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USDA Corn and Soybean Production Forecasting Procedures Revisited With a Focus on Derived Ear Weights

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The National Agricultural Statistics Service (NASS) is the USDA agency responsible for making crop yield and production forecasts and estimates. NASS released the first forecasts of the size of the 2013 U.S. corn and soybean crops on August 12. New forecasts will be issued on September 12, October 11, and November 8 and the final estimates of yields and production will be released in the second week of January 2014. As has often occurred in the past, the August forecasts were met with criticism from some quarters as those forecasts deviated from expectations of some market participants. The critics of the forecasts of yield and production tend to claim incompetence and/or bias on the part of those responsible for the forecasts. While it is not possible to know the motivation of the critics, some of the criticism appears to stem from a persistent lack of understanding of the NASS forecasting methodology. Such a continued lack of understanding is somewhat exasperating since the USDA and others (including the authors) have provided detailed descriptions of the forecasting methodology. (See here, here, and here). In this post, we briefly review that methodology with a focus on one of the main criticisms related to derived ear weights for the August 12 forecast of the U.S. average corn yield.

It is our experience that many of the misunderstandings of USDA yield forecasts revolve around the fact that the USDA uses two types of surveys to collect data for the monthly NASS production forecasts in August through November. These are referred to as the Agricultural Yield Survey (or the farmer-reported survey) and the Objective Yield Survey (or the field measurement survey). Data for the final estimates released in January are collected in the December Agricultural Survey in which respondents report actual acres harvested and the actual yield or production.

For the August 2013 forecasts, the Agricultural Yield Survey (AYS) included 24,363 operations and was conducted in 41 states for corn and 31 states for soybeans. The sample of farm operations surveyed was drawn from those who responded to the survey of planted acreage in June. The sampling design to select the operations to be surveyed uses multiple control items, such as number and type of commodities planted and desired sample size for each commodity, to determine the probability of selecting a particular operation. The same operations will be interviewed each month from September through November. Most of the survey data are collected in electronic form using computer-assisted telephone interviewing. Each state is expected to achieve a minimum response rate of 80 percent.

In the August survey, respondents were asked to identify the number of acres of corn and soybeans to be harvested and to provide a forecast of the final yield of each of these crops. Harvested acreage responses will be retained from month-to- month and the question will not be asked in subsequent surveys. The AYS, however, does contain a distressed acres sub-survey that targets specific crops in states that have experienced extreme weather conditions in order to measure changes when extreme weather does occur. Respondents will be asked to update yield forecasts in subsequent surveys. Note that respondents are not asked to estimate plant population per acre or fruit weights (e.g., ear weights).

The monthly AYS data are reviewed for consistency with previous surveys for the individual respondents and an across-record review is conducted to identify any extreme values that need to be re-checked. A summary program which accounts for sampling weights and includes an adjustment for non-respondents is used to generate an indication of expected average yield for Agricultural Statistics Districts (regions within states) and for each state surveyed. The yield indications from the survey reflect the judgment of respondents (farmers) and historical relationships indicate that respondents tend to be conservative in estimating final yields (underestimate yield potential) particularly under drought conditions. This tendency is quantified and factored into the official yield forecasts.

The Objective Yield Survey (OYS) is designed to generate yield forecasts based on actual plant counts and measurements, eliminating some of the biases associated with the farmer reported yields. Some have referred to this survey as “ground truthing” the yield estimates reported by farm operators in the AYS. The sample of fields selected for the OYS survey is selected from farms that reported corn (soybeans) planted or to be planted in the June Area Survey of acreage (an enumerative survey is conducted in June as well, but is not used for OYS sample selection). Samples are selected in the 10 (11) principal producing states for corn (soybeans). Records from the June Area Survey are sorted by state, district, county, segment, tract, crop, and field. A random sample of fields is drawn with the probability of selection of any particular field being proportional to the size of the tract. For the August 2013 OYS, a total of 4,504 plots were sampled for corn, soybeans, cotton, and winter wheat.

