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Examining the U.S. Corn and Soybean Basis at Harvest

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This study examines whether the harvest corn and soybean market price-futures price basis was abnormally weak in 2018 (for example, see Grant, 2019). The concern arose in part because of the steep decline in soybean prices after May 2018, which has been widely attributed to the tariff war with China (Swanson, Coppess, and Schnitkey, 2018). Moreover, a variety of issues related to basis have emerged over the last 10 years, most prominently lack of convergence of futures and cash prices to the same price at futures contract delivery locations during delivery month (Garcia, Irwin, and Smith, 2014; Irwin, Garcia, Good, and Kunda, 2009). Convergence increases the likelihood that changes in futures and cash market prices are similar, which is important for futures markets and the U.S. crop insurance program to be effective risk management tools. Insurance uses futures prices to set the projected and harvest prices that determine insurance payments for many commodities, including corn and soybeans. Insurance assumes the basis remains constant in a given year or, stated alternatively, changes in futures and cash prices are the same. Thus, understanding determinants of the basis and identifying basis irregularities is important for U.S. agriculture.

This article is organized as follows. Calculation of the harvest basis used in this study is described in the next section. The 2018 corn and soybean harvest basis is then discussed in historical perspective. Next, a conceptual explanatory model of harvest basis is developed, followed by discussion of the findings of a regression analysis of the conceptual model. The article ends with a summary, conclusion and implication section.

Calculation of Harvest Basis

Different types of bases can be calculated depending on the economic issue. This analysis uses a temporal basis, which is the difference between prices quoted at the same time for the same product, but the product has two different time dimensions. For example, one price is for immediate delivery in the cash market while the other price is for delivery of the same product at the same location, but 6 month later. A temporal basis is examined because U.S. corn and soybeans must be stored since U.S. harvest is concentrated in a limited time period while use occurs throughout the year. For more discussion of the different types of basis, see Zulauf (2019).

The specific corn and soybean basis examined is a monthly basis for October and November calculated using average market and futures price for October and November and this formula:

(1) (average market price - average July futures price) / average market price

The bases calculated for October and November in a given year are then averaged.

July futures is used because it is the latest, same-month futures contract traded for corn and soybeans within their market year. July futures prices are from Barchart.com. October and November are usually the months in which the majority of U.S. corn and soybeans are harvested and thus typically have the lowest corn and soybean prices of the market year. Since 1974, U.S. price of corn reported by USDA, NASS (U.S. Department of Agriculture, National Agricultural Statistics Service) averaged $2.76 per bushel in both October and November. Next lowest month was December at $2.83. For soybeans, October and November prices averaged $6.94 and $7.05, with December next lowest at $7.12.

A percent ratio is used because, as discussed below, interest rate impacts a temporal basis. Moreover, even if interest rate stays constant, interest cost and thus a temporal basis will change as price level changes. A percent ratio captures this interest cost effect on a temporal basis.

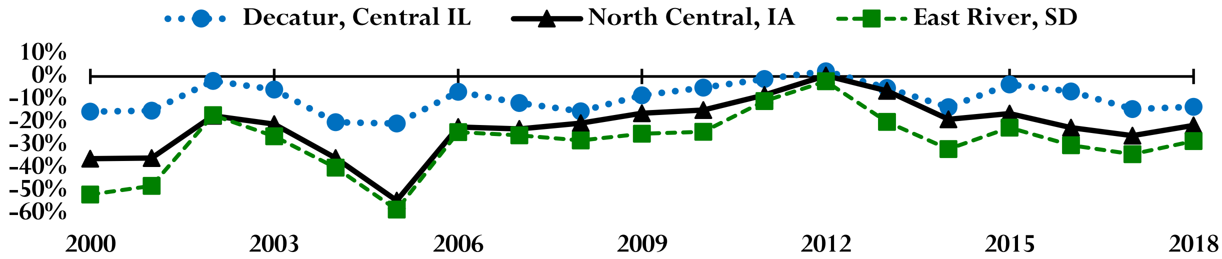
The basis is calculated for four locations. Three are interior U.S. locations tracked daily by USDA, AMS (Agricultural Marketing Service): Decatur, Central Illinois; North Central, Iowa; and East River, South Dakota. Each of these locations is a major corn and soybean production area. AMS describes the data as cash prices paid for truck and rail delivery by mills and processors for Illinois and for truck delivery by country elevators for the other two locations. Grades are U.S. number 2 yellow corn and U.S. number 1 soybeans. Price for each day is the mean of the bid and ask prices reported for that day. Observations start with the 2000 harvest, which is when cash price becomes available electronically for the Iowa and South Dakota locations.

The fourth location is the United States. USDA, NASS reports an average monthly price paid to U.S. farmers by first handlers. NASS measures value of the crop marketed during the month, which is composed not just of cash sales during the month but also forward sales contracted earlier that are delivered during the month. This price series is available for a much longer period of time. This analysis starts with the 1974 market year. Price variability increased after 1973 (Kenyon, Jones, and McGuirk, 1993), in part because the *Agriculture and Consumer Protection Act of 1973* initiated a policy evolution toward greater price flexibility. High fixed price supports that put a floor under market price were gradually replaced by programs that pay farms when market price was less than a Congressionally set target price (Coppess, 2018; Orden, Paarlberg, and Roe, 1999).

