred between 158 and 204 trading days prior to December 1. This period extends from early February through late April. Average gross trading return to a long position over the 47 trading days that occurred between 158 and 204 trading days prior to December 1 was -7.2 percent. The negative return implies a bias for prices to decline, and thus a positive return to a short position.

For soybeans, only six days had a mean percent gross trading return that was significantly different than zero (Panel B). All occurred during the last seven days of trading. Mean return to a long position over this period was +0.9 percent.

The same general conclusions hold for the period beginning with the 1986 futures contract expiration for December corn and November soybeans (see Figure 2). This was the first contract for which options were traded over the year prior to the option expiration date. For December corn, 59 trading days had significant gross returns. All occurred between 114 and 196 trading days prior to December 1. This period extends from the mid-February through mid-June. Mean percent return to a long position over the 83 trading days that occurred between 114 and 196 trading days prior to December 1 was 9.3 percent. In contrast, for soybeans, no trading day had a gross trading return that differed significantly from zero at the 95 percent confidence level.

In order for trading to be profitable, gross returns must exceed transaction costs. At a minimum, transaction costs include brokerage fees and liquidity costs. Based on conversations with brokers, round turn (buy and sell) brokerage fees can vary from $10 via E-trade and other electronic brokerage venders if the trade is made electronically (not a pit transaction) to $75. A common range for small traders using personal brokers is $40 to $60.

Liquidity cost is a payment earned by floor traders (scalpers) for filling an order to sell at the market. Brorsen and Thompson and Waller estimated this cost to be one price tick (1/4 cent per bushel for corn and soybeans futures) for nearby contracts and two price ticks for more lightly traded contracts that are five or more months from delivery.

Given the large spread in brokerage fees and the range of time to expiration, we chose to use for illustrative purposes 1.5 cents/bushel for the brokerage and liquidity costs associated with trading new crop futures contracts. This amount was transformed into a percent using the average futures settlement price observed over the 1974-2009 period. Liquidity plus brokerage costs were 0.5 percent for corn and 0.2 percent for soybeans.

Including these transaction costs reduced the share of trading days with a mean return that differed significantly from zero for corn to four percent over 1974-2009 and 10 percent over 1986-2009. For soybeans, only one trading day had significant trading returns above brokerage and liquidity costs. Thus, transaction costs can explain a significant share of the statistically significant observations. It is also worth noting that, if gross trading returns were calculated on a cents per bushel basis, no trading day for corn and only six trading days for soybeans had a mean return that was significantly greater than zero at the 95% confidence level.

**Test for Routine Price Bias: Option Contracts**

To test for routine bias in December corn and November soybean option prices, gross trading return was calculated to a long position using premiums at the close of trading:

(3) [December corn option premium for day t's at-the-money strike price on the December option expiration date – December corn option at-the-money premium on day t]

(4) [November soybean option premium for day t's at-the-money strike price on November option expiration date – November soybean option at-the-money premium on day t],

where t is a trading day prior to the option expiration date of the December corn (November soybean) contract. The option premiums used in this study are from the Chicago Mercantile Exchange and Barchart.com.

Option expiration day varied substantially over the observation period. It ranged from October 17 through October 27 for the November soybean option contracts and from November 7 through November 26 for the December corn option contracts. Initial date of trading and degree of trading activity early in the contract's trading life also varied across the years, especially during the first few years. Hence, we standardized the number of trading days based on these two considerations at 234 trading days prior to option expiration date for December corn and at 238 trading days prior to option expiration date for November soybeans.

The calculations in equation 3 and 4 yield a gross trading return in cents per bushel. The calculation was made for both a long call and a long put position established on day t and held until option expiration.

Mean gross trading return was calculated for each trading day prior to option expiration over the 1986 through 2009 observation period. The mean change was tested to determine if it was statistically different than zero using a 95 percent confidence test level.

Gross trading returns for a long December corn call and put are presented in Figure 3, while Figure 4 contains the gross trading returns for a long November soybean call and put. For the long put position, little evidence of statistically significant trading returns exists. Only one observation had a statistically significant return at the 95 percent confidence level (soybeans, 5 days prior to expiration). Similarly, only one trading day had a statistically significant return to a long call position in soybeans (next to last day before expiration).

In contrast, for the long corn call, 33 trading days had a significant gross trading return at the 95 percent confidence level. Thirty of these trading days fell between 106 and 159 trading days prior to the December option expiration date. Mean return was -13 cents per bushel for the period from 106 to 159 trading days prior to the December option expiration date, implying that the long call had a statistically significant loss.

As with futures, including brokerage and liquidity costs substantially decreases the number of statistically significant returns. Transaction costs of 2.2 cents per bushel would have been sufficient to reduce statistical confidence below the 95 percent test level for all observations. Such a level of transaction cost is not unreasonable given the relatively low liquidity that can exist in option contracts until the contract becomes the nearby contract.

## Public Information Efficiency Test – Procedures and Data

The efficient market hypothesis is the most commonly-accepted model of price behavior in speculative markets. Among its implications is that information known by the public should not be able to explain changes in price that occur after the information becomes known to the public. Results from previous studies of the incorporation of new information contained in U.S. government reports are generally consistent with the efficient market hypothesis (for example, French *et al.*, Colling and Irwin, and Garcia, *et al.*). These studies focused on the immediate incorporation of new information contained in the public reports over the first few trading days after the release of the public report.

This study investigates a related, but different issue regarding the incorporation of public information. Specifically, we investigate whether information contained in the widely-followed *World Agricultural Supply and Demand Estimates* (WASDE) released monthly by the U.S. Department of Agriculture can explain changes in December corn futures and November soybean futures prices observed between the first non-limit close after the release of WASDE and December 1 (November 1), the first trading day in the contract expiration month. One motivation for this investigation is the widely-discussed idea that new crop December corn and November soybean futures prices have a conditional bias toward a price decline, with the condition being whether or not the current crop year is a short crop year in terms of production (for example, see Wisner, et al. and Zulauf and Irwin). This condition falls into the category of public information.

A contemporaneous data set is created at the first non-limit close of the December corn and November soybean futures contract after the release of a WASDE report. The ratio of stocks-to-use is a summary measure of the relative availability of supply to satisfy demand. This variable is a more encompassing measure of relative scarcity than the dummy variable associated with whether or not the crop year is a short crop year. In addition, using the ratio of stocks-to-use means that the difficulty of defining short crop years is avoided. The analysis specifically includes the stocks-to-use ratio for corn (soybeans) reported for the current crop year in WASDE. Because futures markets are forward looking, the analysis also includes the change in the stocks-to-use ratio between the current crop year and the forthcoming new crop year reported in WASDE. To summarize, the analysis includes a measure of the relative scarcity of supply in the current crop year and a measure of expected change in the relative scarcity of supply between the current and forthcoming crop year.

