Volatility Factor in Concept and Practice

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Starting in crop year 2011, the Risk Management Agency (RMA) introduced the Common Crop Insurance Policy (Combo policy) with the goal of unifying and simplifying the crop insurance program. [1] With the Combo policy, Crop Revenue Coverage (CRC), Revenue Assurance (RA), Income Protection (IP), and Indexed Income Protection (IIP) are replaced by a single uniform policy: Revenue Protection with or without harvest price exclusion (RP-HPE and RP, respectively). The APH plan of insurance is replaced by Yield Protection (YP) for crops with Commodity Exchange price discovery.

In Combo policy rating, RMA integrates the main elements of the major crop insurance plans and develops a single rating and pricing procedure in order to make insurance coverage, protection and cost consistent across the board. A single projected price will be used in all three (YP, RP, and RP-HPE) plans of insurance, helping to simplify and streamline the program. In order to account for price risk, volatility factors are used in calculating premium rates for revenue protection coverage. Prior to 2011, price volatility factors were used for rating the Revenue Assurance (RA) program only. Despite the industry's familiarity with the RA program, the use of volatility factors in the calculation of the revenue add-on component of the premium rate in the Combo policy has created some confusion and operational issues. The objective of this article is to examine how the price and volatility factors are determined in Combo rating and assess the reasonableness of the process.

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[1] http://www.rma.usda.gov/news/2010/06/combo.pdf

Price Component of Combo Rating:

The Commodity Exchange Price Provisions (CEPP) endorsement defines the price component in Combo rating. CEPP uses exchange prices because these are well-studied and established as unbiased and efficient in utilizing all the information available to market participants. The exchanges used are the Chicago Board of Trade (CBOT), the Kansas City Board of Trade (KCBOT), the Minneapolis Grain Exchange, Inc. (MGEX), and IntercontinentalExchange (ICE).

Combo rating applies for the following crops: corn, cotton, grain sorghum, rice, soybeans, sunflowers, wheat, barley, malting barley, and canola/rapeseed. These crops constitute the bulk of the crop insurance business, about 73% of the total liability. Exchange prices are available for corn (CBOT), wheat (CBOT, MGE, or KCBT depending on the state and type of wheat), cotton (ICE), soybeans (CBOT), rice (CBOT), and canola/rapeseed (ICE). Because the price of corn is highly correlated with the prices of barley and grain sorghum, the latter are based on the corn exchange price (CBOT). Similarly, soybean oil futures from CBOT are used for the price of oil-type sunflowers.

For a given crop, different futures contract delivery months can be applicable for determining the projected price (base price). For example, the CBOT September futures contract is used for determining the price for Texas corn (whose sales closing date is January 31). For counties with a March 15 sales closing date, corn policies use the harvest year’s CBOT December corn futures contract. Using the latter example, daily settlement prices for the harvest year’s December corn futures contract are averaged in February, which is the base price discovery month as defined by the CEPP. The reason the base price discovery month is so close to the sales closing date is to establish the policy price using the most current market information. For the harvest price, the December futures contract's daily settlement prices are averaged in October, which is the harvest price discovery month in most counties. Furthermore, RMA uses the average price over the entire price discovery period (base or harvest) with the purpose of smoothing out day-to-day variations.

RMA provides an on-line price discovery tool in their website.[2] The tool reports the price election for the RP plan (therefore for the YP plan) along with volatility figures as the discovery month proceeds. The tool lists month-to-date values for the average price and the average volatility over the most recent five days (prior to the end of the price discovery period). Averages are listed at the top of the exhibit.

Volatility Component of Combo Rating:

The CEPP describes how prices are determined for the Combo program. However, it doesn't explain how volatility factors are to be determined. RMA determines the volatility factors based on the last five days of the price discovery period. Using the last five days of volatility seems to have the purpose of estimating the most current volatility possible prior to

[2]To view active discovery periods: http://www3.rma.usda.gov/apps/pricediscoveryweb/ActiveDiscoveryPeriods.aspx. By the time this article was written, there were no crops in discovery.
To view commodities recently in discovery: http://www3.rma.usda.gov/apps/pricediscoveryweb/CropsInDiscovery.aspx
For location specific daily prices: http://www3.rma.usda.gov/apps/pricediscoveryweb/DailyPrices.aspx .

sales closing date. RMA recently posted a one-page summary on their website describing the volatility procedure.[3]

RMA calculates implied volatility using data from barchart.com.[4] Anyone at any time can acquire the same information by paying a subscription fee to access the website. Once the implied volatility estimates are available, they are further adjusted for the time difference specific to crop insurance. RMA provides an example for 2010 Iowa corn in their one-pager. We update that example for 2011 in the following.

For Iowa corn, the harvest price discovery period is October, and the relevant futures contract is the December 2011 contract (CZ11 in barchart.com notation). Using Excel, the number of days from each day during February (the projected price discovery month) to the 16th day of October is calculated and divided by 365. The square root of the quotient is then taken. The result is a time adjustment which is then multiplied by the implied volatility corresponding to the same date.