Corn Basis – Historical Perspective

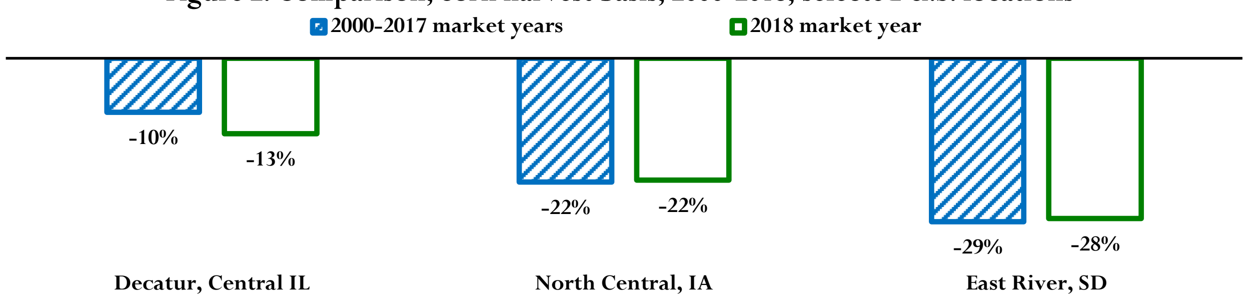
The October-November July futures basis, hereafter called the harvest basis, for corn during the 2018 harvest is well within the range of the corn harvest basis since 2000 at each of the three interior locations (see Figure 1). Almost all of these harvest bases are negative.

Figure 1. Percent corn harvest basis, October-November, 2000-2018, selected U.S. locations



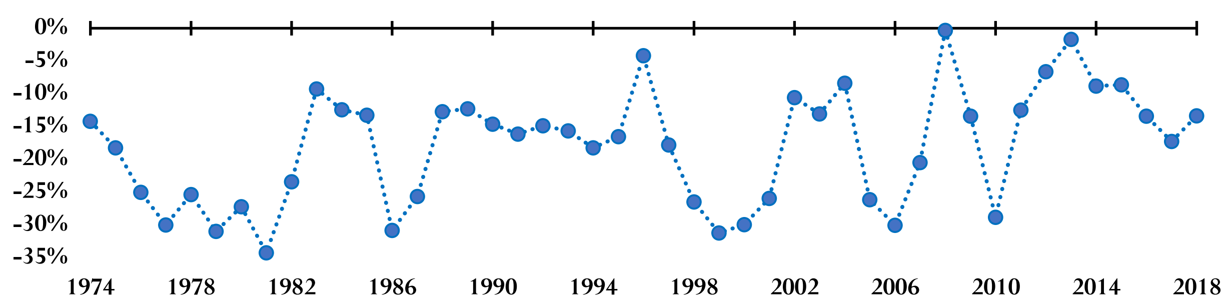
The 2018 harvest basis at Decatur, Central Illinois is slightly weaker than the average basis over 2000-2017 (see Figure 2). A weaker basis means the cash price is further below the futures price; specifically in this case, the basis is more negative. The 2018 corn harvest basis is nearly identical to the average basis since 2000 for North Central, Iowa and East River, South Dakota.

Figure 2. Comparison, corn harvest basis, 2000-2018, selected U.S. locations



Over 1974-2017, the corn harvest basis for the U.S. averaged -18 percent. Range was -34 percent (1981) to 0 percent (2008) (see Figure 1). The 2018 U.S. corn harvest basis was -13 percent, which is stronger (less negative) than average. It was also slightly stronger than the average U.S. corn harvest basis since 2000 of -15 percent.

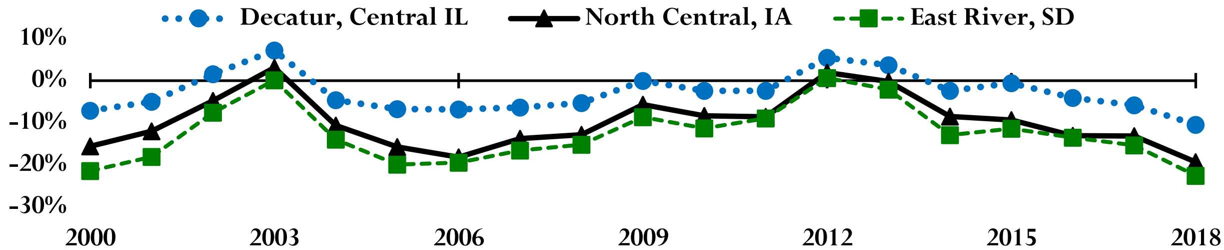
Figure 3. Percent U.S. corn harvest basis, October-November, 1974-2018