A fundamental principle of finance is that return and risk are inversely related. Since the return to futures trading involves the change in price and prices on speculative markets are volatile, it is reasonable to ask whether an empirical relationship exists between changes in futures prices (i.e., return to futures trading) and the volatility at the time that the trade is placed. To test whether the degree of price volatility is related to the subsequent change in futures prices, the price volatility implied by the December corn (November soybean) option markets at the first non-limit close after the release of WASDE is included in the analysis. The implied volatility is calculated using Black's option model. Sources of the implied volatility are Barchart.com and the author's original calculations using data from the Chicago Mercantile Exchange.

The first estimate of the forthcoming new crop year's supply and demand is published in the May WASDE. Information about new crop year supply and demand appears in subsequent WASDE reports through August, the last old crop month for corn and soybeans. Therefore, one analytical approach is to pool all WASDE reports from May through and August, and then to estimate a fixed effects model with month of release and year dummy variables. However, the overlapping sample that results from this approach will induce autocorrelation into the error terms. Newey West can be used to correct for this autocorrelation, but Newey West does not have stable properties in small samples. The observation period for this analysis is 1986-2009, which is the period over which option trading exists. Because our sample period is small, we decided to take the conservative approach of estimating the regression equation only for the WASDE reports released in May. In addition, we conducted sensitivity tests.

To summarize this discussion, the following regression equation is estimated to test for public information efficiency in the new crop December corn and November soybean futures contract:

(5) $[\ln(\text{new crop futures price}_{t+n}) - \ln(\text{new crop futures price}_{t}) = f[\text{stocks-to-use ratio}_{cjt}, (\text{stocks-to-use ratio}_{ckt} - \text{stocks-to-use ratio}_{cjt}), \text{implied option volatility}_{t})],$

where t+n equals December 1 for corn and November 1 for soybeans, t equals the date of the first non-limit close of the December corn (November soybean) futures price after the release of the May WASDE, c is the crop (corn or soybeans), j is the current crop year, and k is the forthcoming new crop year.

**Public Information Efficiency Test – Results**

The mean and standard deviation of the regression variables are presented in Table 1. Both the December corn and November soybean contract declined on average between the May WASDE and first trading day of the contract expiration month over the 1986-2009 observation period. The average percent decline for corn was nearly three times larger than the average percent decline for soybeans. However, the standard deviation of the ln change in futures price was approximately the same for corn and soybeans. Corn's average stocks-to-use ratio is approximately 50 percent higher than soybean's average stocks-to-use ratio reported in the May WASDE, and the standard deviation of corn's stocks-to-use ratio is more than twice as large as the standard deviation of soybean's stocks-to-use ratio.

For both the December corn and November soybean regressions, the intercept, change in stocks-to-use ratio reported in the May WASDE, and option market implied volatility are significantly different than zero at the 95 percent confidence level (see Tables 2 and 3). The stocks-to-use ratio reported in the May WASDE is not statistically significant. Both equations are also statistically significant at the 95 percent confidence level, with an adjusted $R^2$ of 0.46 for corn and 0.24 for soybeans.

The estimated intercept term is positive in both equations. Since the dependent variable is measured in percent change, the intercept coefficient implies that, for example, on average the December corn futures price will increase by 0.51 percentage point between the release of the May WASDE and December 1.

The estimated coefficient on the change in stocks-to-use is negative in both equations. Again, using corn as an example, each one percentage point increase in the stocks-to-use ratio from the current crop year to the next new crop year reported in the May WASDE implies that the December corn futures price will decrease by 2.42 percentage points after the release of the May WASDE. The corresponding decrease for November soybean futures price is 1.57 percentage points after the release of the May WASDE.

The estimated coefficient on the implied option volatility is negative in both equations. For corn, each one percentage point increase in the implied option volatility derived at the first non-limit close after the May WASDE release implies that the December corn futures price will subsequently decrease by 0.02 percentage points through December 1. The corresponding decrease for the November soybean futures price is 0.01 percentage points after the release of the May WASDE.

To test the sensitivity of the results, the observation period for the May WASDE analysis was split in half: 1986-1997 and 1998-2009. In each subperiod, the change in stocks-to-use variable is significant at the 95 percent confidence level and has a negative sign. In contrast, the intercept and implied option volatility are significant only in the earlier subperiod for corn and the later subperiod for soybeans.

As another sensitivity test, the regression equation was estimated at five additional times after the May WASDE release date: one day and one week after the first non-limit close following release of the May WASDE, plus the first non-limit close following release of the June, July, and August WASDE reports. For corn, significance and sign of the statistically significant variables did not change for the regressions tied to the May and June WASDEs (see Tables 4 and 5). However, all variables were statistically insignificant at the 95 percent confidence level for the July and August WASDE release dates.

For soybeans, significance and sign on the statistically significant variables did not change for the regression estimated at one day after the first non-limit close following release of the May WASDE. The intercept was statistically insignificant in the regression estimated for one week after the first non-limit close following release of the May WASDE, but returned to significance in the June WASDE regression (Tables 6 and 7). In contrast, change in stocks-to-use was statistically significant in the regression estimated for one-week-after May WASDE regression but was insignificant in the June WASDE regression. Implied option volatility was statistically significant in both regressions. As with corn, all variables were insignificant at the 95 percent confidence level for the July and August WASDE release dates.

**Conclusions and Implications**

This study revisited the debate over whether new crop December corn and November soybean futures and option prices are biased. Some evidence of bias is found for December corn futures and long December corn calls. For December corn futures beginning with the 1974 contract expiration, 45 of the 47 trading days that occurred between 158 and 204 trading days prior to December 1 had a statistically significant negative return to a long position. For the long corn call, significant gross trading returns at the 95 percent confidence level were observed for 30 of the trading days between 106 and 159 trading days prior to the December option expiration date. However, subtracting an estimate of brokerage fees and liquidity costs from gross returns substantially reduced the evidence of bias. The number of trading days with a statistically significant mean return for December corn futures declined to less than 10 days. For corn calls, transaction costs of 2.2 cents per bushel would have been sufficient to reduce statistical confidence below the 95 percent test level for all observations. Such a level of transaction costs is not unreasonable given the relatively low liquidity that can exist in option contracts until the contract becomes the nearby contract.

