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Revisiting USDA Corn and Soybean Grain Stocks Estimates

Scott Irwin and Darrel Good

Department of Agricultural and Consumer Economics
University of Illinois

Dwight Sanders

Department of Agribusiness Economics
Southern Illinois University

July 20, 2016

***farmdoc daily* (6):136**

Recommended citation format: Irwin, S., D. Good, and D. Sanders. "Revisiting USDA Corn and Soybean Grain Stocks Estimates." *farmdoc daily* (6):136, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, July 20, 2016.

Permalink: http://farmdocdaily.illinois.edu/2016/07/revisiting-usda-corn-and-soybean-grain-stocks.html

The June 1 estimates of corn and soybean stocks released by the USDA on June 30 provided some big surprises. The corn stocks estimate was about 200 million bushels larger than anticipated, while the soybean stocks estimate was about 40 million bushels larger than anticipated. The larger corn stocks estimate has especially contributed to the "heaviness" of corn prices in recent weeks. This certainly has not been the only example of the USDA grain stocks reports providing a major surprise to the market in recent years. In fact, the grain stocks estimates have generated enough controversy that the Office of the Chief Economist of the USDA commissioned a study to examine this, and other, issues related to USDA forecasts (Irwin, Sanders, and Good, 2014). Several *farmdoc daily* articles subsequently featured different parts of the study. (January 17, 2014; January 29, 2014; February 7, 2014; February 13, 2014; February 14, 2014). The study found that there had indeed been a sharp decline in analysts' ability to anticipate actual quarterly corn stock estimates beginning with the start of the 2006 marketing year. The availability of data for three more marketing years provides an opportunity to update our previous analysis and determine whether the "problem" with corn stocks estimates has continued or not. In addition, we also analyze in this article the typical degree of uncertainty in the crucial September 1 corn and soybean stock estimates.

USDA Grain Stocks Estimates

The National Agricultural Statistics Service (NASS) of the USDA provides estimates of U.S. corn and soybean stocks at the end of each quarter of the marketing year. The reference dates for those estimates are December 1, March 1, June 1, and September 1. Estimates of on-farm grain stocks are based on data collected in the quarterly Agricultural Surveys in which a sample of producers are asked to identify the storage capacity of all structures normally used to store whole grains or oilseeds and to estimate the total number of bushels of corn and soybeans stored on the reference date on the total acres operated by the respondent regardless of ownership or intended use of the crops. The report form does

not instruct on-farm survey respondents to report the number of 56-pound bushels of corn and 60-pound bushels of soybeans. NASS apparently assumes on-farm respondents use these standards without prompting. For the December report, estimates of un-harvested production are also included in the stocks estimate. Respondents are specifically asked to estimate the number of acres and expected yield for crops remaining to be harvested for the current crop year. Respondents are also asked if the un-harvested production was included in the respondent's estimate of stocks on hand. For the September report, respondents are specifically asked to exclude any new crop inventories. Stocks estimates are imputed for non-respondents.

The sample size for the Agricultural Surveys is large in order to provide sufficient observations needed for statistical rigor when the range of potential responses is very large. In a recent survey cycle, the sample size was 96,022 in June, 65,953 in September, 82,760 in December, and 83,089 in March (Prusacki, 2013). The sample consisted of 2,804 very large farms and 6,390 farms identified in the June Area Survey that were missing from the NASS list of farm operators. These two groups were surveyed every quarter. The rest of the sample was drawn from the NASS list of farm operators and the number and make-up of those respondents varied by quarter.

Estimates of off-farm stocks of corn and soybeans are based on data collected in the *Grain Stocks* report from mills, elevators, warehouses, and other storage facilities. This survey is intended to be a census of all commercial facilities. Respondents are asked to identify the number of storage locations operated and being reported, the rated storage capacity of all locations being reported, and to estimate the number of bushels of corn and soybeans stored at those facilities on the reference date. The report form reminds off-farm survey respondents to report the number of 56-pound bushels of corn and 60-pound bushels of soybeans. For the September 1 report, respondents are also asked to separately estimate stocks harvested in previous crop years (old crop) and stocks harvested in the current crop year (new crop).