Soybean Basis – Historical Perspective

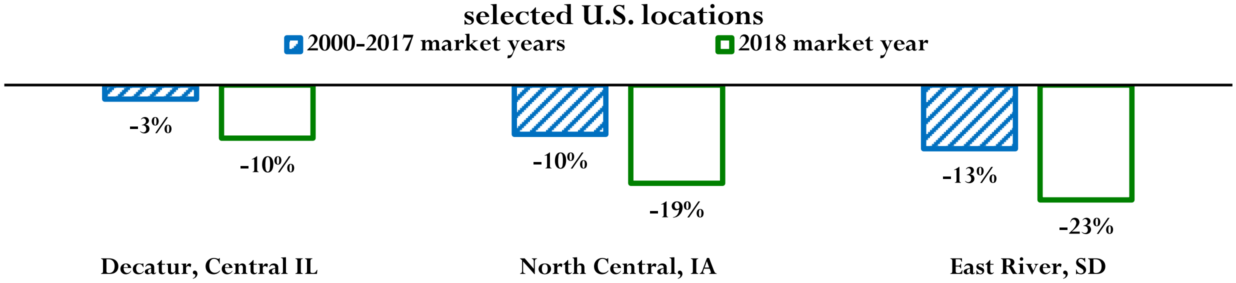
The 2018 soybean harvest basis at the three interior positions is the weakest (most negative) since 2000 (see Figure 4). The 2018 basis vs. next weakest basis is -10 vs. -7 percent (2000, 2005, 2006) for Decatur, Central Illinois; -19 vs. -18 percent (2006) for North Central, Iowa; and -23 vs. -21 percent (2000) for East River, South Dakota. Thus, while the 2018 soybean harvest basis is the weakest since 2000 at the interior locations, they are not notably weaker than the next weakest basis.

Figure 4. Percent soybean basis, October-November, 2000-2018 selected U.S. locations



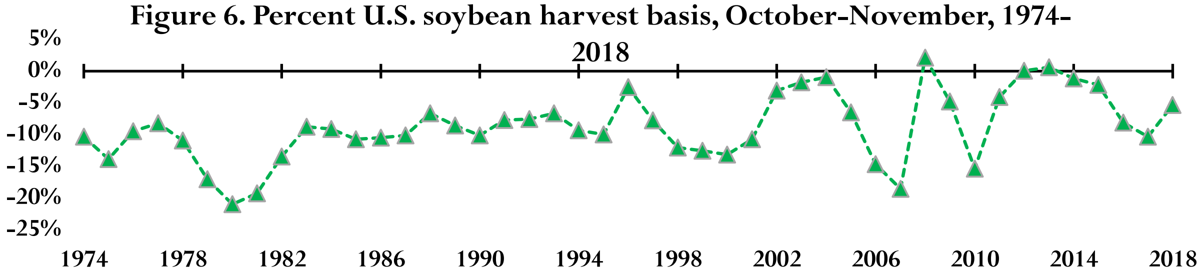
The 2018 soybean harvest basis is notably weaker than the average basis since 2000 at all three interior locations (see Figure 5).

Figure 5. Comparison, soybean harvest basis, 2000-2018, selected U.S. locations



Over 1974-2017, the U.S. soybean harvest basis averaged -9 percent. Range was -21 percent (1980) to +2 percent (2008) (see Figure 6). The 2018 basis of -5 percent is stronger than normal since 1974, and essentially the same as the average U.S. basis of -6 percent over 2000-2017.

Figure 6. Percent U.S. soybean harvest basis, October-November, 1974-2018



The preceding discussion prompts the question, "During the 2018 harvest, how representative was NASS soybean price to the cash soybean price?" As noted earlier, NASS price for a month is a composite of cash sales made during the month and forward contract sales delivered during the month but priced earlier. If forward contracts compose a non-trivial share of the crop marketed during a month and price has declined notably, then the NASS price should exceed the cash price, making the NASS basis stronger than the cash market basis. Forward sales for delivery in October and November are usually priced off the December corn and November soybean futures. Between May and October-November 2018, average monthly November 2018 soybean futures price declined 16 percent ($10.32 to $8.63). This large decline is consistent with the relative weakness in the 2018 soybean harvest basis at the interior locations vs. the basis calculated using the NASS average price for the United States. In contrast, average monthly December 2018 corn futures price declined only four percent ($4.18 to $4.00). This small decline is consistent with the similarities in the interior and U.S. 2018 harvest bases with their respective historical values.

Explaining Corn and Soybean Harvest Basis: Conceptual Model

To explore further the 2018 corn and soybean harvest basis, existing literature is used to develop an explanatory model of harvest basis. The model is then examined empirically.

Working (1949) is credited with showing that the price spread between futures contracts of a crop is related to its level of stocks. Specifically, more stocks are associated with a greater spread. By extension, a crop's temporal basis should be related to stocks; and, as quantity of stocks increase, the basis should be weaker (immediate market price is lower relative to more distant futures price). It is now more common to express stocks as a ratio to use. The reason is that, other variables the same, stocks need to increase as

Explanatory Variables, An Example

(Values during the 2018 harvest period are used to illustrate their measurement and interpretation.)

