MEASURING GRAIN MARKET PRICE RISK

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Grain Market Risk

Grain production involves considerable risk, which can include input costs, weather conditions, and yield, among others. However, one of the most significant sources of risk, and the one that ultimately affects production decisions is selling price. The purpose of this fact sheet is to develop a way to measure the magnitude of grain price risk over time. Grain option market traders bid price uncertainty into the prices of options on grain futures in the form of implied volatility. Implied volatility serves as a forecast of the price risk producers face in the grain market. We summarize how price risk in the grain market is measured by the implied volatility from options and we detail how volatility has changed over time.

Implied Volatility

Measuring the expected futures market price risk (in this case—grain futures) can be done by calculating implied volatility. Implied volatility, or IV, is a measure of the expected future price risk for a futures contract that option traders price into option premiums. Option premiums, *ceteris paribus*, are driven by market price risk; greater risk in the price of the underlying asset implies higher option premiums. In this way, options and option premiums function quite like insurance products.

To derive the volatility from option market traded premiums, several option pricing formulas can be used. To calculate forward looking market implied volatility, this fact sheet uses the Black-Scholes option pricing model. This pricing model uses five parameters to price an option: 1) current underlying price (corn, soybean, and soft red winter wheat futures prices in this instance), 2) option strike price, 3) time until option expiration, 4) risk-free interest rate, and 5) implied volatility. Volatility is the only variable in the Black-Scholes equation that cannot be directly observed in the market, and must be derived from the model. In actuality, option prices are discovered through supply and demand factors in the option market. So, with option premiums already known, the pricing model can be solved backwards to determine the expected future volatility that is being priced into option market premiums. This implied volatility is generally quoted as an annualized percentage variation in price.

Options can be used to calibrate future volatility because market participants actively incorporate knowledge of past price movements and all other relevant market information into the price of the options. Considering that options derive their value from underlying futures contracts, and the underlying futures contracts derive their value from underlying cash prices, information regarding cash price volatility is incorporated into discovered option prices,

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or premiums. This means implied volatilities obtained from options on futures provide a reasonable, market-based estimation of future price volatility for both a cash commodity and its derivatives.

Collecting Implied Volatility Data

IVs were collected starting with the first trading day of 2003 and for all CME contract months of corn, soybeans, and Chicago soft red winter wheat. The IVs were collected from Bloomberg, except for time periods of missing data, in which case Commodity Research Bureau (CRB) PowerGen software was used to fill in the missing IV information. While hard red winter wheat (corresponding to the Kansas City contract) is the predominate class of wheat grown in the United States, the hard red winter wheat options market is thinly traded relative to the Chicago soft red winter contract. Consequently, IVs were obtained from the Chicago contract, as they provide a more reliable indicator of volatility present in the wheat complex.

Implied volatilities of a commodity are calculated by Bloomberg for both call and put options. Call option IVs are calculated from a weighted average of the volatilities of the two call options closest to the at-the-money strike price. Put option IVs are calculated in a similar fashion, but using the two put options closest to the at-the-money strike price. IVs are derived from at-the-money options because this is where most trade volume occurs. This fact sheet uses an average of the call and put option implied volatilities to calculate a single, daily implied volatility. In instances where either a call or put IV was missing from the data, the IV present was used instead of an average.