The far right column Table 1 presents the resulting time-adjusted volatilities for the last five days of February. As an example, we work out the first row of Table 1. For 2/22/2011, the quotient is calculated as (from the following Excel formula)

$$((DATE(2011,10,16)-DATE(2011,2,22))/365)^{\wedge}0.5 = 0.804099087$$

From barchart.com, the implied volatility for the December contract is 0.375 for February 22, 2011. Multiplying 0.375 by 0.804099087 yields 0.302. Similar calculations are done for the

[3] http://www.rma.usda.gov/pubs/2011/volatilitymethodology.pdf

[4] http://acs.barchart.com/ .

Table 1. Determining the Volatility Factor for 2011 Iowa Corn

Contract	Date	Implied Volatility	Time Adjusted Implied Volatility (RMA's volatility factor)
CZ11	2/22/2011	0.375	0.302
CZ11	2/23/2011	0.365	0.293
CZ11	2/24/2011	0.360	0.288
CZ11	2/25/2011	0.362	0.289
CZ11	2/28/2011	0.365	0.290
Simple average			0.29

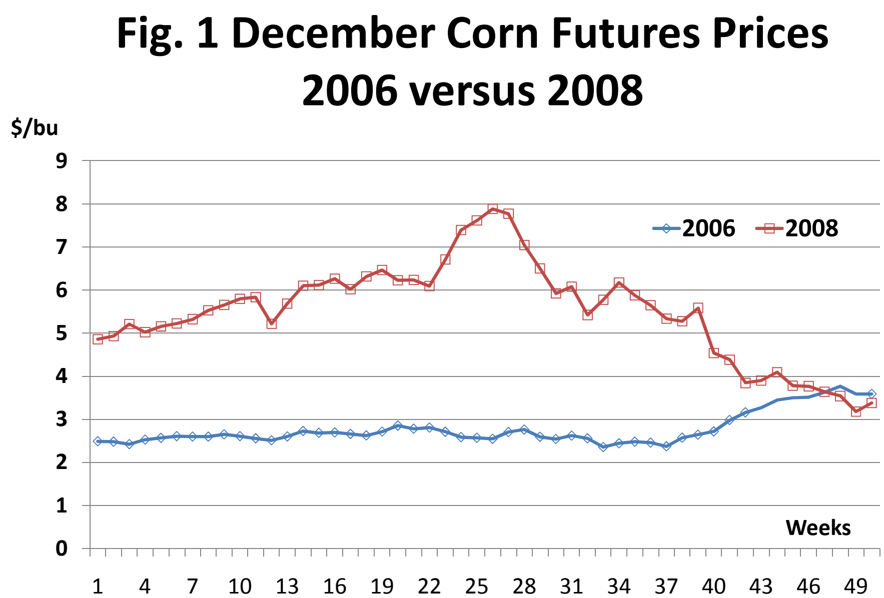
remaining days of February. Finally, a simple average of time-adjusted volatility factors is obtained and rounded to two decimals. The result is 0.29 in this example. Note that for corn, the harvest price discovery month is October for the majority of states. For some states such as Idaho, Michigan, Oregon and Washington, the harvest price is determined in November. That would result in a different time adjustment; the average would be calculated as 0.31, implying slightly higher risk and higher premium for those states.

A Closer Look at the Implied Volatilities—Theoretical Roots:

Volatility essentially is a measure of *the degree of change* in futures price over a year and represents the market's view on the uncertainty (risk) associated with a futures price over a year.[5] Based on visual inspection of Fig. 1, it is apparent that December Corn futures price was more volatile (that is, it showed a higher degree of change) in 2008 as compared to 2006. In 2008, the

[5] For a technical (more precise and involved) definition of volatility, the readers are referred to Appendix 1 in the Supplementary Material for this article posted at the NCIS website: http://www.ag-risk.org/NCISPub.htm.

futures price showed a dramatic surge in the first half of the year and a sharp decline during the rest of that year. Along these downward and upward paths, the data exhibited sharp spikes followed by steep drops. In comparison, corn December futures prices in 2006 remained mostly stable and the changes were minor and much smoother.



Of course, the preceding discussion of Fig. 1 is after the fact, that is, after the entire data was observed. At the planting time of a given year, the underlying futures price data is only partially observed and provides only limited information to infer the underlying volatility. In any case, volatility during in a given year is not directly observable and needs to be estimated. One way to estimate volatility is to utilize time-series (historical) information on the futures price which would be a backward-looking approach. A sophisticated econometric method based on this approach is discussed later in this section. Another way is to take a forward-looking approach and compute the implied volatility based on the prices of current options linked to the futures price. The latter is the approach taken by RMA.