Stocks-to-Use of a Crop: The October 2018 and November 2018 *WASDEs* reported 0.44 billion bushels of U.S. soybeans carried from the 2017 market year on September 1, 2018 (beginning of a new soybean market year). The October 2018 *WASDE* estimated that domestic U.S. use plus U.S. exports of soybeans would total 4.27 billion bushels during the 2018 market year. The November 2018 *WASDE* reduced estimated total use to 4.11 billion bushels. The carryover stocks-to-use ratio for the 2018 market year is thus 10.3 percent in the October 2018 *WASDE* (0.44/4.27) and 10.7 percent in the November 2018 *WASDE* (0.44/4.11). Average carryover stocks-to-use ratio of 10.5 percent ((10.3% + 10.7%) / 2) is used in the analysis. This ratio means that stocks of U.S. located soybeans brought into the 2018 market year from the 2017 market year are large enough to supply 10.5 percent of U.S. projected use during the 2018 market year. The rest of 2018 U.S. use is supplied by 2018 U.S. production of soybeans and by imports of soybeans into the U.S. during the 2018 market year.

Storage Cost – Interest Rate: Opportunity cost of selling at harvest is the only component of storage cost included in this study. Selling at harvest provides immediate cash flow that can be invested or used to pay off loans. This study assumes that the rate of return on funds generated by selling at harvest is the interest rate on the 6-month U.S. Treasury bill. The secondary market six-month U.S. Treasury bill rate from FRED (Federal Reserve Economic Data website) averaged 2.5 percent during both October and November 2018 used here.

Relative Supply and Demand for Storage Bin Space: The December 2018 grain stocks report, released in February 2019 by USDA, NASS; reported that 24.99 billion bushels of storage bin capacity was divided between 13.52 billion bushels on farms and 11.47 billion bushels off-farms. It would be desirable to have stocks of all commodities that can be stored in this bin space as the measure of demand for this storage capacity, but stocks are consistently available only for barley, corn, oats, sorghum, soybeans, and wheat over the analysis period that started with the 1990 harvest. As of December 1, 2018, combined stocks of these six crops was reported as 18.25 billion bushels, divided between 10.12 billion bushels on farms and 8.13 billion bushels off-farm. Supply and demand for off-farm storage capacity is the explanatory variable used in this analysis. The ratio of off-farm stocks to off-farm storage capacity is 70.9 percent (8.13 / 11.47). Thus, on December 1, 2018; combined stocks of barley, corn, oats, sorghum, soybeans, and wheat filled 70.9 percent of grain and oilseed storage bin space located off-farm as enumerated by USDA, NASS. The ratio of 70.9 percent is used in this analysis.

use increases since stocks allow a harvest that occurs over a limited time to satisfy continuous consumption (Routledge, Seppi, and Spatt, 2000).

The need to store stocks to meet continuous demand means cost of storage is expected to impact temporal basis. Higher storage cost should mean a weaker basis to pay for the higher cost, assuming other variables remain the same. Storage cost for grain include insurance against physical loss, opportunity cost of selling in the cash market, and physical storage cost to keep the grain in usable condition. Due to its small size for grains and oilseeds, insurance is often not included, a practice adopted in this study. Studies not including insurance span from Telser (1958) to more recent studies, such as Siaplay, Adam, Brorsen, and Anderson (2012).

A third variable identified in studies is the relative demand and supply for bin space in which the crop can be stored. This variable is not just for the crop of interest but for all crops that can be stored in the same bin space (Paul, 1970;' Frechette, 1997). Higher the demand for storage relative to supply of available storage bin space, the higher should be return to storage, assuming other variables remain the same. Thus, the temporal basis should be weaker.

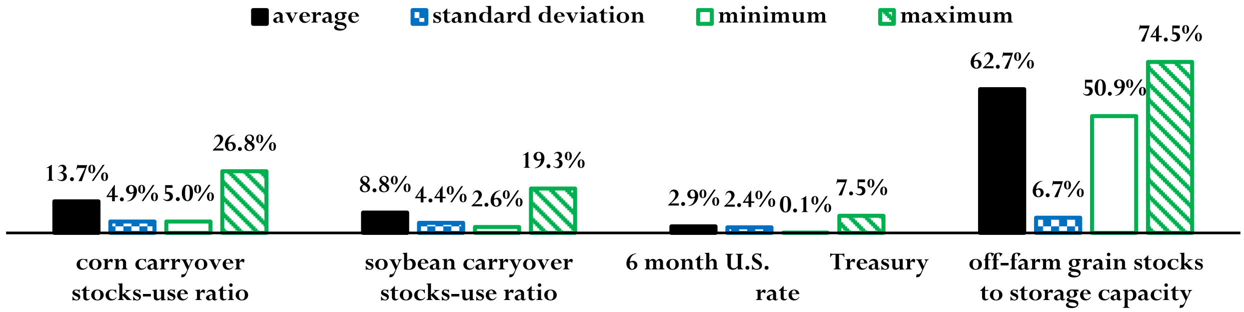
Explaining Corn and Soybean Harvest Basis: Data

The desired data are market expectation of a variable at the time price is determined. Economists call this contemporaneous or synchronous data. However, such data is not always obtainable.

