PROSPECTIVE FED CATTLE MARKET RISK

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Live Cattle Risk

Cattle feeding involves substantial risk that includes animal performance, production cost, and output price risk. Over time, the most prominent risk is fed cattle selling price. The purpose of this fact sheet is to develop a way to measure and monitor the magnitude of prospective fed cattle price risk present over time. Prospective risk here refers to the risk fed cattle option market traders bid into the price of options on fed cattle futures. The risk measure used here serves as a forecast of price risk cattle feeders face in fed cattle prices. In particular, we summarize how risk in fed cattle markets can be measured by implied volatility from the options market and we document how volatility has changed over time.

What is Implied Volatility?

One way of measuring expected futures market price risk is to calculate implied volatility. Implied volatility is a measure of future price risk option traders price into option premiums. Option premiums, all else constant, are driven by market price risk; greater risk implies higher option premiums because options function similar to insurance products. To calibrate volatility from option market traded premiums, an option pricing formula is used. We use what is referred to as the Black-Scholes option pricing formula to calculate forward looking market implied volatility. The option pricing model uses five parameters to price an option: 1) price of the underlying asset (in this case—live cattle futures prices), 2) strike price, 3) time to expiration, 4) interest rate, and 5) market price volatility. Volatility is the only variable in the Black-Scholes model that cannot be directly observed in the market and, therefore, must be imputed from the option pricing model. Since supply and demand in the option market discover the option's price, the pricing model can be solved backwards to determine the implied volatility being priced into option market premiums. The implied volatility is generally quoted as an annualized percentage variation in price.

Options are used to determine future volatility because investors are able to incorporate knowledge of past price movements and all relevant market information into the price of an option. Options on futures derive their value from futures contracts, which, in turn, derive their value from underlying cash prices. Therefore, information regarding cash price volatility is incorporated into discovered option prices, or premiums. As such, implied volatilities obtained from futures options provide a reasonable, market-based assessment of future price volatility for a commodity.

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Collecting Implied Volatilities

Live cattle implied volatilities (IV) were collected starting with the first trading day of 2003 and for all six live cattle futures contract months: February, April, June, August, October, and December. IVs were collected from Bloomberg. Some time periods had missing data in Bloomberg and these were filled in using IV information obtained from the Commodity Research Bureau (CRB) PowerGen software.

Bloomberg computes implied volatilities 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 at-the-money strike prices. Bloomberg calculates the put option IVs in a similar fashion, using the two put options closest to at-the-money strike prices. This fact sheet uses a simple average of the call and put option implied volatilities for calculating daily implied volatilities. In instances where either a call or put IV was missing, the IV present was used instead of the average.

Daily implied volatilities can be calculated for each contract month trading. In this fact sheet we focus on daily implied volatilities for the four-month deferred contract. For instance, the IV on February 1, 2017 was the implied volatility of the June 2017 contract on February 1, 2017. We use the deferred contract instead of the nearby so that the IV represents volatility into the future, as opposed to volatility in a nearby contract that is close to expiration and may be sporadic as positions are being closed. Live cattle contracts trade on even calendar months, so odd numbered months do not have a contract that expires exactly four months out. Therefore, the values for odd numbered months were determined by counting forward four months and using the next adjacent contract. For example, March values are based on the implied volatilities of the August live cattle contract traded during March.

To illustrate changes 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 base day, the change in volatility and magnitude of that change relative to the base can be determined. The data set used for this fact sheet starts with January 2, 2003 set as the base (index=100%) and live cattle implied volatilities being collected through December 12, 2017.

Findings. Graphing the data allows us to see how volatility has changed over the last 15 years. Figure 1 shows the four-month deferred implied volatilities as a percentage of the base, January 2, 2003. The IV on January 2, 2003 was 13%. The fed cattle IV index over time provides an interesting summary of market risk present in live cattle. The BSE-infected dairy cow in the state of Washington on December 23, 2003 caused havoc in U.S. fed cattle markets. On December 23, 2003, IV went from 18% the previous day to an all-time record high for live cattle of more than 50% on the four-month deferred (April) contract (more than 380% of the early 2003 IV) and more than 75% on the nearby (February) contract. IV remained relatively high through 2004, before settling back to values similar to early 2003 in 2007. In December 2009 IV again increased to twice the level it was in early 2003 in the midst of turbulent macroeconomic conditions and the recession that created volatility in commodity markets in general. The live cattle market was relatively calm during 2014, but as fed cattle markets started to rapidly decline in 2015, IV escalated again to about 150% of early 2003.