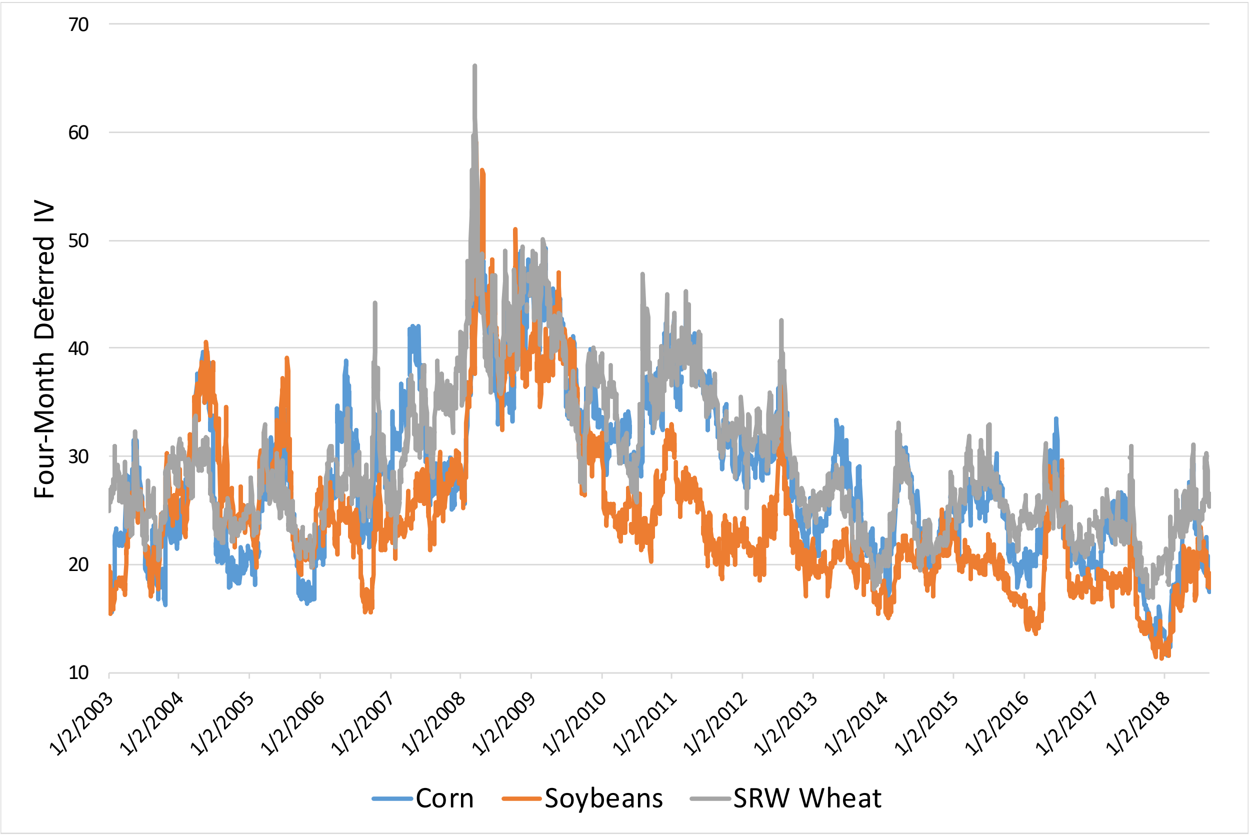
Daily implied volatilities can be calculated for each contract month, assuming there is volume trading in the option market. In this fact sheet we compute daily implied volatilities for a four-month deferred contract. For instance, the corn IV calculated for March 1, 2018 would be the implied volatility of the July 2018 Corn contract on March 1, 2018. We use a four-month deferred measure instead of a nearby so the IV represents volatility into the future, as opposed to volatility in a front month that is nearing expiration and may exhibit erratic changes as positions are being offset or rolled forward. Also, it is not always possible to calculate an IV for an exact four-month deferred contract. For instance, corn trading in February would require an IV corresponding to a June Corn contract, which does not exist. In these instances, the implied volatility values were determined by counting forward four months and using the next succeeding contract. For example, the previously mentioned corn trading in February would have IV values corresponding to the July Corn contract.

To illustrate changes in volatility over time, each implied volatility is converted to an index by calculating it as a percentage of the IV at the beginning of our data set. By anchoring all implied volatilities around a single base day, the change in volatility and magnitude of that change relative to the base can be determined. The data for this fact sheet begins with January 2, 2003 set as the base (index=100%) and corn, soybean, and Chicago soft red winter (SRW) wheat IVs being collected through August 20, 2018.

Findings

Figure 1 below depicts the four-month deferred implied volatilities for corn, soybeans, and soft red winter wheat. The first thing to notice is that, for the most part, implied volatilities of the three grains move together. This can be attributed to major economic, geopolitical, and weather events that have profound effects across many asset classes. Each grain experienced elevated volatility during the turbulent economic times of 2008-2009 and then again through the era of high commodity prices until around 2013. Volatility across the grain complex has since fallen to levels on par with that of the early 2000s. The correlation between corn and soybean IV is 0.786, between corn and wheat is 0.868, and between soybeans and wheat is 0.743. Wheat and corn IVs are generally greater than soybeans, averaging about 28-29% compared to 24% for soybeans. Corn IV varies the most with standard deviation of 7.5%. Soybean and wheat IV standard deviations are 7.2% and 7.1%, respectively. While highly correlated, implied volatilities follow unique paths across the grain complex over time.