Given differences found for the 2018 soybean harvest basis between U.S. price and price at the three interior location, it would be desirable to estimate the explanatory equation for soybeans for the U.S. and the three interior locations. However, information on stocks and storage bin capacity of soybeans (and corn) is not available for any of the locations. Not including this omitted and statistically significant variable would result in a misspecified and thus potentially misleading equation. Therefore, the equation is estimated only for the U.S. harvest basis.

Stock-to-use ratio for corn and soybeans is measured as stocks carried into a market year divided by expected use during the market year. Corn and soybean market year begins September 1. Both variables are reported in the *World Agricultural Supply and Demand Estimates*. *WASDE* is a widely-followed, publically available report issued each month by USDA's Office of the Chief Economist. It dates to 1973. October and November *WASDE* reports are contemporaneous with October and November prices. The ratios calculated for October and November are averaged. Over 1990-2017, carryover corn stocks-to-use ratio averaged 14 percent, ranging from 5 percent (1996) to 27 percent (1993) (see Figure 7). The comparable ratios for soybeans are smaller at 9, 3 (2014), and 19 percent (2007), respectively. A smaller ratio means stocks carried into the year provide a smaller share of that year's use and thus that year's production is a more important determinant of use during the year.

Figure 7. Explanatory variables, statistics, 1990-2017 harvest basis, U.S.



In the context of this study, deciding to store means foregoing the opportunity to use the cash receipts from selling at harvest. Opportunity cost of storage will vary by storer, depending on the return on the alternative investment or the interest rate on a loan paid off. This study uses the average secondary market six-month U.S. Treasury bill rate for October and November. Six months is the Treasury bill maturity length closest to the nine- and eight-month periods from October and November to July. Source is FRED (Federal Reserve Economic Data) maintained by the Federal Reserve Bank of St. Louis. The 6-month Treasury bill rate averaged 2.9 percent over 1990-2017, ranging from 0.05 percent in 2011 to 7.5 percent in 1990 (see Figure 6).

Physical storage cost is commonly measured as a monthly storage fee charged by first handlers, often elevators (see, for example, Kastens and Dhuyvetter, 1999; Siaplay, Adam, Brorsen, and Anderson, 2012, and Zulauf, Zhou, and Roberts, 2006). However, the fee charged by first handlers is in part determined by supply and demand for storage space and is thus determined simultaneously with basis. Moreover, the measure of physical storage fee used in this analysis was not statistically significant and not including it did not materially impact the regression equation. Given the simultaneity issue and lack of statistical significance, it was decided not to include physical storage fee in the model. Data Note 1 has more discussion of this decision.

Contemporaneous data for supply and demand of storage bin space is the market's expectation of these variables during October and November. Total stocks expected to be stored after harvest is a measure of demand for storage bin space while available bin space is a measure of supply. USDA, NASS issues *Grains Stock* reports for stocks as of March 1, June 1, September 1, and December 1. The December report is closest to the corn and soybean harvest period and also contains storage bin capacity. Expectations data on December 1 stocks are compiled, but not until approximately a week before the December *Grains Stocks* report is released in January. In short, expectations data are not available for grain stocks or storage bin space during October and November. The analysis therefore uses the grain stock and storage bin capacity data reported in the December *Grain Stocks* report as contained in USDA, NASS's *QuickStats* website.

It would be desirable to have stocks of all commodities that can be stored in a given storage bin. However, stocks are consistently available only for barley, corn, oats, sorghum, soybeans, and wheat starting with December 1, 1990 (see Data Note 2). Stocks of these crops are summed, then divided by the storage bin capacity reported in the same December report. This ratio is this study's measure of the relative relationship between demand and supply for storage bin space.

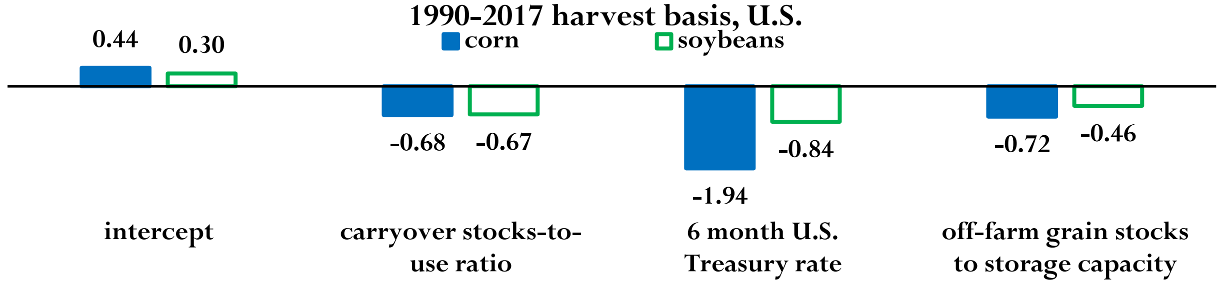
Storage bin capacity and stocks are reported by on-farm and off-farm location. NASS and AMS prices are offers of first handlers. First handlers often have to bid more for stocks held on-farm since farmers incur costs to move grain off-farm (see Kastens and Dhuyvetter, pages 487-488 (1999) for more discussion of this issue) and since selling means giving up the valuable option to sell on-farm stocks to other, potentially higher-priced buyers. Thus, off-farm stocks and storage capacity are used initially. Data Note 3 has more information about the stock and storage capacity data. Data Note 4 has further discussion of the decision to use off-farm stocks.