Figure 1. Index of Daily Four-Month Deferred Live Cattle Futures Implied Volatility as a Percentage of January 2, 2003 Base: January 2, 2003 – December 12, 2017

Per Head Volatility

Another important measure of risk in the fed cattle market is per head volatility. This refers to the dollar risk, or potential value fluctuation, associated with feeding one animal. Per head volatility can also be summed across an entire pen (or feedlot) to determine total pen-level risk. Per head volatility is important because it allows producers to calculate the increased risk involved when cattle are fed to heavier weights. Cattle feeders realize larger price risk per head as finishing weights increase.

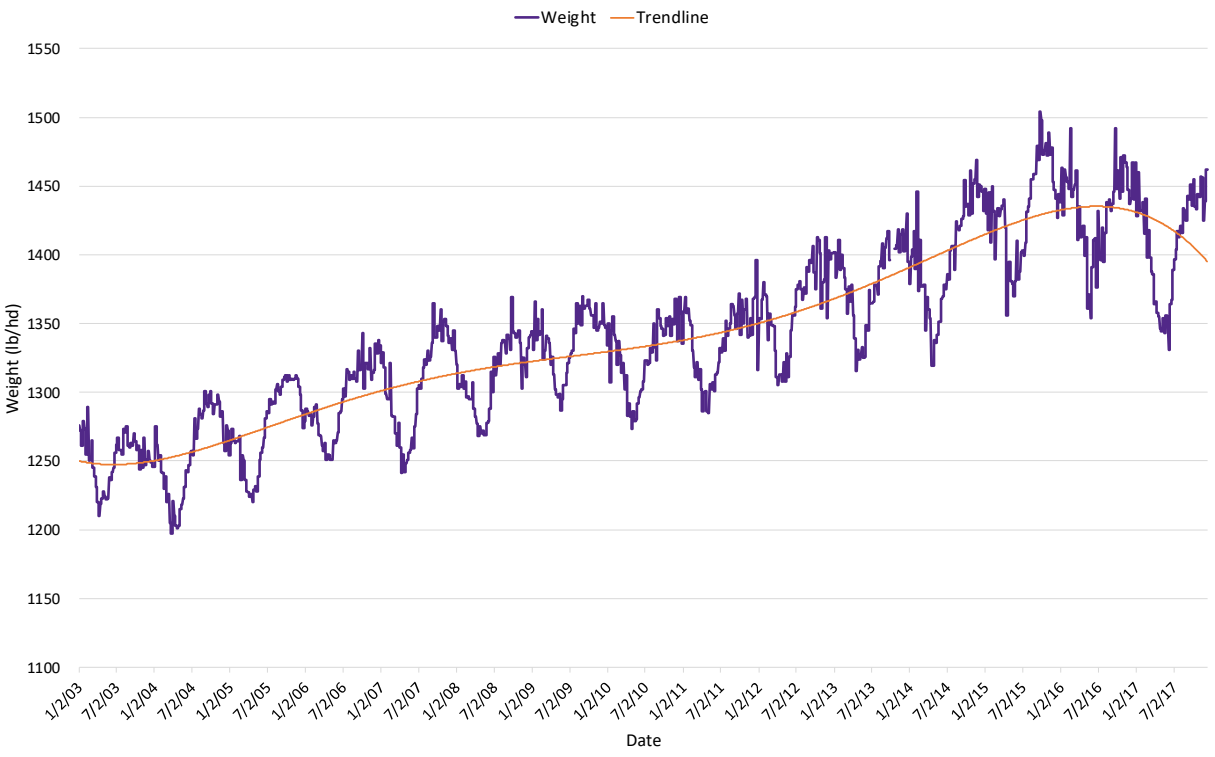
Dollar per head live cattle volatility was calculated using the following formula:

$$\frac{Four\ Month\ Deferred\ IV}{100} \times Live\ Weight\ (lbs/hd) \times \frac{Four\ Month\ Deferred\ Futures\ Price\ (cents/lb)}{100}$$

Implied volatility, times live cattle weight, times futures price provides a per head volatility measure that adjusts futures price volatility as cattle weights change over time.

Live cattle finished weights were obtained from the live steer weekly weighted averages provided by the Livestock Marketing Information Center. Figure 2 shows weekly average finished weights of fed cattle. The trendline illustrates how finished cattle weight has changed since 2003. Peak live cattle weight occurred between 2015 and 2017. The higher weights result in greater per head value risk for a given market price and IV.