The survey procedures for the quarterly stocks estimates is expected to provide relatively accurate stocks estimates even though the sampling variability for the on-farm stocks estimate is relatively large for some quarters. The relative standard errors reported for the 2014-15 marketing year were as follows:

	Corn	Soybeans
December 1, 2014	1.5%	1.9%
March 1, 2015	2.1%	3.0%
June 1, 2015	2.7%	3.5%
September 1, 2015	4.4%	7.1%

There is an interesting pattern of increasing standard errors through the marketing year, with the September 1 standard error for corn and soybeans 2.9 and 5.2 percentage points, respectively, larger than the December 1 standard error. This presumably reflects the smaller number of farm operators holding corn and soybeans as the marketing year progresses, which, all else constant, would result in smaller sample sizes for estimating on-farm stocks.

For further perspective, the on-farm stocks standard errors can also be compared to the standard errors of 1.1% reported for corn and 1.0% for soybean yield indications from the farm operator survey for the 2015 U.S. production estimates released in January 2016. However, the objective yield indications reflected in that report are also subject to sampling variability since only a sample of crop acreage is included in that survey. In contrast, the survey for the off-farm grain stocks estimates is a near census of commercial facilities, and therefore, estimates are not subject to sampling error (but may contain non-sampling errors).

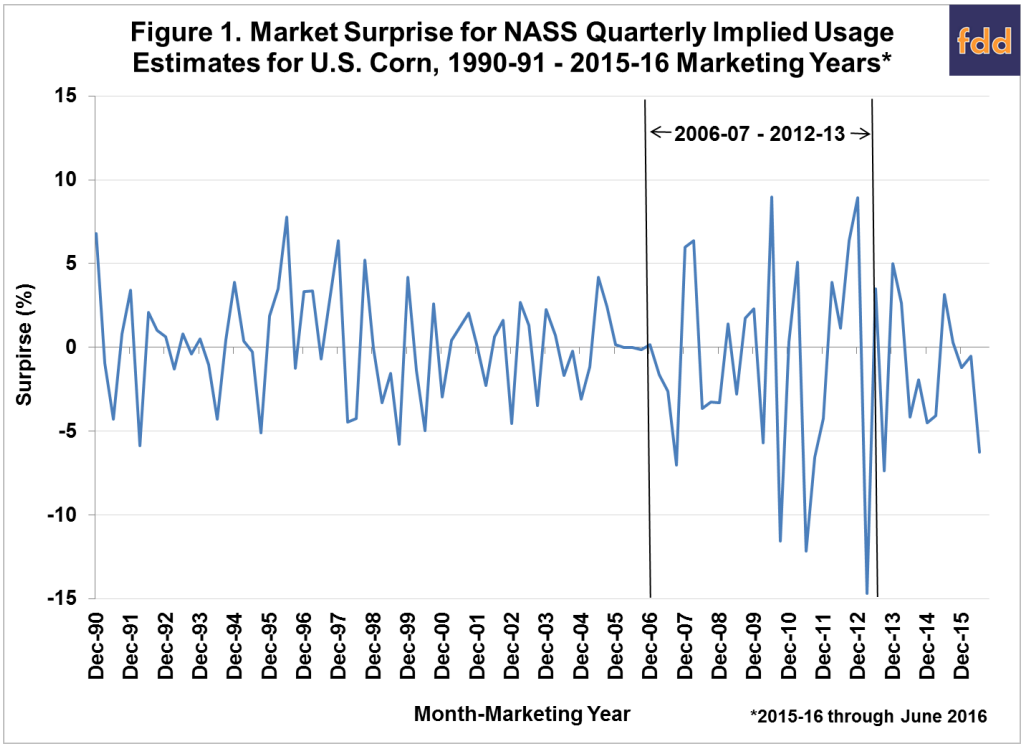
Analysis

NASS estimates of quarterly grain stocks provide important market information regarding the magnitude of consumption during the previous quarter of the marketing year as well the supply available for future consumption. Unlike the USDA crop production forecasts, which can be compared to a final production estimate in order to evaluate forecast accuracy, there is no independent estimate for judging the accuracy of quarterly NASS stocks estimates. Instead, we analyze the history of the NASS quarterly corn and soybean stocks estimates relative to pre-release estimates by private sector analysts. While this type of

analysis is limited due to the lack of a “final” benchmark, the history of differences between USDA and analyst stocks estimates should reveal estimates that market analysts find particularly problematic.