This study also examines if information contained in the widely-followed *World Agriculture Supply and Demand Reports* (WASDE) issued by the U.S. Department of Agriculture as well as the implied volatility from new crop corn and soybean options are incorporated efficiently into the December corn and November soybean futures price. Previous studies have examined the immediate incorporation of public information into futures prices. In contrast, this study examines whether public information is incorporated efficiently from the perspective of the change in price between the first non-limit close after the release of a WASDE report and the first delivery day of the December corn and November soybean futures contracts.

The May WASDE is the first release of the calendar year to include estimates for the forthcoming new crop year's supply and demand. For both the December corn and November soybean regressions, the intercept, change in stocks-to-use ratio between the current and new crop year reported in the May WASDE, and option market implied volatility are significantly different than zero at the 95 percent confidence level. The current crop year's stocks-to-use ratio is not statistically significant. Statistical significance of the intercept and implied volatility was sensitive to dividing the period of analysis in half. For corn, the intercept, change in stocks-to-use, and implied option volatility were statistically significant at the 95 percent confidence level and had the same sign for the regressions estimated at the first non-limit close after the release of the May and June WASDEs as well as for the regressions estimated at one day and one week after the first non-limit close of the May WASDE. More sensitivity existed for these regressions for soybeans. The intercept was statistically insignificant in the one-week-after the May WASDE regression while the change in stocks-to-use was insignificant in the June WASDE regression. For both corn and soybeans, all variables were statistically insignificant for the regressions estimated at the first non-limit close after release of the July and August WASDEs.

Before discussing the implications of these results, it is important to note that there are only 24 observations. This limited number of observations implies caution. Additional data and analysis is needed to assess the robustness of these findings. Given this important caveat, the results suggest the following conclusions and implications:

(1) The lack of statistical significance of the current crop year's stocks-to-use ratio implies that public information on the current crop year's supply and demand is incorporated efficiently into the December corn and November soybean futures prices.

(2) The estimated intercept term is generally statistically significant and positive in the equations estimated for the May and June WASDEs, *ceteris paribus*, this finding is consistent with the existence of normal backwardization in the December corn and November soybean futures price.

(3) The change in stocks-to-use is generally statistically significant and negative in the equations estimated for the May and June WASDEs. This finding implies that new crop supply and demand is not incorporated efficiently into the December corn and November soybean futures prices. However, this variable is no longer statistically significant at the release of the July WASDE, implying that new crop supply and demand information is incorporated efficiently by mid-July. The negative sign on change in stocks-to-use ratio implies that, the higher is the increase in the stocks-to-use ratio from the current to the next year ratio reported in the May/June WASDE report, the greater is the decline in December corn and November soybean futures prices subsequent to the first non-limit close after the release of the May/June WASDE.

(4) Implied option volatility is generally statistically significant and negative in the equations estimated for the May and June WASDEs. This finding implies that new crop option volatility is not incorporated efficiently into December corn and November soybean futures prices. This variable is no longer statistically significant at the release of the July WASDE, implying that new crop option volatility is incorporated efficiently by mid-July. The negative sign on implied volatility implies that, the higher is the implied volatility derived at the first non-limit close after the release of the May/June WASDE, the greater is the subsequent decline in the futures prices.

These conclusions and implications raise potentially intriguing questions regarding market efficiency and price determination in new crop corn and soybean prices. However, as noted earlier, the same sample size places these findings more into the category of something that needs to be monitored than as a direct confrontation to the theory of market efficiency.

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**Table 1. Descriptive Statistics, Regression Variables, Corn and Soybeans, May WASDE Release Date, 1986-2009.**

| | ---------- Corn ---------- | | --------- Soybeans ---------- | |
|---|---|---|---|---|
| Variable | Mean | Standard Deviation | Mean | Standard Deviation |
| ln Change in Futures Price | -8.5% | 18.1% | -2.9% | 16.5% |
| Stocks-to-Use | 21.0% | 16.5% | 13.0% | 7.0% |
| Change in Stocks-to-Use | -0.1% | 4.8% | 1.2% | 4.4% |
| Implied Option Volatility | 27.7% | 6.2% | 24.8% | 5.6% |

Sources: U.S. Department of Agriculture, *World Agricultural Supply and Demand Estimates*; Chicago Mercantile Exchange, and Barchart.com

**Table 2. Public Information Efficiency Test of Percent Change in December Corn Futures Price, First Non-Limit Close after May WASDE Release Date to December 1, 1986-2009.**

**Panel A: Observation Period of 1986-2009**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.515 | 0.158 | 3.255 | 0.004 |
| Stocks-to-Use | -0.192 | 0.116 | -1.650 | 0.115 |
| Change in Stocks-to-Use | -2.420 | 0.538 | -4.494 | < 0.000 |
| Implied Option Volatility | -0.020 | 0.006 | -3.444 | 0.003 |
| | | | | |
| R-squared | 0.53 | F-statistic | | 7.64 |
| Adjusted R-squared | 0.46 | Probability (F-statistic) | | 0.00 |

**Panel B: Observation Period of 1986-1997**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.481 | 0.115 | 4.178 | 0.003 |
| Stocks-to-Use | -0.193 | 0.112 | -1.730 | 0.122 |
| Change in Stocks-to-Use | -2.115 | 0.493 | -4.293 | 0.003 |
| Implied Option Volatility | -0.019 | 0.004 | -4.616 | 0.002 |
| | | | | |
| R-squared | 0.72 | F-statistic | | 6.75 |
| Adjusted R-squared | 0.61 | Probability (F-statistic) | | 0.01 |

**Panel C: Observation Period of 1998-2009**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.491 | 0.529 | 0.929 | 0.380 |
| Stocks-to-Use | 0.310 | 1.482 | 0.209 | 0.839 |
| Change in Stocks-to-Use | -3.279 | 1.099 | -2.984 | 0.018 |
| Implied Option Volatility | -0.022 | 0.013 | -1.784 | 0.112 |
| | | | | |
| R-squared | 0.42 | F-statistic | | 1.97 |
| Adjusted R-squared | 0.21 | Probability (F-statistic) | | 0.20 |

Notes: (1) Percent change is calculated: ln futures $price_{Dec.\ 1}$ – ln futures $\text{price}_{May\ WASDE\ Release\ Date}$
(2) White Heteroskedasticity-Consistent Standard Errors and Covariance.