Ratio of the sum of off-farm stocks of barley, corn, oats, sorghum, soybeans, and wheat to off-farm storage capacity averaged 63 percent on December 1 over the 1990-2017 analysis period. Range was 51 percent in 1996 to 74 percent in 2017 (see Figure 6).

Explaining Corn and Soybean Harvest Basis: Empirical Analysis

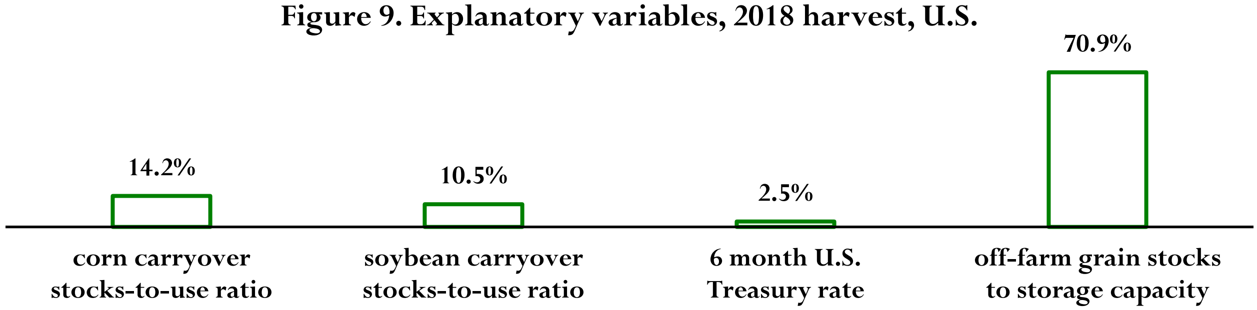
The estimated regression coefficients are all significant with 99 percent statistical confidence except for interest rate in the soybean equation (see Data Note 5). It is significant with 97 percent statistical confidence. As a group, the variables explain 63 and 66 percent of the year-to-year variation in U.S. corn and soybean harvest basis, respectively. The coefficient of each explanatory variable has a negative sign (see Figure 8). A negative sign implies that an increase in the explanatory variable is associated with the corn or soybean harvest basis becoming more negative or weaker, assuming other variables remain the same.

Figure 8. Regression coefficients, explanatory variables, 1990-2017 harvest basis, U.S.



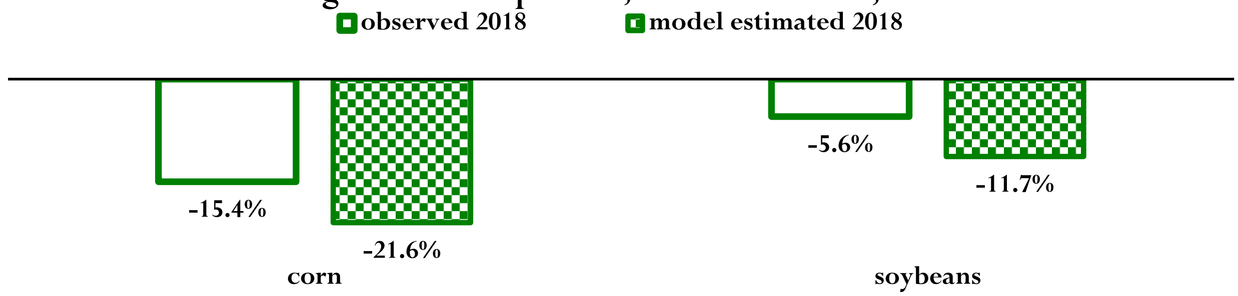
The regression equation is estimated over 1990-2017, not 1990-2018, so an out-of-sample estimate of the 2018 U.S. harvest basis can be made. Values of the explanatory variables during the 2018 harvest period (see Figure 9) are multiplied by the estimated regression coefficients (see Figure 8), then summed to derive a model estimated U.S. basis during the 2018 harvest.

Figure 9. Explanatory variables, 2018 harvest, U.S.



The model-estimated 2018 U.S. corn and soybean harvest basis is weaker than the observed 2018 harvest basis (see Figure 10). This finding suggests the 2018 harvest basis is stronger than the expected value based on 2018 harvest values of the explanatory variables and the 2000-2017 historical relationship between the explanatory variables and harvest basis. This finding is also not consistent with the concern that the 2018 harvest basis was abnormally weak.

Figure 10. Comparison, 2018 havest basis, U.S.