Newswires report the expected stocks estimates of various market analysts from which an average analyst estimate is computed. Using the average analyst estimates reported by the Dow Jones Newswire (or their predecessor, Oster Dow Jones and Knight Ridder) or Reuters, the difference from NASS stocks estimates was calculated for each quarter for the 1990-91 through 2015-16 marketing years. Since analysts' estimates of stocks are really estimates of usage or implied usage during the quarter that ends with the reference date of the NASS *Grain Stocks* report, we compute the differences as a percentage of quarterly usage (see the appendix for technical details). This difference is commonly referred to as the “market surprise.”

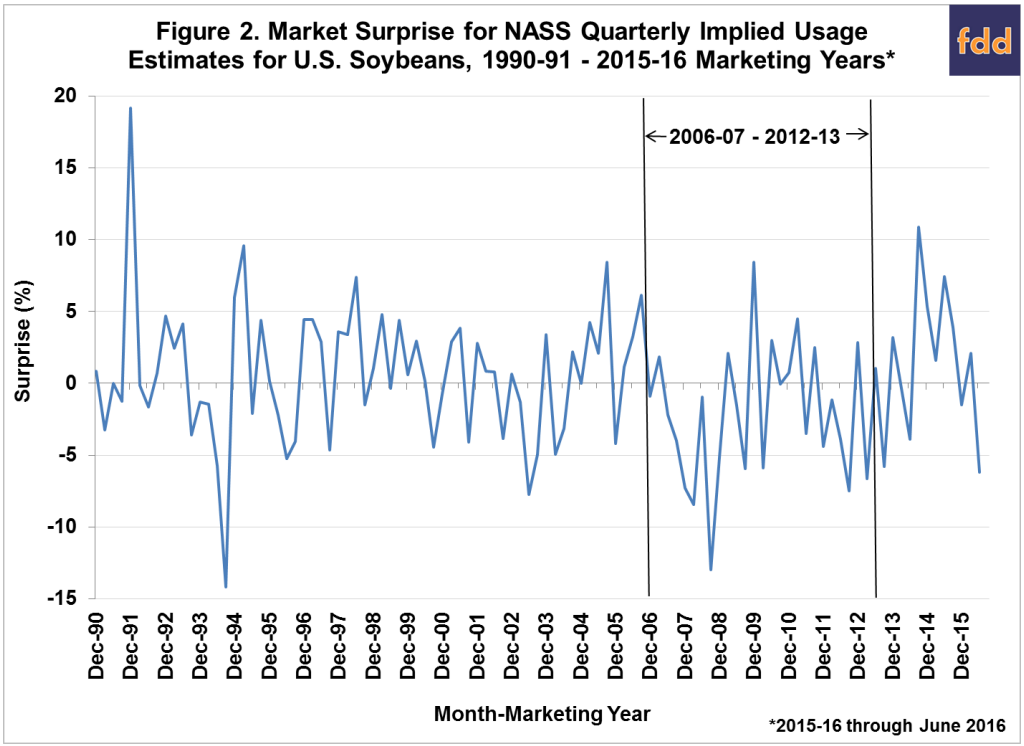
Figure 1 presents the history of surprises for NASS implied usage estimates for corn over the 1990-91 – 2015-16 marketing years in chronological order. Note that a positive surprise implies that market analysts under-estimated usage (over-estimated stocks) and a negative surprise implies analysts over-estimated usage (under-estimated stocks). This figure highlights the sharp increase in the volatility of market surprises for implied corn usage that occurred over 2006-07 – 2012-13. There were only 7 instances out of 64 over 1990-2005 where the surprise exceeded 5 percent. In contrast, over 2006-2012, there were 12 instances out of 28 where the surprise exceeded 5 percent. Furthermore, double-digit usage surprises occurred three times during 2006-2012 (-11.55 percent: June-August 2009; -12.13 percent: March-May 2010; -14.67 percent: December-February 2012), and each substantially exceeded the largest surprise observed over 1990-2005 (+7.78 percent: March-May 1995).



There have been 11 quarterly stocks reports released since our original analysis was completed at the end of the 2012-13 marketing year, with the latest being for June 1, 2016. In absolute terms, the usage surprises revealed in those reports ranged from 0.29 to 6.26 percent and averaged about 3.1 percent (in absolute value). That compares to the period 2006-07 through 2012-13 when the quarterly usage surprise, in absolute terms, ranged from 0.17 to 14.67 percent and averaged 5.1 percent. The more recent observations indicate that the issues associated with surprises in the USDA corn stocks estimates that were most notable in the 2009-10 through 2012-13 marketing years, when the usage surprise averaged 6.4 percent, have mostly disappeared.