Two counting areas, or plots, are randomly selected in each field. Objective measurements (such as counts of plants, ears, and pods) are made for each plot each month during the survey cycle. When mature, the plots are harvested and yield is calculated based on actual production minus an allowance for harvest loss. During the August survey, the operator is asked to verify, field-by-field, the acreage reported in June.

For corn, each of the two independently located sample plots consists of two parallel 15 foot sections of row. For soybeans, each plot consists of two parallel 3.5 foot sections of row, portioned into a 3-foot and a 6-inch section. Each plot is selected by using a random number of rows along the edge of the field and a random number of paces into the field.

Enumerators count all fruit and fruiting positions in corn and, if ears have formed, a sample of ears is measured for length and circumference. Just before the field is harvested, both plots are hand harvested and weighed by the enumerator. Four ears are sent to the NASS lab for shelling and measurement of moisture. These data are used to compute gross yield at 15.5 percent moisture. Harvest loss is measured in separate units near the yield plots.

Data collected from each corn plot during the forecast cycle are used to measure size of the unit and to measure or forecast the number of ears, grain weight, and harvest loss. These data include (as available) row width, number of stalks per row, number of stalks with ears or ear shoots per row, number of ears with kernels, kernel row length, ear diameter, ear weight in dent stage, weight of shelled grain, moisture content, total ear weight of harvested unit, lab weight of sample ears, weight of grain from sample ears, and moisture content of shelled grain from sample of mature ears.

At each visit, the enumerator establishes a corn maturity category for the plot, ranging from 1 (no ear shoots) to 7 (mature). Prior to the blister stage, the number of ears is forecast based on the number of stalks, ear shoots, or ears and both the weight per ear and harvest loss are forecast based on the 5-year average. From the blister through the dough stage, the weight per ear is forecast based on kernel row length and harvest loss is forecast based on the past 5- year average. Ear weight is measured in the dent and/or mature stage. Harvest loss is measured following harvest.

Prior to maturity and harvest, the OYS corn yield is forecast based on the forecast of the number of ears,

the forecast of the weight per ear, and the forecast of harvest loss. Forecasts are based on conditions as of the survey date and projected assuming normal weather conditions for the remainder of the growing season. The OYS forecast of gross corn yield then is based on the following formula:

Gross Yield= [number of ears X weight per ear at 15.5% moisture] ÷ 56

Number of ears and ear weight are either forecast or actual and 56 is a conversion from weight to bushels.

The state average gross corn yield for the OYS is the simple average of the gross yields for all the sample fields. In addition, a state yield forecast is also made by first averaging the forecast or actual yield factors (such as stalk counts, ear counts, and ear weight) and then forecasting the state average yield directly from these averages. This forecast is based on a regression analysis of the historical relationship (15 years) between the yield factors and the state average yield.

For soybeans, the plot selection and data selection process for the OYS is the same as described for corn. Data collected from soybean plots (as available) include row width; number of plants in each section of row; number of main stem nodes, lateral branches, dried flowers and pods, and pods with beans in the 6 inch section; weight and moisture content of beans harvested by enumerator; and weight and moisture content of harvest loss.

On each visit, enumerators classify each soybean plot into four maturity categories and these categories are further refined into 10 forecasting categories ranging from no plants present in the 6-inch section to field maturity 5. Forecasting models for each of the forecasting categories are used to forecast the number of plants per 18 square feet and the number of pods with beans per plant for each of the 2 units in the plot using the counts and measurements at each visit. The models are based on the historical relationship between the measured factors and plant and pod numbers. The weight of beans per pod with beans is forecast using a 5-year average, excluding any unusual years.