Figure 1. Daily Four-Month Deferred Corn, Soybean, and SRW Wheat Implied Volatilities: January 2, 2003 — August 20, 2018



Graphing indexed data allows us to see how volatility in the grain markets has changed over the last 15 years. Figure 2 shows the deferred IVs for corn as a percentage of January 2, 2003. Figures 3 and 4 depict the same volatility measure but for soybeans and Chicago SRW wheat, respectively.

Corn IV demonstrates substantial variation over time with a marked seasonal pattern where it often increases notably during the summer growing and pollination period when production risk is greatest. While certainly having seasonal variations of their own, soybeans and wheat do not exhibit the same distinct seasonal trend. The volatilities of all three grains spiked to record levels at 2.5 to 3 times their 2003 levels in 2008 during the major commodity price increases experienced across these markets, which was associated with numerous global demand and supply factors including the rapid corn ethanol market expansion. IVs have since settled down to more "normal" seasonal variation. At time of writing, the United States has had major international trade disputes, particularly with China. This can be seen in the indexed IV graphs, as volatility has noticeably increased across the grain space since around February 2018, when China launched an anti-dumping probe into U.S. grain sorghum presumably in retaliation against tariffs imposed by the Trump administration.

Figure 2. Index of Daily Four-Month Deferred Corn Futures Implied Volatility as a Percentage of January 2, 2003 Base: January 2, 2003 — August 20, 2018