Figure 2 presents the history of surprises for NASS implied usage estimates for soybeans over the 1990-91 through 2015-16 marketing years in chronological order. The contrast in the pattern of implied usage surprises for soybeans across all quarters in Figure 2 with that of corn in Figure 1 is striking. Unlike corn, there is little evidence that quarterly soybean usage surprises in the period from 2006-07 through 2012-13

were outside of previous historical ranges. The average absolute surprise was 3.6 percent during the 1990-91 through 2005-06 period and 4.1 percent during 2006-07 through 2012-13. However, the usage surprise in absolute terms exceeded five percent in 8 of the 28 years in the latter period and only 10 out of 64 times in the earlier period.



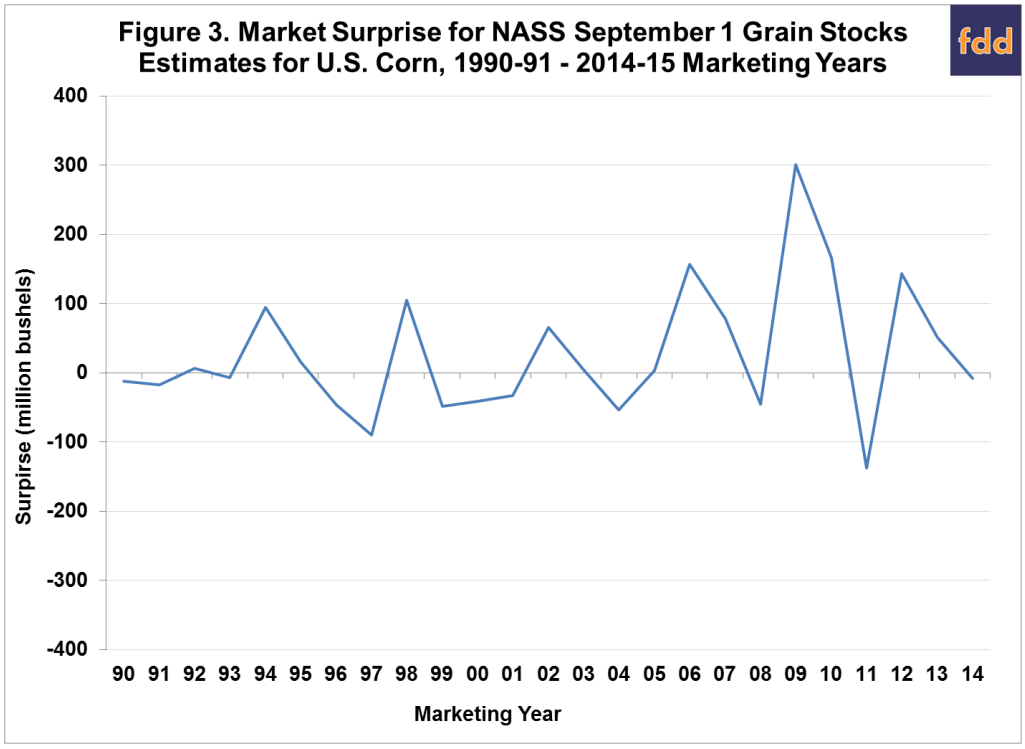
In the 11 stocks reports following the 2012-13 marketing year, the absolute value of the quarterly soybean usage surprise ranged from 0.3 to 10.9 percent, averaged 4.2 percent, and exceeded five percent four times. The pattern of soybean surprises remains similar to that of 2006 -07 to 2012-13.