Source: Original calculations by authors using data from U.S. Department of Agriculture, *World Agricultural Supply and Demand Estimates*; Chicago Mercantile Exchange, and Barchart.com

**Table 3. Public Information Efficiency Test of Percent Change in November Soybean Futures Price, First Non-Limit Close after May WASDE Release Date to November 1, 1986-2009.**

**Panel A: Observation Period of 1986-2009**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.435 | 0.178 | 2.443 | 0.024 |
| Stocks-to-Use | -0.609 | 0.495 | -1.232 | 0.232 |
| Change in Stocks-to-Use | -1.569 | 0.675 | -2.323 | 0.031 |
| Implied Option Volatility | -0.015 | 0.006 | -2.624 | 0.016 |
| | | | | |
| R-squared | 0.34 | F-statistic | | 3.36 |
| Adjusted R-squared | 0.24 | Probability (F-statistic) | | 0.04 |

**Panel B: Observation Period of 1986-1997**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.298 | 0.222 | 1.344 | 0.216 |
| Stocks-to-Use | -0.293 | 0.358 | -0.819 | 0.437 |
| Change in Stocks-to-Use | -1.583 | 0.587 | -2.695 | 0.027 |
| Implied Option Volatility | -0.013 | 0.010 | -1.314 | 0.225 |
| | | | | |
| R-squared | 0.36 | F-statistic | | 1.51 |
| Adjusted R-squared | 0.12 | Probability (F-statistic) | | 0.28 |

**Panel C: Observation Period of 1998-2009**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.840 | 0.336 | 2.503 | 0.037 |
| Stocks-to-Use | -1.147 | 1.120 | -1.024 | 0.336 |
| Change in Stocks-to-Use | -1.942 | 0.728 | -2.669 | 0.028 |
| Implied Option Volatility | -0.025 | 0.008 | -3.000 | 0.017 |
| | | | | |
| R-squared | 0.56 | F-statistic | | 3.33 |
| Adjusted R-squared | 0.39 | Probability (F-statistic) | | 0.08 |

Notes: (1) Percent change is calculated: ln futures $price_{Nov.\ 1}$ – ln futures $\text{price}_{May\ WASDE\ Release\ Date}$
(2) White Heteroskedasticity-Consistent Standard Errors and Covariance.

Source: Original calculations by authors using data from U.S. Department of Agriculture, *World Agricultural Supply and Demand Estimates*; Chicago Mercantile Exchange, and Barchart.com

**Table 4. Public Information Efficiency Test of Percent Change in December Corn Futures Price, First Non-Limit Close 1 Day and 1 Week after May WASDE Release Date to December 1, 1986-2009.**

**Panel A: One Day after May WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.508 | 0.159 | 3.205 | 0.004 |
| Stocks-to-Use | -0.139 | 0.116 | -1.201 | 0.244 |
| Change in Stocks-to-Use | -2.335 | 0.562 | -4.153 | < 0.000 |
| Implied Option Volatility | -0.020 | 0.006 | -3.396 | 0.003 |
| R-squared | 0.52 | F-statistic | | 7.34 |
| Adjusted R-squared | 0.45 | Probability (F-statistic) | | < 0.00 |

**Panel B: One Week after May WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.491 | 0.173 | 2.845 | 0.010 |
| Stocks-to-Use | -0.052 | 0.119 | -0.433 | 0.670 |
| Change in Stocks-to-Use | -2.200 | 0.554 | -3.973 | < 0.000 |
| Implied Option Volatility | -0.020 | 0.006 | -2.983 | 0.007 |
| R-squared | 0.49 | F-statistic | | 6.38 |
| Adjusted R-squared | 0.41 | Probability (F-statistic) | | < 0.00 |

Notes: (1) Percent change is calculated: ln futures $price_{Dec.\ 1}$ – ln futures $\text{price}_{May\ WASDE\ +\ 1(7)\ days}$
(2) White Heteroskedasticity-Consistent Standard Errors and Covariance.

Source: Original calculations by authors using data from U.S. Department of Agriculture, *World Agricultural Supply and Demand Estimates*; Chicago Mercantile Exchange, and Barchart.com

**Table 5. Public Information Efficiency Test of Percent Change in December Corn Futures Price, First Non-Limit Close after June/July/August WASDE Release Date to December 1, 1986-2009.**

**Panel A: June WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.514 | 0.162 | 3.174 | 0.005 |
| Stocks-to-Use | 0.002 | 0.142 | 0.015 | 0.989 |
| Change in Stocks-to-Use | -2.215 | 0.651 | -3.403 | 0.003 |
| Implied Option Volatility | -0.022 | 0.006 | -3.357 | 0.003 |
| | | | | |
| R-squared | 0.49 | F-statistic | | 6.43 |
| Adjusted R-squared | 0.41 | Probability (F-statistic) | | 0.00 |

**Panel B: July WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.289 | 0.219 | 1.318 | 0.202 |
| Stocks-to-Use | 0.119 | 0.181 | 0.666 | 0.520 |
| Change in Stocks-to-Use | -0.563 | 0.634 | -.0891 | 0.384 |
| Implied Option Volatility | -0.014 | 0.010 | -1.450 | 0.163 |
| | | | | |
| R-squared | 0.14 | F-statistic | | 1.07 |
| Adjusted R-squared | 0.01 | Probability (F-statistic) | | 0.38 |

**Panel C: August WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.149 | 0.188 | 0.792 | 0.438 |
| Stocks-to-Use | 0.131 | 0.104 | 1.263 | 0.221 |
| Change in Stocks-to-Use | -0.227 | 0.378 | -0.600 | 0.556 |
| Implied Option Volatility | -0.008 | 0.009 | -0.927 | 0.365 |
| | | | | |
| R-squared | 0.10 | F-statistic | | 0.72 |
| Adjusted R-squared | -0.04 | Probability (F-statistic) | | 0.55 |

Notes: (1) Percent change is calculated: ln futures $price_{Dec.\ 1}$ – ln futures $\text{price}_{WASDE\ Release\ Date}$
(2) White Heteroskedasticity-Consistent Standard Errors and Covariance.