Last, due to the intense focus on the tariff war with China and its impact on U.S. agriculture, it is useful to keep in perspective the changes over the 2018 growing season in 2018 market year carryover stocks from the 2017 market year, as well as 2018 market year exports and total use. The May 2018 *WASDE* was the first to report estimates for the 2018 market year. Comparing the average of the October-November *WASDEs* with the May *WASDE*, 2018 carryover stocks of corn from the 2017 market year declined by 42 million bushels while projected 2018 market year use of corn increased by 528 million bushels. Primary cause for the increase in use of corn was a reduction in corn production in South America and a resulting increase in U.S. corn exports. Projected U.S. corn exports for the 2018 market year increased by 363 million bushels between the May and October-November 2018 *WASDEs*. Carryover stocks of soybeans from the 2017 market year decreased by 92 million bushels while projected 2018 market year use of soybeans decreased by 233 million bushels. China accelerated imports of U.S. soybeans ahead of the increase in tariffs but reduced imports of U.S. soybeans after the tariffs went into effect, resulting in an initial increase in demand but a longer term decline in demand. Projected exports of U.S. soybeans in the 2018 market year decreased by 310 million bushels between the May 2018 *WASDE* and the October-November 2018 *WASDEs*.

Summary, Conclusions, and Implications

This paper examines whether the corn and soybean basis was abnormally weak during the 2018 harvest. The basis was measured using July Chicago futures price; market price for the United States reported by USDA, NASS; and cash price reported by USDA, AMS for Decatur, Central Illinois; North Central, Iowa; and East River, South Dakota. Prices were for October and November, peak harvest months of U.S. corn and soybeans.

The 2018 corn harvest bases for the United States and the three interior locations are well-within historic ranges. Moreover, the 2018 U.S. corn harvest basis is stronger than the basis derived for 2018 from the estimated regression relationship over 1990-2017 between U.S. corn harvest basis and harvest values of the statistically significant explanatory variables: ratio of corn carryover stocks-to-use, six-month U.S. Treasury bill interest rate, and ratio of grain stocks to storage capacity.

Like corn, the U.S. 2018 soybean harvest basis is well within historic ranges and is stronger than the basis estimated using the explanatory model. Unlike corn, the 2018 soybean harvest basis at the three interior positions is the weakest since 2000 or start of the analytical period for this component of the analysis. However, it is the weakest basis by only 3, 2, and 1 percent, respectively, for Decatur, Central Illinois; East River, South Dakota; and North Central, Iowa. Nevertheless, weakness in the 2018 soybean harvest cash market basis coincides with the tariff war with China and its impact on U.S. exports and total use. This coincidence bears watching going forward and underpins concern that the cash market basis may remain under pressure until the tariff war with China is resolved.

A potential explanation for the weakness in the 2018 soybean harvest basis at interior locations but not for the United States is that NASS monthly prices comingle cash and forward sales. The objective of the NASS survey is to measure the price farmers receive for grain marketed during a month, not the cash price during the month. The greater the decline in price over the growing season, the greater can be the difference between cash market price and NASS price for a month. Consistent with this argument, the average monthly November 2018 soybean futures price declined 16 percent from May 2018 to October-November 2018. In comparison, average monthly December 2018 corn futures price declined only 4 percent. This small decline in corn price is consistent with the observed similarities in 2018 corn harvest basis for the United States and the three interior locations relative to their respective historical values.

In summary, this analysis finds no consistent evidence that the 2018 corn basis was abnormally weak at harvest. For soybeans, some evidence is found for a weak basis at harvest in 2018. The evidence is not conclusive, but does suggest the soybean basis during harvest bears further monitoring during the upcoming 2019 and subsequent harvests. Moreover, this analysis leads to two recommendations related to information reported by USDA:

- Include share of storage bin capacity that is being used in the NASS quarterly stock reports.
- Differentiate prices by forward contract sales and cash market sales in NASS price reports.

Each proposal needs to pass a cost-benefit test, but each proposal would improve the ability to track and understand U.S. farm prices and bases and thus to better track and understand the risk management performance of futures markets and the U.S. crop insurance program.

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Data Notes

(1) To cross check the decision not to include physical storage cost as an explanatory variable, a measure of physical storage rate was found to be not statistically significant in explaining U.S. harvest basis even at 90 percent, the lowest commonly-used confidence level in economic studies. Including it also had little impact on the coefficients of the three explanatory variables. Source of physical storage cost was USDA, CCC (Commodity Credit Corporation) through the 2005 market year. CCC then changed its methods. Rates of 35 cents per bushel for corn and soybeans in 2005 jumped to 87.5 cents for corn and 85 cents for soybeans in 2006. Two Ohio grain elevators were checked and quoted 48 cents for both crops. Thus, beginning with the 2006 market year, physical storage cost is from an Ohio country elevator, cross checked with another Ohio country elevator. Expressed as a percent of harvest price, physical storage cost for corn averaged 13.1 percent, with a range of 7.6 percent (2012) to 17.1 percent (1999). Soybean cost averaged 5.1 percent, with a range of 3.7 percent (2012) to 7.1 percent (2001).

(2) For other crops, stocks are available for some year. For example, the December 2018 *Grain Stocks* report contains stocks for sunflowers, mustard seed, safflower, flaxseed, rye, canola, rapeseed, dry edible peas, lentils, large and small chickpeas, and Austrian winter peas.