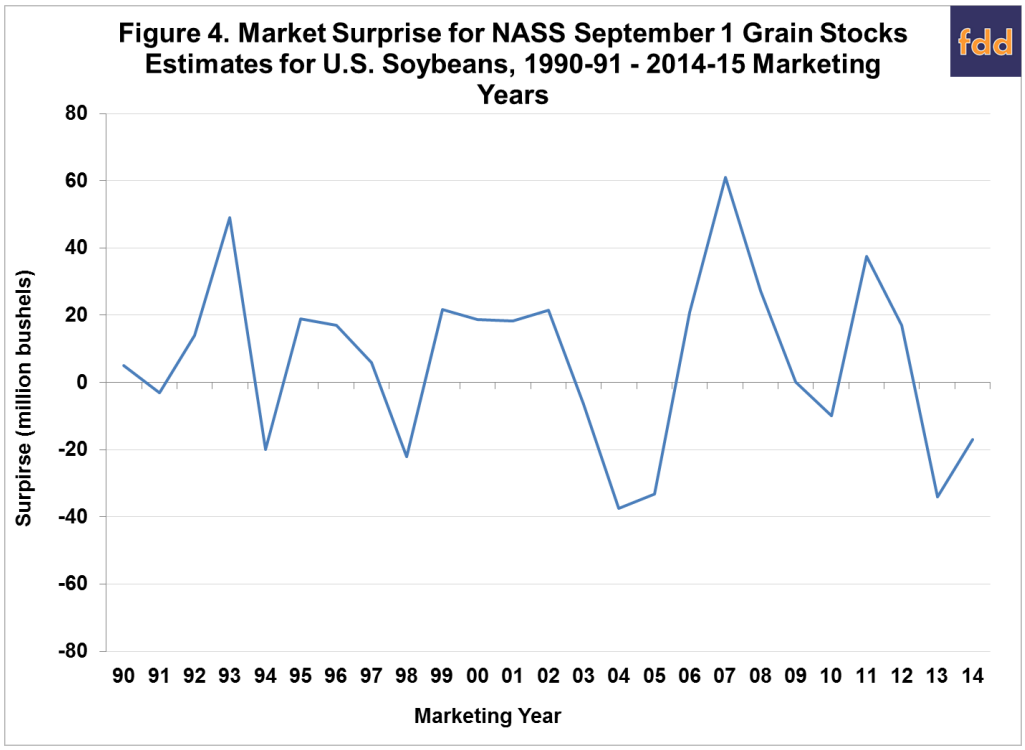
There is one remaining stock estimate (September 1) for the 2015-16 marketing year. As indicated in Figures 3 and 4, there have been some relatively large surprises in the September 1 stocks estimate for both crops (measured in bushels) particularly in recent years. Given the relatively large sampling variability associated with the September 1 on-farm stocks estimate as described earlier, large surprises in the September 1 stocks estimate might be expected more often than for the other three estimates and cannot be ruled out for this year. However, for the entire period starting in 1990-91, the average absolute magnitude of the usage surprise provided by the September 1 corn stocks estimate has not been much different than other quarters (3.1 percent vs. 3.0 to 3.4 percent). In contrast, for soybeans, the average surprise provided by the September stocks estimate (5 percent) has been larger than the average surprise for the other three quarters (3.2 to 3.6 percent).

Implications

A major controversy about USDA grain stocks estimates erupted during the last decade. We found in an earlier study that there had indeed been a sharp decline in analysts' ability to anticipate actual quarterly corn stock estimates over the 2006-07 through 2012-13 marketing year. The availability of data for three more marketing years provides an opportunity to update our previous analysis and determine whether the "problem" with corn stocks estimates has continued or not. Interestingly, usage surprises stemming from USDA's quarterly estimates of corn stocks have been less pronounced since the 2012-13 marketing year. This reinforces our previous conclusion that there was nothing inherently amiss with the USDA's corn stocks estimates and the decline in analysts' ability to anticipate actual quarterly corn stock estimates was most likely explained by unusually large and unresolved sampling errors in USDA corn production estimates, particularly for the 2009, 2010, and 2012 crops. For additional perspective, the pattern of surprises provided by the quarterly soybean stocks estimates has been fairly consistent since 1990-91 and did not change much in the most recent period of 2013-14 through June 1 of the 2015-16 marketing year. For the current marketing year, usage surprises stemming from the December 1, 2015 and March, 1 2016 stocks estimates were quite small, averaging less than one percent for corn and less than two

percent for soybeans (in absolute terms). The usage surprises stemming from the June 1 stocks estimates, however, exceeded six percent for both crops, providing further evidence that the USDA grain stocks estimates can be difficult to anticipate with a high degree of accuracy. The next quarterly stocks estimates will be released on September 30.