Figure 2. Weekly Average Negotiated Live Steer Weights, 5-Market Average: January 2, 2003 – December 12, 2017



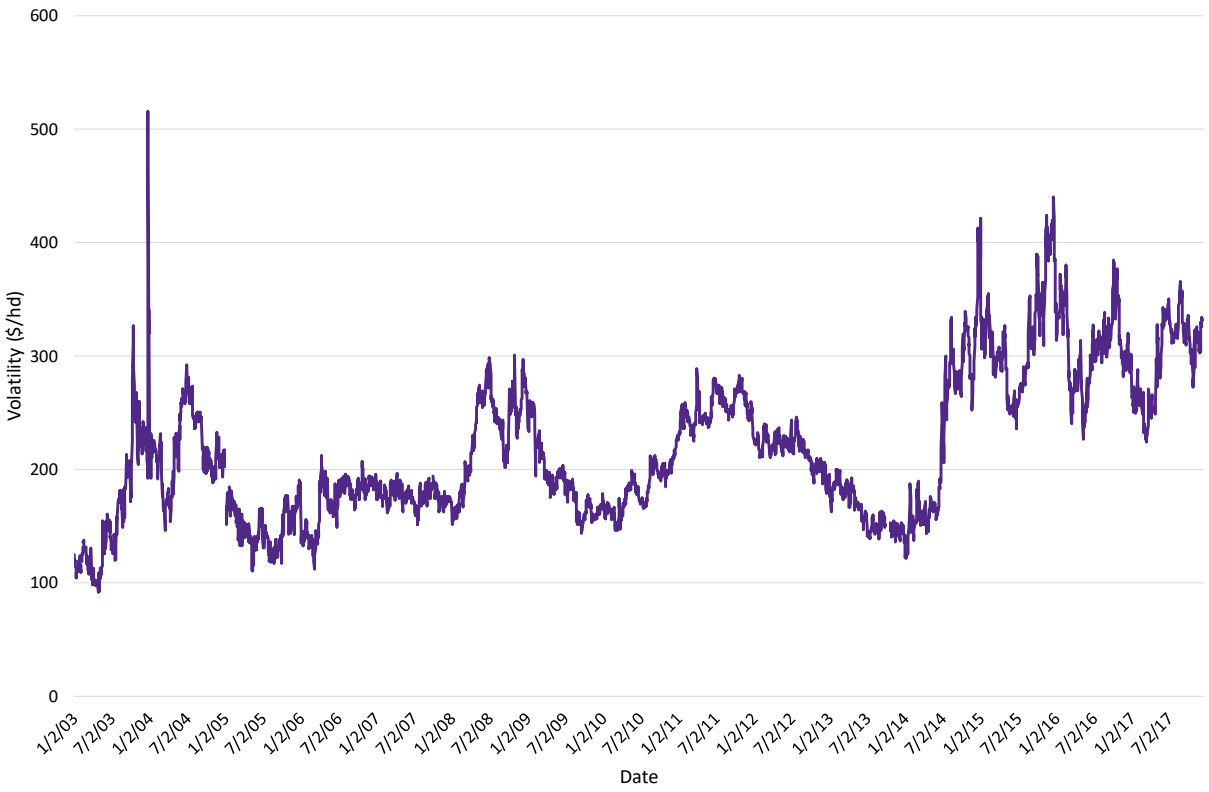
To exemplify how per head volatility was calculated, consider a situation where the four-month deferred implied volatility is 20.0%, four-month deferred live cattle futures price is $120/cwt, and the weekly average finished fed cattle weight is 1350 lbs/hd. The per head volatility calculation would be:

$$\frac{20.0}{100} \times 1350 \left(\frac{lbs}{hd}\right) \times \frac{120 \left(\frac{\$}{cwt}\right)}{100} = \$324.00/hd$$

This means that, given an implied volatility of 20.0% and a futures price of $120/cwt, a steer weighing 1350 lbs would have a total value risk of $324/hd. Since heavier market weights imply higher price risk, an animal fed to over 1350 lbs would have a total price risk greater than $324.

Findings. Per head volatility was calculated for each trading day starting on January 2, 2003 and going through December 12, 2017. The same four-month deferred implied volatilities as indexed in Figure 1 were used to calculate per head volatility. Figure 3 depicts how live cattle volatility, on a dollar per head basis, has changed over the last 15 years.

Figure 3. Live Cattle Value Volatility on a Dollar per Head Basis: January 2, 2003 – December 12, 2017