Source: Original calculations by authors using data from U.S. Department of Agriculture, *World Agricultural Supply and Demand Estimates*; Chicago Mercantile Exchange, and Barchart.com

**Table 6. Public Information Efficiency Test of Percent Change in November Soybean Futures Price, First Non-Limit Close 1 Day and 1 Week after May WASDE Release Date to November 1, 1986-2009.**

**Panel A: One Day after May WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.452 | 0.185 | 2.451 | 0.024 |
| Stocks-to-Use | -0.636 | 0.495 | -1.284 | 0.214 |
| Change in Stocks-to-Use | -1.571 | 0.683 | -2.300 | 0.032 |
| Implied Option Volatility | -0.015 | 0.006 | -2.593 | 0.017 |
| | | | | |
| R-squared | 0.35 | F-statistic | | 3.35 |
| Adjusted R-squared | 0.25 | Probability (F-statistic) | | 0.03 |

**Panel B: One Week after May WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.397 | 0.193 | 2.055 | 0.053 |
| Stocks-to-Use | -0.570 | 0.526 | -1.084 | 0.291 |
| Change in Stocks-to-Use | -1.579 | 0.692 | -2.283 | 0.034 |
| Implied Option Volatility | -0.013 | 0.006 | -2.190 | 0.041 |
| | | | | |
| R-squared | 0.30 | F-statistic | | 2.91 |
| Adjusted R-squared | 0.20 | Probability (F-statistic) | | 0.06 |

Notes: (1) Percent change is calculated: ln futures $price_{Nov.\ 1}$ – ln futures price $_{May\ WASDE\ +\ 1(7)\ days}$
(2) White Heteroskedasticity-Consistent Standard Errors and Covariance.

Source: Original calculations by authors using data from U.S. Department of Agriculture, *World Agricultural Supply and Demand Estimates*; Chicago Mercantile Exchange, and Barchart.com

**Table 7. Public Information Efficiency Test of Percent Change in November Soybean Futures Price, First Non-Limit Close after June/July/and/August WASDE Release Date to November 1, 1986-2009.**

**Panel A: June WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.369 | 0.158 | 2.336 | 0.030 |
| Stocks-to-Use | -0.900 | 0.517 | -1.741 | 0.097 |
| Change in Stocks-to-Use | -0.646 | 0.537 | -1.202 | 0.243 |
| Implied Option Volatility | -0.010 | 0.003 | -2.950 | 0.008 |
| | | | | |
| R-squared | 0.26 | F-statistic | | 2.37 |
| Adjusted R-squared | 0.15 | Probability (F-statistic) | | 0.10 |

**Panel B: July WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.162 | 0.208 | 0.779 | 0.445 |
| Stocks-to-Use | -0.192 | 0.552 | -0.348 | 0.732 |
| Change in Stocks-to-Use | 0.744 | 0.625 | 1.190 | 0.248 |
| Implied Option Volatility | -0.006 | 0.005 | -1.206 | 0.242 |
| | | | | |
| R-squared | 0.23 | F-statistic | | 2.01 |
| Adjusted R-squared | 0.12 | Probability (F-statistic) | | 0.15 |

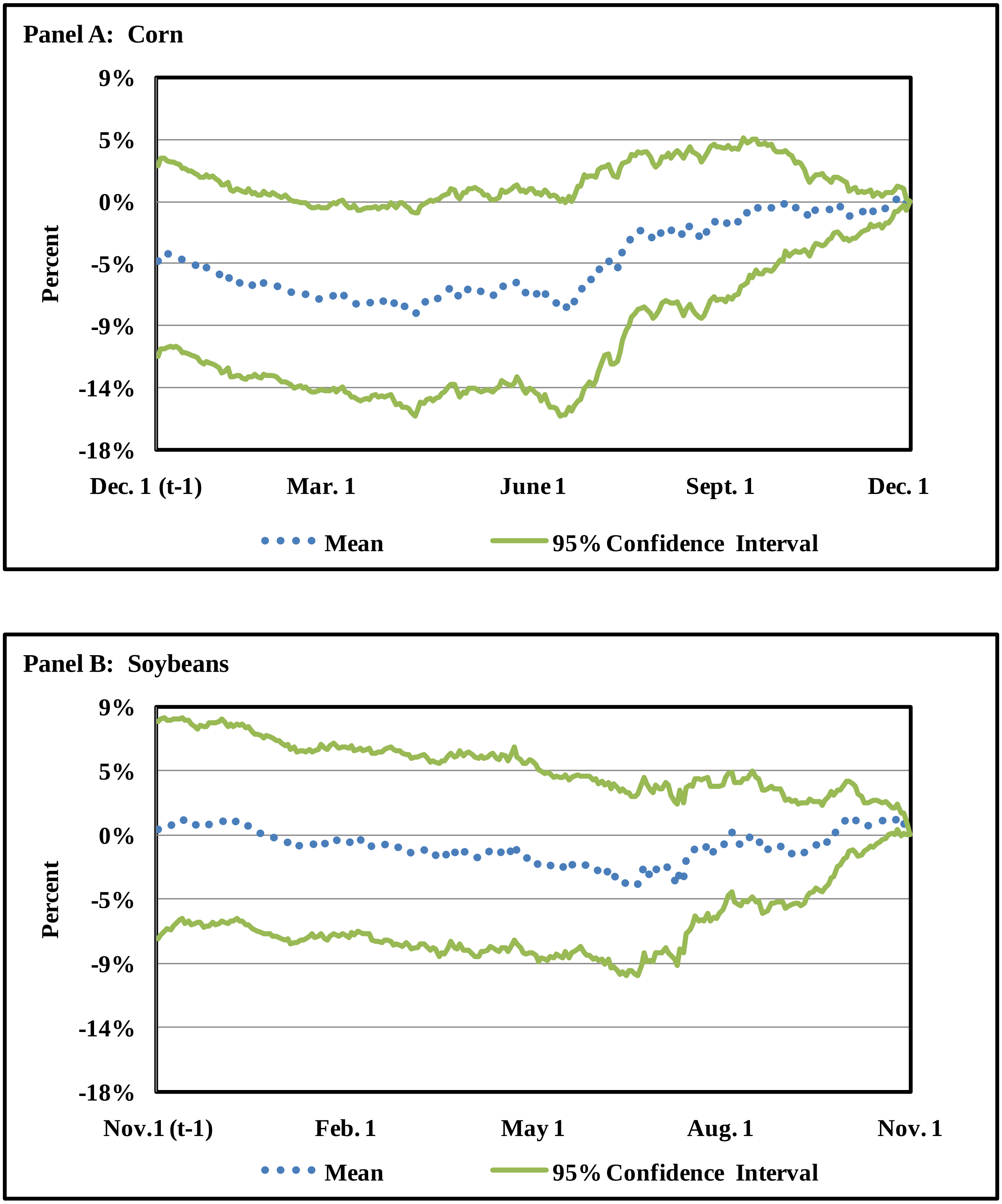
**Panel C: August WASDE Release Date**

| Independent Variable | Coefficient | Standard Error | t-Statistic | Probability |
|---|---|---|---|---|
| Intercept | 0.221 | 0.162 | 1.363 | 0.188 |
| Stocks-to-Use | -0.455 | 0.516 | -0.882 | 0.388 |
| Change in Stocks-to-Use | 0.333 | 0.374 | 0.889 | 0.385 |
| Implied Option Volatility | -0.006 | 0.004 | -1.480 | 0.155 |
| | | | | |
| R-squared | 0.18 | F-statistic | | 1.46 |
| Adjusted R-squared | 0.06 | Probability (F-statistic) | | 0.26 |