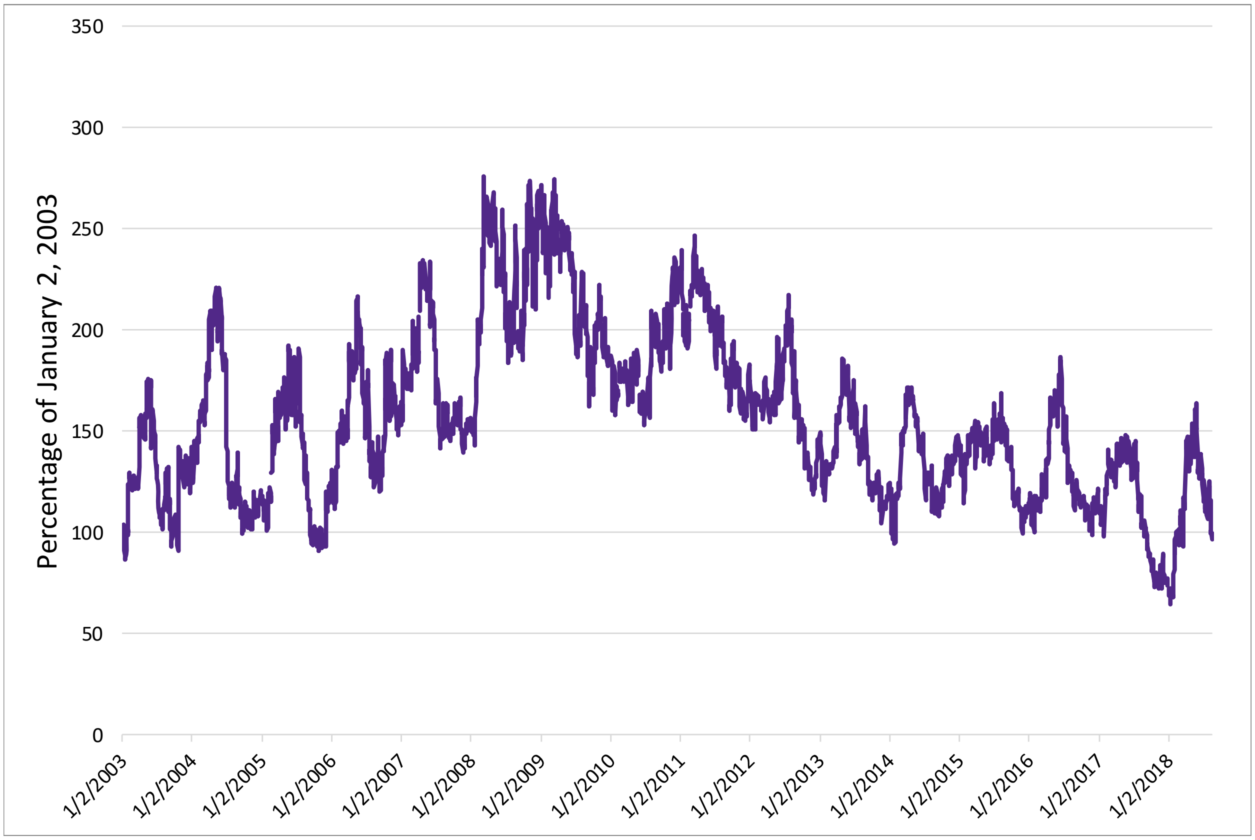
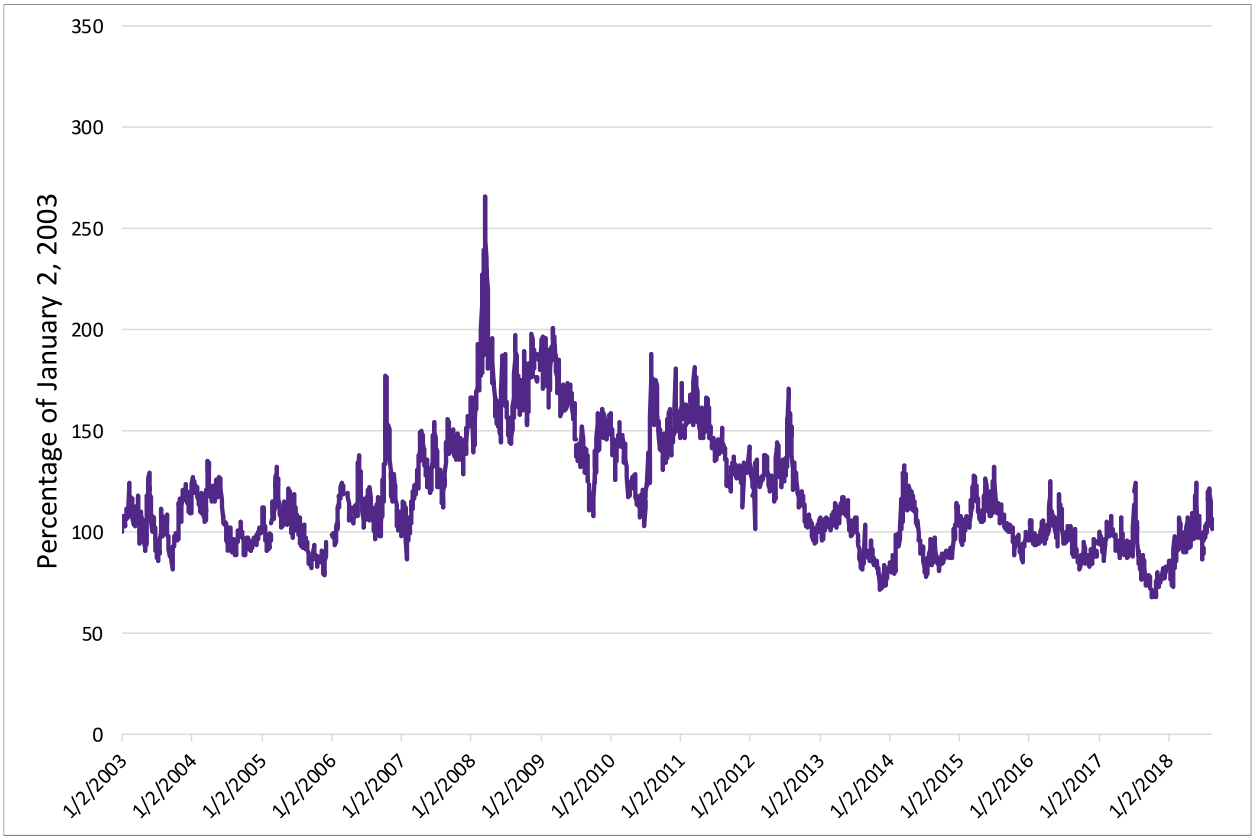