(3) From the December 2018 *Grain Stocks* report, pages 30-33: "on-farm grain storage capacity includes all bins, cribs, sheds, and other structures located on farms that are normally used to store whole grains, oilseeds, or pulse crops…."Off-farm grain storage capacity includes all elevators, warehouses, terminals, merchant mills, other storage, and oilseed crushers which store whole grains, soybeans, canola, flaxseed, mustard seed, safflower, sunflower, rapeseed, Austrian winter peas, dry edible peas, lentils, and chickpeas/garbanzo beans. "Capacity data exclude facilities used to store only rice or peanuts, oilseed crushers processing only cottonseed or peanuts, tobacco warehouses, seed warehouses, and storage facilities that handle only dry edible beans, other than chickpeas/garbanzo beans…."Separate surveys are conducted to obtain the on-farm and off-farm estimates. The on-farm stocks survey is a probability survey that includes a sample of approximately 82,000 farm operators selected from a list of producers that ensures all operations in the United States have a chance to be selected. These producers are asked to provide the total quantities of grain stored on their operations as of December 1, 2018. This includes all whole grains and oilseeds stored whether for feed, seed, or sale as well as any stored under a government program. The off-farm stocks survey is an enumeration of all known commercial grain storage facilities."

(4) To provide empirical perspective on the decision to use off-farm stocks and storage bin space, the ratio of on-farm stocks to storage bin capacity was added to the equation. The on-farm ratio was statistically insignificant with a t-value of 0.49 in the corn equation and 0.69 in the soybean equation. These are well below any t-value commonly used for statistical significance. Including the on-farm ratio did not impact statistical significance of the off-farm ratio. Substituting off-farm plus on-farm data for off-farm data in the equation reduced R^2 explanatory power from 63 to 56 percent for the corn equation and from 66 to 58 percent for the soybean equation. In summary, findings of the empirical sensitivity analysis were consistent with the initial decision to use only off-farm stocks and storage bin space.

(5) For time series regression analysis to be free from what is called "spurious regression phenomenon," the dependent variable should be stationary. Stationarity is a complex concept but a simple description is

that no trend occurs in the level or variability of the variable (for example, values do not consistently increase over time). A commonly-used test for stationarity is the Dickey-Fuller test. It finds that both the corn and soybean harvest basis are stationary.

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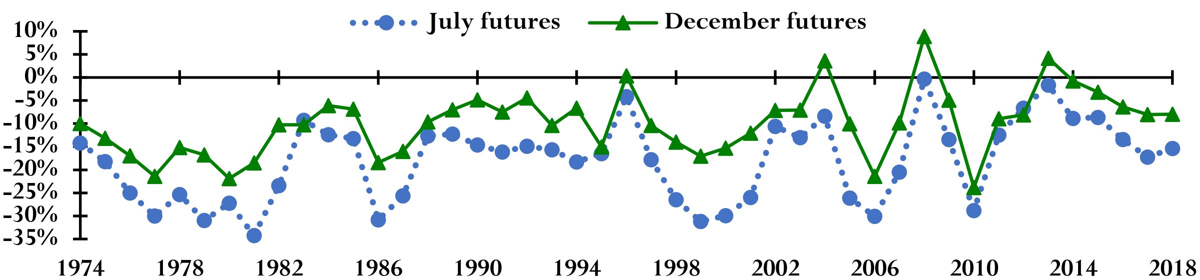
Appendix: Corn and Soybean Harvest Basis Using December and November Futures

It is probably more common to think of the harvest basis for corn and soybeans as the basis using the December corn futures and November soybean futures rather than the July futures. The same descriptive story emerges regardless of which futures contract is used. Whether using the December or July futures, the 2018 corn harvest basis for the United States and for the three interior locations are well within their historical ranges. The same is found for the U.S. soybean harvest basis. For both the November and July futures, the 2018 soybean harvest basis at the three interior locations is the weakest over the available observations since 2000 but the next weakest basis is close in magnitude. The basis is almost always less negative for the December and November futures than for the July futures. This relationship reflects the need to store corn and soybeans until July. While the spread between the December/November and July futures price, or the difference between the two bases, is not constant from year to year, it tends to follow the cost of storage between the December/November and July futures contracts. Appendix Figures 1 and 2 illustrate the similarity in the findings for the U.S. corn and soybean harvest basis.

Explanatory power of the explanatory variables for the December/November bases is much lower than for the July bases. R^2 is 32 percent for the December U.S. corn basis and 19 percent for the November U.S. soybean basis. Carryover stocks-to-use is the only variable significant with 95 percent statistical confidence. The decline in R^2 was expected. The November/December harvest basis is expected to be more affected by near term supply and demand factors for storage bin space, such as harvest progress and transportation availability and bottlenecks. The July basis reflects the moderating impact of being able to adjust storage and use over a longer time period.

Appendix Figure 1. Percent U.S. corn harvest basis, July vs. December futures, October-November, 1974-2018



Appendix Figure 2. Percent U.S. soybean harvest basis, July vs. November futures, October-November, 1974-2018