Notes: (1) Percent change is calculated: ln futures $price_{Nov\ 1}$ – ln futures $\text{price}_{\textit{WASDE Release Date}}$
(2) White Heteroskedasticity-Consistent Standard Errors and Covariance.

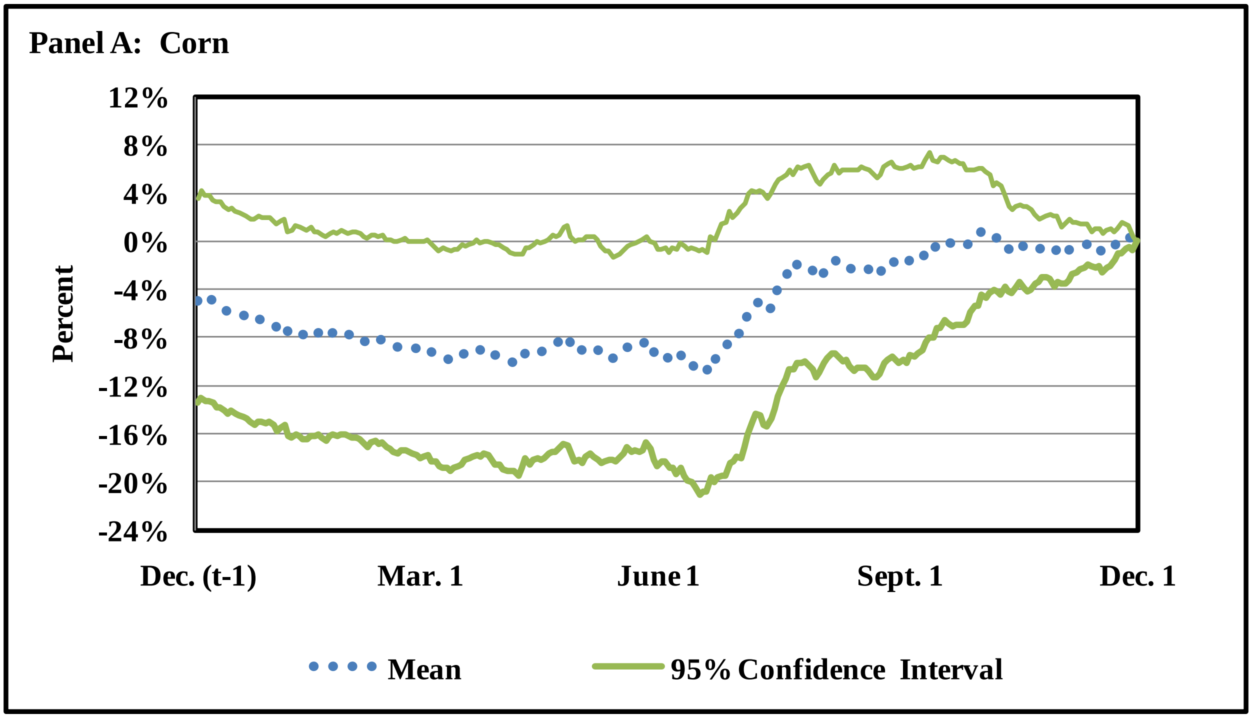
Source: Original calculations by authors using data from U.S. Department of Agriculture, *World Agricultural Supply and Demand Estimates;* Chicago Mercantile Exchange, and Barchart.com

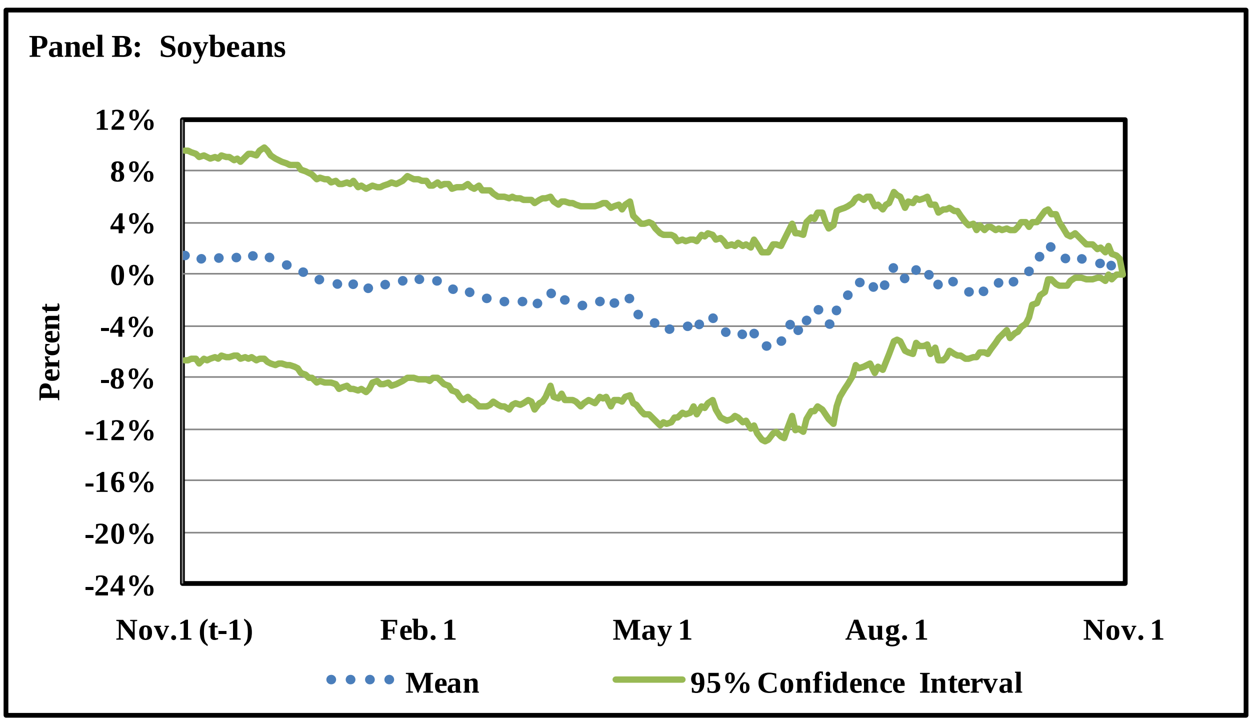
**Figure 1. Gross Trading Return (Percent), Long December Corn Futures and Long November Soybean Futures, 1974-2009**