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Appendix

To begin, the $Bushel\ Surprise_{m,t}$ for the stock estimate made in quarter m of marketing year t is calculated as:

(1) $Bushel\ Surprise_{m,t} = (NASS\ Estimate_{m,t} - Analyst_{m,t})$

where $NASS\ Estimate_{m,t}$ is the NASS total U.S. stock estimate (on- and off-farm) for marketing year t made in quarter m (December 1, March 1, June 1, and September 1) and $Analyst_{m,t}$ is the average analyst stock estimate for marketing year t made in quarter m. The marketing year in the case of stock estimates is assumed to the standard September-August marketing year. Therefore, the first stock estimate for the marketing year refers to December 1 of the calendar year of harvest and the last refers to September 1 of the calendar year after harvest.

Denominating the market surprises in bushels may not represent the most useful way to examine the magnitude and pattern of market surprises for NASS grain stock estimates. That is because the magnitude of stocks declines seasonally and sharply from December 1 to September 1 so that a surprise of equal bushel size in December and September has very different market implications. In addition, comparing market surprises for corn and soybeans in absolute terms is not meaningful since corn stocks are much larger than soybean stocks. An alternative is to view the analyst errors in percentage terms.

This makes comparisons across quarters and across commodities more meaningful. However, calculating surprises in percentage terms does not provide a completely satisfactory method of normalizing surprises within a context of declining stock levels through the marketing year. That is, in calculating the percent surprise, the divisor gets smaller through the marketing year and even relatively small bushel surprises can create large percentage surprises for September 1 stocks (especially in years with minimal carryout stocks). Additionally, to the best of our knowledge, market analysts do not actually directly estimate stock levels each quarter. Instead, analysts start with the NASS stock estimate for the previous quarter, estimate usage for the current quarter, and then estimate stocks for the current quarter by subtracting estimated usage for the quarter from the sum of the NASS stock estimate for the previous quarter and imports during the current quarter. So the focus of the analysis is on usage for the current quarter, not ending stocks for the quarter. More formally, this approach starts with the following relationship:

(2) $E_t(Stocks_t) = Stocks_{t-1} + E_t(Production_t) - E_t(Domestic_t) + E_t(Imports_t) - E_t(Exports_t)$.

That is, the expectation of stocks for the end of quarter *t* equals the known stocks level at the end of quarter *t-1* plus expected production during quarter *t* less expected domestic usage during the quarter plus expected net trade. The *t* subscript on the expectations operator indicates the expectation is taken at the end of quarter *t*. The use of the expectations operator for current quarter observations reflects reporting lags.

For corn, monthly Census Bureau trade statistics coupled with weekly *Export Inspections* data provide for fairly accurate assessments of trade during the quarter. Domestic usage of corn consists of food use, seed use, industrial use, and feed or residual use. Quarterly seed use is small and relatively consistent from year-to-year so it can be very accurately estimated for the current quarter. Previous to January 2015, ethanol use of corn could be estimated from weekly and monthly estimates of ethanol production provided by the U.S. Energy Information Administration. Starting in February 2015, direct estimates of the use of corn for ethanol and co-product production became available in the monthly Grain Crushings and Co-Product Production report. The estimate of the last month of the quarter, however, is not available at the time the Grain Stocks report is released. Estimates for that final month can be made based on the weekly estimates of ethanol production. Other food and industrial uses of corn are also very stable from year-to-year and quarter-to-quarter and can be fairly accurately estimated. The estimate of feed and residual use contains the most uncertainty as there is no official measure or method to track corn disappearance into animal feeds. Analysts rely on the historical pattern of quarterly feed and residual use and changes in livestock numbers and availability of other grains for feeding in order to form estimates of use during the quarter. The historical pattern includes the well-known tendency of feed and residual use in corn to vary more with the size of the corn crop than is expected based purely on price changes. This leads to a positive correlation between feed and residual use and crop size that is "large." We assume that market analysts are aware of this historical tendency and incorporate it into their expectations of usage and stocks.

For soybeans, the trade also has good data on imports and exports. Soybeans processed domestically were traditionally known from the monthly Census Bureau report on *Oilseed Crushings*. However, that report was terminated after July 2011 so that analysts relied on the crush estimates supplied by the National Oilseed Processors Association (NOPA). Beginning in May 2015, the USDA has provided monthly estimates of the soybean crush in the Fats and Oils: Oilseed Crushings, Production, Consumption and Stocks report. That report is not available for the last month of the quarter at the time the Grain Stocks report is release so estimates for that month are based on NOPA estimates. Unlike corn, soybeans do not have a direct and material use as animal feed. The difference between total use during the quarter and known exports and domestic use is allocated to a feed, seed, and residual category. Use in that category is small and follows a seasonal pattern that allows analysts to anticipate use in that category. As a result, use of soybeans during a quarter is known with more accuracy than the use of corn.