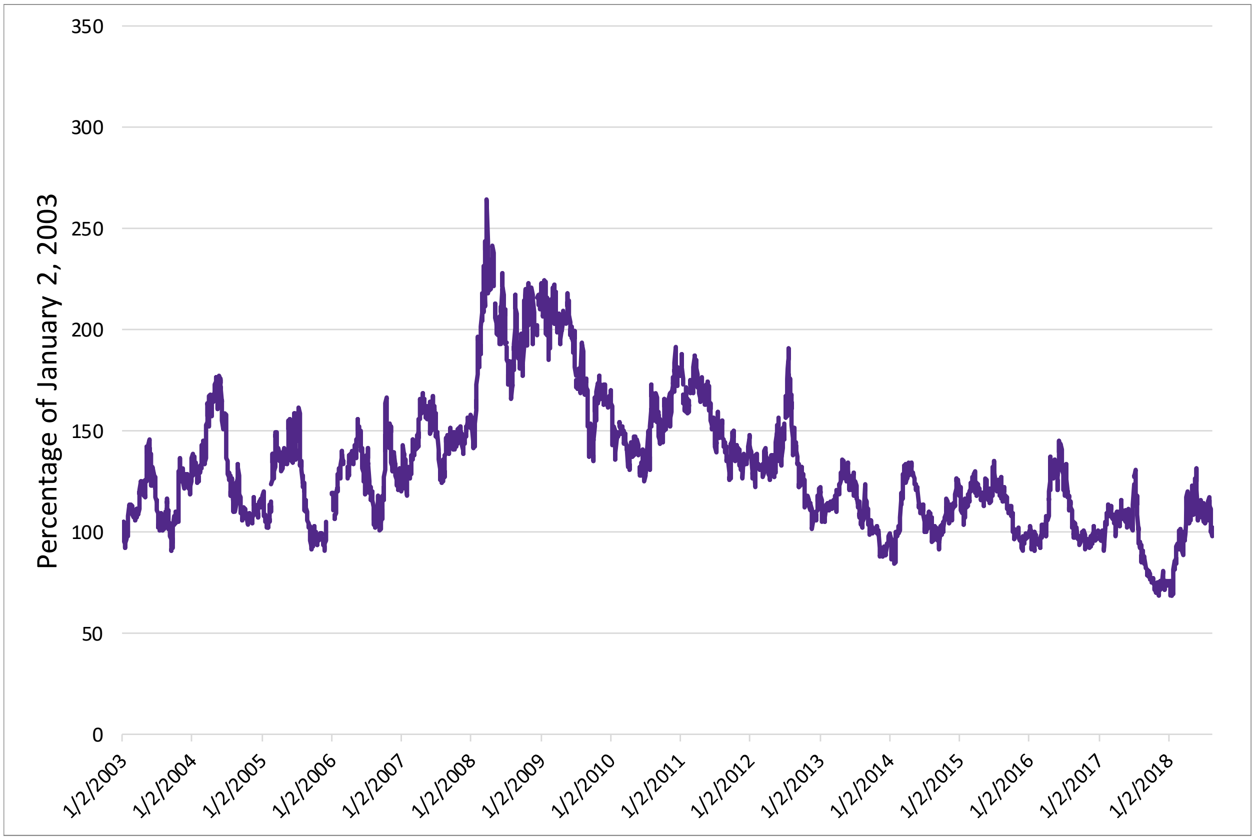
Figure 3. Index of Daily Four-Month Deferred Soybean Futures Implied Volatility as a Percentage of January 2, 2003 Base: January 2, 2003 — August 20, 2018

Figure 4. Index of Daily Four-Month Deferred Chicago SRW Wheat Futures Implied Volatility as a Percentage of January 2, 2003 Base: January 2, 2003 — August 20, 2018



To quantify risk in the grain complex as a whole, daily IVs for corn, soybeans, and wheat were averaged together and then indexed in the same fashion as the individual grains. Figure 5 shows how volatility in the overall grain market has evolved over time. This overarching risk measure is important because it allows market players, such as producers and commercial firms, who work with multiple grain types to understand the price risk they face by participating in the grain market.

Figure 5. Index of Daily Four-Month Deferred Grain Implied Volatility as a Percentage of January 2, 2003 Base: January 2, 2003 — August 20, 2018



Importance of Volatility Tracking in Today's Grain Markets

Volatility plays an important role in commodity markets, especially in the agricultural space. Grain prices have declined considerably from their highs in 2008 to 2013, leaving producers with declining working capital and narrowing profit margins. A strengthening U.S. dollar and current political tensions between longtime trade partners have also hurt the agriculture industry, which is highly dependent on global export markets. Being such an international market, grain price is not only affected by domestic supply and demand factors, but also issues arising around the globe. As such, players in the grain markets are exposed to price risk that is often unexpected and completely out of their control.

This volatility provides opportunity for those who wish to take on risk and speculate in the market, but also requires an emphasis on risk management practices for those who have stake in the physical commodity. Whether a futures and options trader, investor, producer or commercial user, or agricultural lender, all persons involved in these grain markets must understand price volatility and the impact that it has on the balance sheet. Understanding and being able to measure expected future volatility is not just an important concept, but a necessity in today's markets.

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