Sources: Chicago Mercantile Exchange and Barchart.com

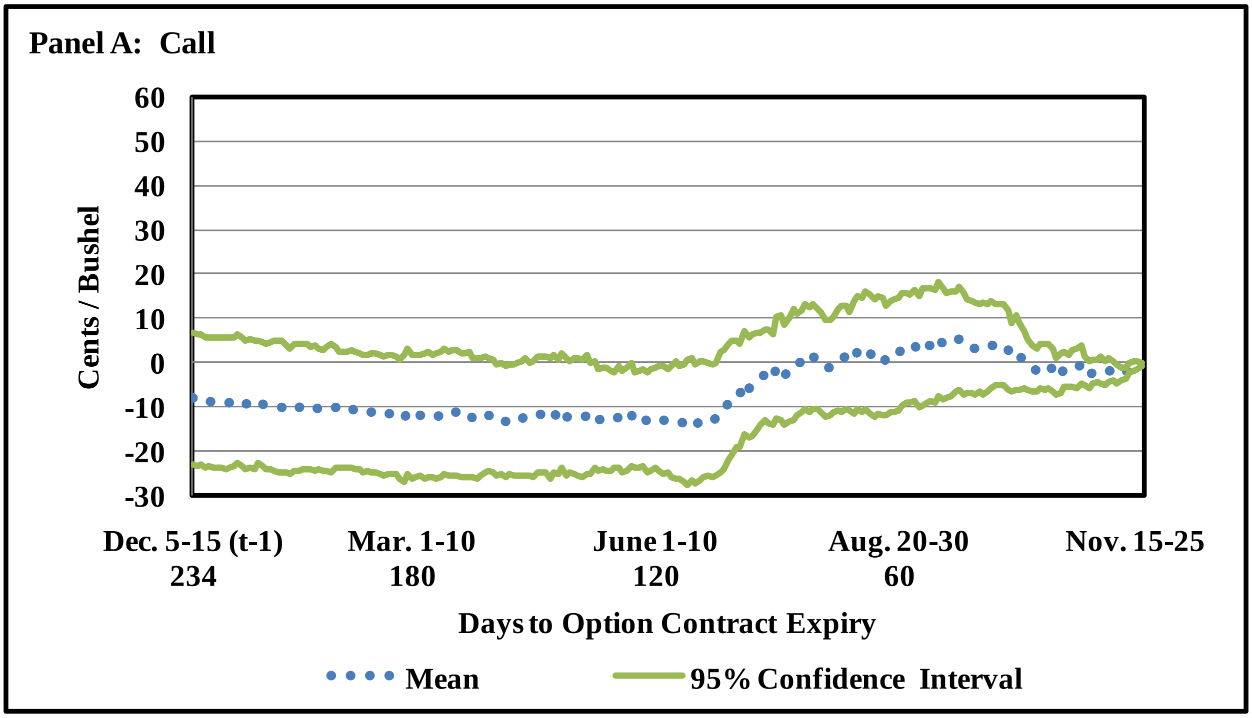
**Figure 2. Gross Trading Return (Percent), Long December Corn Futures and Long November Soybean Futures, 1986-2009**