When viewed in this manner, it is clear that analysts' estimates of corn and soybean stocks are really estimates of usage or implied usage during the quarter that ends with the reference date of the NASS *Grain Stocks* report. This can be seen by first defining total usage as:

(3) $E_t(Usage_t) = E_t(Domestic) + E_t(Exports_t) - E_t(Imports_t)$,

Then, substituting (3) into (2), we can write:

(4) $E_t(Stocks_t) = Stocks_{t-1} + E_t(Production_t) - E_t(Usage_t)$.

This shows that given stocks for the previous quarter and estimates for production and total usage one can derive an estimate for ending stocks for the current quarter. Finally, we can use equation (4) to convert the ending stocks estimates reported by market analysts back to total implied usage as follows:

(5) $E_t(Usage_t) = Stocks_{t-1} + E_t(Production_t) - E_t(Stocks_t)$.

We use the term "implied usage" to describe the results of the conversion. For example, the average analyst estimate for the March 1 corn stocks in the 2011-2012 marketing year was 6,151 million bushels. The actual stocks on December 1 were 9,642 million bushels. Production during the December-February quarter was zero so the usage level implied in the average analyst estimate is 3,491 million bushels (9,642 – 6,151) for the quarter. The actual March 1 grain stocks were reported by NASS at 6,009 million bushels for an actual usage of 3,633 (9,642 – 6,009). In this example, the percent surprise for the average market analyst implied usage is 3.9 percent [(3,633-3,491)/3,633]. This compares to the -2.4 percent surprise that is computed using the NASS and average analyst stocks estimates [(6,009-6,151)/6,009]. The sign reversal between the two measures is expected, as bigger stocks imply less implied usage and *vice versa*.

One remaining issue is that for the first quarter (September-November) implied usage, the expected production for corn and soybeans is not zero. To correctly make this adjustment, the average market analyst estimate of production in January is used as the expected production. For example, the implied estimate of usage in the first quarter of the 2011-2012 marketing year (4,007) equals the average market analyst estimate for production (12,280) plus the actual September 1 stocks (1,128) minus the average market analyst estimate for December 1 stocks (9,401). The implied market analyst estimate for corn usage can then be compared to the actual usage (3,844) which equals the actual final production (12,358) plus the actual September 1 stocks (1,128) less the actual December 1 stocks (9,642). In this case, then the market surprise is computed as -4.2 percent [(3,844-4,007)/3,844]. Importantly, the surprise in the analyst's estimates of first quarter usage necessarily comingles uncertainty regarding actual production. For comparison purposes, the surprise in the analyst stocks estimate was 2.5 percent [(9,642-9,401)/9,642].

Using this approach to examining corn and soybean stocks estimates—through implied usage estimates—makes it clear that surprises in anticipating stocks largely reflect analyst surprises in estimating usage. For corn, this is primarily manifest in the estimation of feed and residual usage. From a statistical perspective, surprises measured relative to implied usage are true "apple-to-apples" comparisons, as there are no distortions due to changing stock levels seasonally and across commodities.

We use equation (5) to compute analysts' estimates for implied usage for each quarter in the September-August marketing year and compare to the actual usage implied in the NASS corn and soybeans stocks estimates. The bushel surprise for implied usage is computed as:

(6) $Bushel\ Surprise_{m,t} = Actual\ Implied_{m,t} - Analyst\ Implied_{m,t,}$

where $Actual\ Implied_{m,t}$ is the implied usage for quarter m in marketing year t based on NASS stocks estimates and $Analyst\ Implied_{m,t}$ is the implied usage for quarter m in marketing year t based on the average market analyst stocks estimates. Computing implied usage surprises in percentage form is likely more relevant than computing surprises in bushel form because usage is not equal across marketing years, through the marketing year, or across corn and soybeans. The percent surprise for implied usage is calculated for each quarter m in each marketing year t as follows:

(7) $Percent\ Surprise_{m,t} = 100 \times (Actual\ Implied_{m,t} - Analyst\ Implied_{m,t})/ Actual\ Implied_{m,t,}$

where the variables are as defined previously.