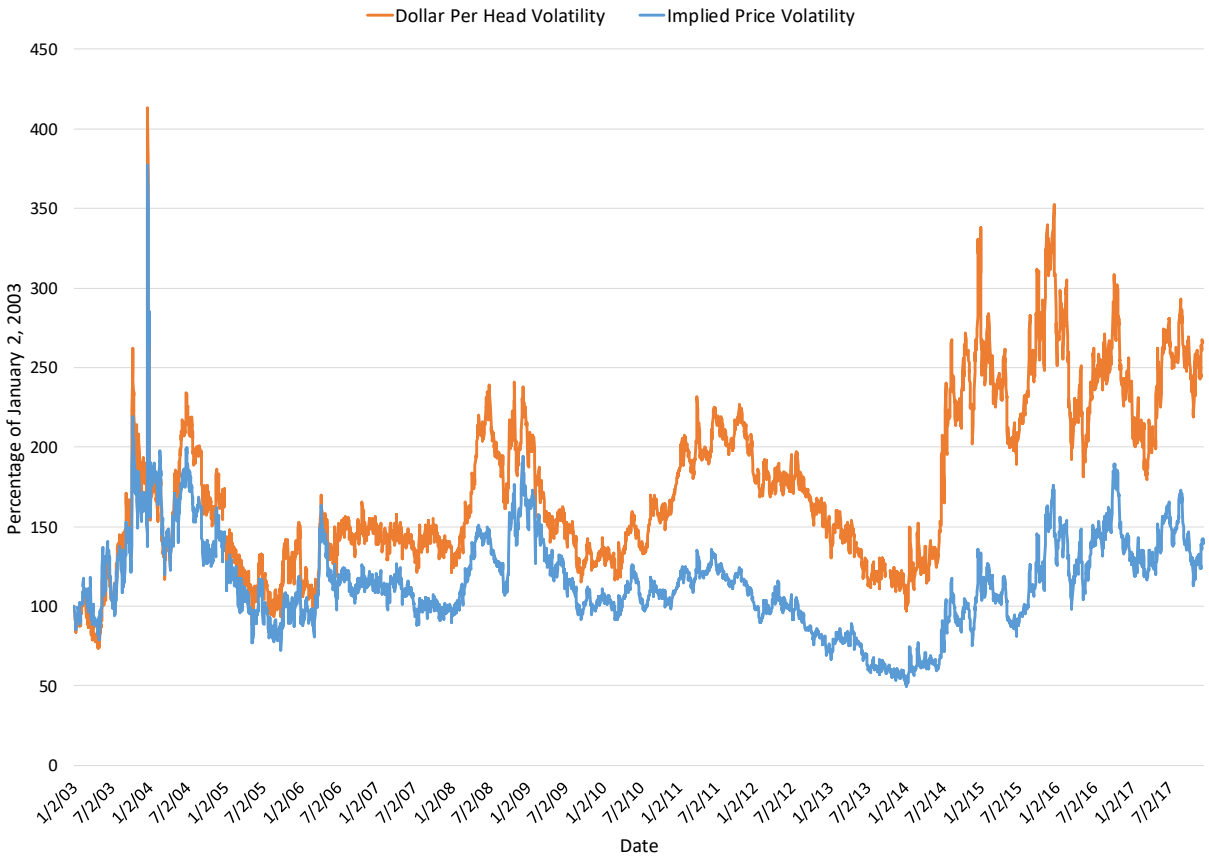
Fed cattle market weights have increased about 200 lbs/hd since 2003 (Figure 2). Based on just weight increase alone, a 20% IV and $120/cwt fed cattle price translates into nearly $50 greater per head fed cattle value risk today than was present just 15 years ago. Since fed cattle price has also increased substantially since 2003, the overall increase in per head fed cattle value risk is much greater today than 15 years ago. For example, in early 2003 fed cattle prices were about $70/cwt and finished weights were about 1270 lbs, resulting in a $180/hd fed cattle value risk with 20% IV. In contrast, in 2017 with fed cattle price at $120/cwt and finished weights at 1460 lbs, per head value risk is $350. The spike in volatility at the end of 2003 attaining greater than a $500/hd level was associated with discovery of the BSE-infected cow in the state of Washington in late December of that year. Per head volatility settled back down to around $150/hd during 2014 corresponding to lower market volatility observed in Figure 1. However, a dramatic rise in per head volatility occurred after 2014, as both fed cattle weights and market volatility increased. Even with much lower fed cattle prices in 2017 than 2015, fed cattle volatility per head has hovered around $250-$350.

Implied vs. Per Head Volatility

Implied volatility is a measure of the expected future volatility of a commodity's price. Per head volatility is the volatility of one head and depends on futures price, IV, and cattle finished weight. To compare how each of these values have changed relative to one another over the last 15 years, per head volatility was converted to a percentage

of a base value, similar to the implied volatility index in Figure 1. Figure 4 shows live cattle implied and per head volatilities calculated as a percentage of their January 2, 2003 values.

Figure 4. Implied Price and Dollar per Head Volatility Indexed Relative to January 2, 2003 Value: January 2, 2003 – December 12, 2017



The difference between price and per head volatility has widened since 2010, as per head volatility has increased more than price volatility. Per head volatility increased as live cattle weights increased. Producers may consider implied volatility for risk management purposes. However, a per head measure should also be considered, as it allows one to determine dollar price risk for a single animal. This is especially useful if live cattle weights continue to increase, and, consequently, the dollar risk per animal rises.

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