The forecast of the number of plants per 18 square feet uses the count of plants in the 3.5 feet of row expanded to 18 square feet. The number of pods with beans per plant is forecast using the measurements that are available, which in turn depends on the stage of maturity (five maturity stages are defined). The forecast at each maturity stage is based on the relationship of the measured factors to actual pod counts in the previous 5 years. The bean weight per pod is forecast using the past 5-year average bean weight per pod at 12.5 percent moisture. Forecasts are based on conditions as of the survey date and projected assuming normal weather conditions for the remainder of the growing season. Actual bean weight is used at maturity. The average gross soybean yield in the OYS for each unit is then forecast as follows:

Gross yield = [number of plants per 18 square feet x pods with beans per plant x average bean weight], all converted to bushels per acre.

The two unit level yields are averaged for each plot and plot averages are averaged to obtain an OYS state level yield forecast. A second state level yield forecast is generated in the same manner as described for corn. At maturity, the gross yield is calculated as the number of pods with beans per 18 square feet times bean weight per pod, and then converted to bushels per acre. Harvest loss is estimated using plots near each unit for one quarter of the samples and is used to compute net yield.

The survey and forecasting procedures described above produce a number of indictors of the net yield of corn and soybeans. In August these indicators include: 1) average field level yields from the OYS, average state level counts from the OYS in the Objective Yield states, and the average yield reported by farm operators in the AYS. After harvest begins, yields reported by farmers are also included as an indicator of final yield. Each of the indicators results in a point yield forecast for which forecast errors are computed based on the historical relationships between forecasts and actual yield. The range of yields is evaluated relative to all of the pieces of available data to assist in the selection of the official yield forecast. This process is completed independently for each state and at the national level. A formal Agricultural Statistics Board (ASB) consisting of 7 to 10 statisticians from both the Regional offices and Headquarter divisions is convened to review yield indicators and determine an official yield forecast.

NASS releases an executive summary of each crop report that also contains an estimate of “derived ear

weight" for corn. We have seen numerous attempts over the years to interpret this as the assumed ear weight used by the USDA to compute the monthly yield estimate. Such statements are not strictly correct. As described above, prior to blister stage, 5-year average ear weights are assumed in OYS yield estimates and after blister stage, kernel counts are used to forecast ear weight. So, NASS does use some element of forecasting ear weights when making OYS yield estimates prior to actual harvest. However, there is no analogue available for the AYS yield estimates, where farm operators are only asked to report harvested acreage and yield. This means that the ear weight assumptions or calculations used by respondents to the AYS are not known. The key to a proper understanding of the NASS calculation of "derived" ear weight is to realize it is based on the average population count from the OYS and the 10 state average yield forecast based on **both** the OYS and the AYS. In other words, the derived ear weight is a "hybrid" measure reflecting information from both the OYS and AYS surveys. The population is drawn from the OYS but the average yield is based on both the OYS and AYS surveys. That is why NASS calls the measure "derived" rather than "assumed." There is only one way that the derived ear weight measure reported by NASS can equal the assumed 5-year average ear weights for the OYS: the average ear weight and population used by farm operators in responding to the AYS would have to be exactly the same as the 5-year average weight and population assumed by NASS for the OYS. Obviously, this is highly unlikely to be the case, and hence, one should not equate derived ear weights reported by NASS as the same thing as the 5-year average ear weight used by NASS in one part of the yield estimation process.

Conclusion

This review of the USDA's corn and soybean yield and production forecasting procedures is a reminder of the size and robustness of the survey and forecasting methodology. The methodology is time tested and has no parallel in the private sector. One of the criticisms of the August corn yield forecast this year was that assumptions about ear weight included in the forecast process may have been too conservative, resulting in a forecast that understated actual yield potential. The "too low" ear weight argument may reflect some misunderstanding of the yield forecasting methodology used by NASS, the USDA agency responsible for making the forecasts. In particular, the derived ear weight reported by NASS is a "hybrid" measure reflecting information from both the objective yield survey (OYS) and agricultural yield survey (AYS). Ear weight assumptions or calculations used by farm operator respondents to the AYS are not known and this makes it impossible to "back out" the 5-year average ear weight assumption used by NASS for the OYS side of the yield estimation process. Ironically, given the way the 2013 corn growing season is ending, average ear weights this year may be lower than most expected a month ago.

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