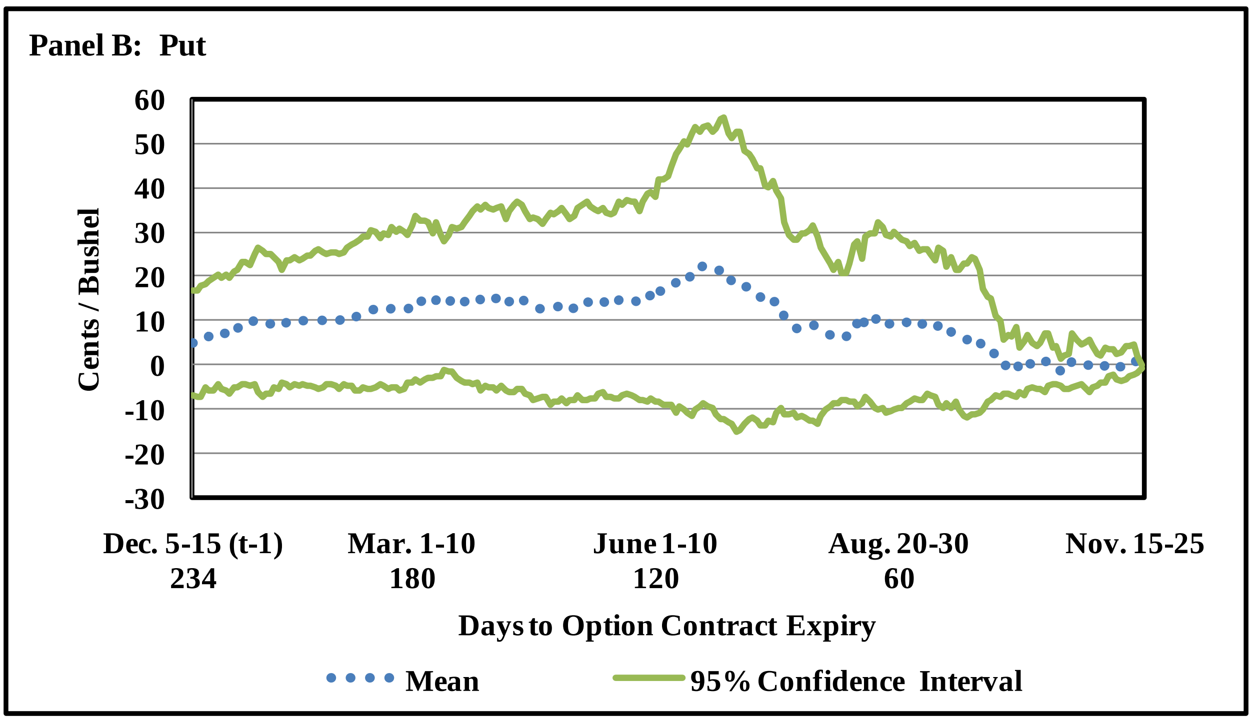



Sources: Chicago Mercantile Exchange and Barchart.com

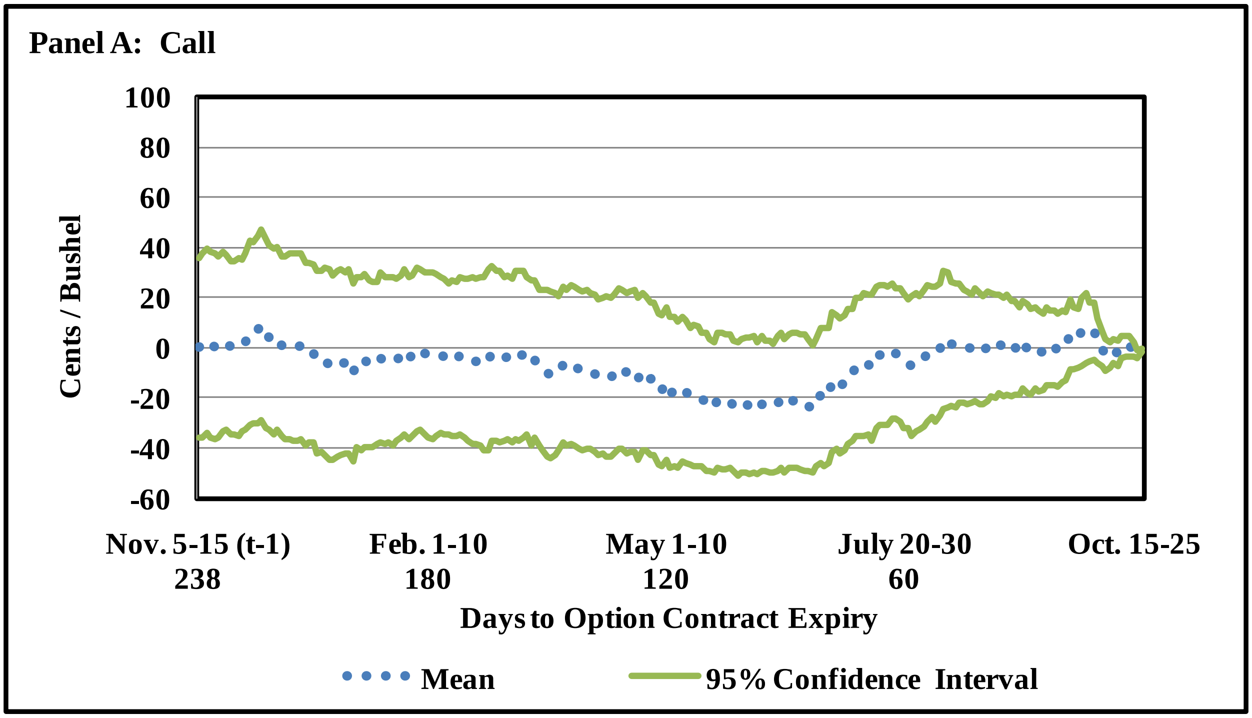
**Figure 3. Gross Trading Return (Cents/Bushel), Long December Corn Options, 1986-2009**

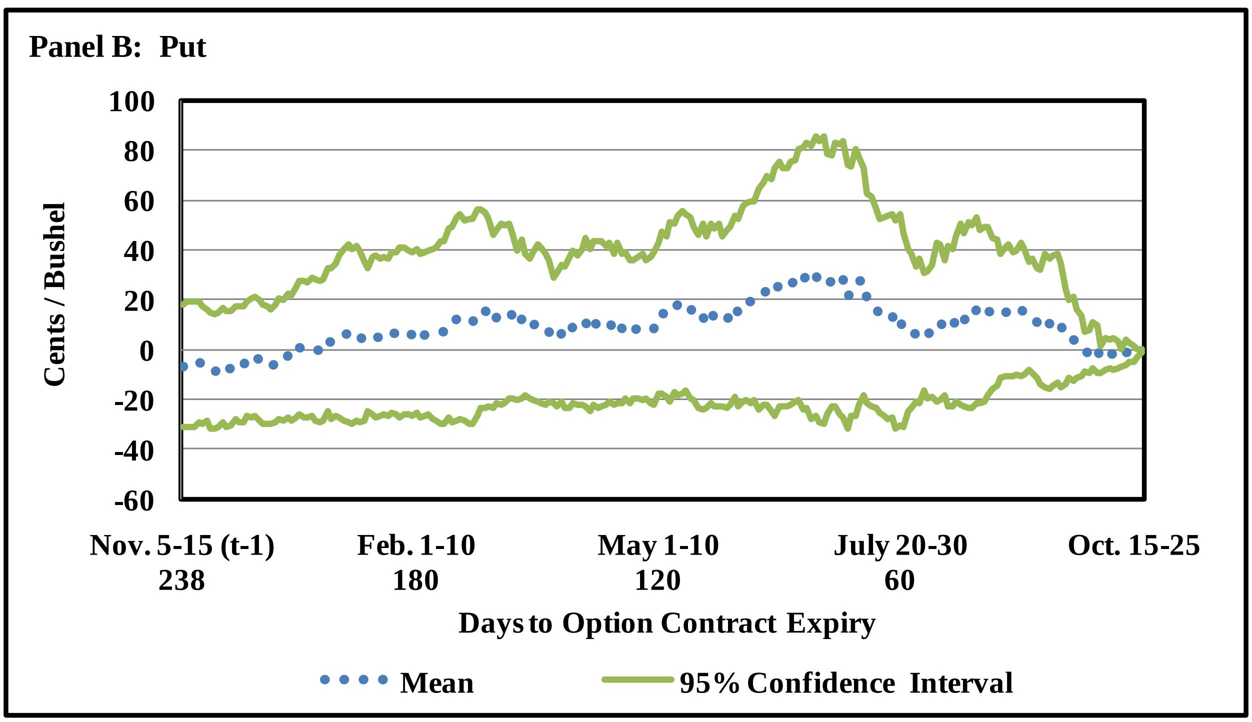



Sources: Chicago Mercantile Exchange and Barchart.com

**Figure 4. Gross Trading Return (Cents/Bushel), Long November Soybean Options, 1986-2009**




Sources: Chicago Mercantile Exchange and Barchart.com