Black-Sholes formulas relate prices of put and call options to volatility and provide a convenient way to estimate the volatility factor.[6] The formulas are based on a few readily available parameters: the prices for call and put options, the current futures price, and the strike price of the option are all available from the futures market. The interest rate for the risk-free asset and the time period before the options expire are known. The only remaining factor is the volatility factor, which can be computed using the formula for determining the price of the put or call option.[7]

The Black-Sholes model assumes that volatility is constant. This assumption needs to be justified as price volatility can vary over time (Hull, page 493). If the volatility is not constant, then that requires using sophisticated econometric models, such as generalized autoregressive conditional heteroscedasticity (GARCH) models which are frequently used in estimating volatility in finance literature (Hull, Chapter 21). These methods utilize historical data to estimate the volatility, albeit most recent observations carry higher weights. The final estimated model provides weights for the following components (in a particular specification): long-term volatility value, volatility estimate in the last period, and the squared percentage change in the futures price in the last period.

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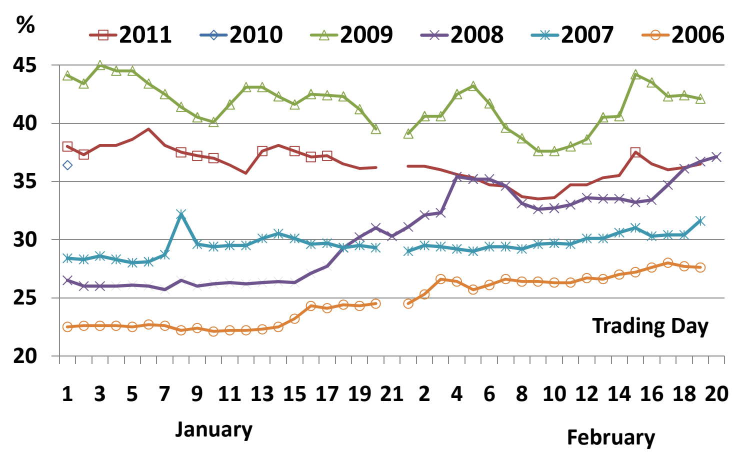
[6] For Black-Sholes formulas and their derivation, the readers are referred to Appendix 2 section of the Supplementary Material.

[7] Barchart.com provides the resulting implied volatilities. Otherwise, iterative search methods such as Goal Seek in Excel, can be used to calculate the implied volatilities from the Black-Sholes formulas. Alternatively, using *blkimpv* function (where Black-Sholes formulas are coded) in MatLab software, we are able to replicate the numbers provided by barchart.com.

RMA gives equal weights to the implied volatilities from the last five days of the price discovery period. In doing so, RMA's method ignores the information on the futures contract prior to last five days of February (for March 15 sales closing dates), therefore, it does not fully utilize all the available information on the futures contract. Finally, the assumption of equal weights on the last five observations in the price discovery period seems to be based on practicality, and does not appear to be derived from an econometric estimation.

Fig. 2 presents the implied volatilities for December corn futures in January and February from 2011 to 2006, respectively. Note that the implied volatilities in these figures are obtained from barchart.com, on an annual basis and are not time adjusted. As shown in the Figure, implied volatilities can differ from one year to the next. Based on visual inspection, volatility within a year mostly varies within five basis points (except 2008 where it shows wider variation up to 10 basis points). Nevertheless, volatility behavior appears to be changing over time.

Fig. 2. Implied Volatilities in January and February 2011-2006*



* Implied volatilities based on put option for the December corn futures price. January had 21 trading days in 2008.

Combining Price and Volatility Components in Combo Rating:

RMA combines the base price with the volatility estimate in simulations to obtain the revenue-add on component in the Combo premium rating. The method draws from price and yield distributions and imposes an historical price-yield correlation to obtain the joint distribution.[8] Because the variance of the price distribution is determined by the volatility factor, the volatility factor affects price draws, which in turn affect premium rates. The revenue add-on component of the Combo rating is then obtained as the difference between simulated price risk and simulated yield risk.[9] Adding the resulting revenue add-on rate to the Yield Protection rate gives the premium rates for revenue plans. Note that with the RP-HPE plan the guarantee is fixed at the base price, whereas the RP plan uses the higher of the planting and harvest prices in setting the guarantee. The simulation process takes this difference into account and produces the rates accordingly.

Barnaby describes RP and RP–HPE as a yield-adjusted Asian (YAA) put option. Asian options are those options where the payoff depends on the average price of the underlying asset for a pre-determined time period (Hull). Indeed, in crop insurance, harvest price for major crops is the average of futures prices obtained over the harvest price discovery period. RMA states (in

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[8] The distribution of futures prices is also derived in Appendix 1 section of the Supplementary Material.

[9] In effect, the rating procedure computes the indemnity payment for 500 possible combinations of yield and price for an insured unit, finds the probability of each outcome, and uses the combination of indemnity payments and probabilities to determine the average indemnity payment. A similar simulation process is used to determine the average indemnity payment for the same 500 yield outcomes, this time using a fixed price equal to the projected price at planting.

their one-pager) that the premium rate to lock-in a harvest price with crop insurance is equivalent to the amount the market charges to lock in a futures price via options. This statement may need some clarification. One distinction is that a CME option uses spot price, whereas a YAA option uses an average of prices during the price discovery period. In addition, Barnaby finds that RP as a YAA put option is much cheaper than a CME put option in 2011, as the former costs less than 3 cents per bushel of corn versus the latter costing 75 cents. The main reason for this difference is that for CME contracts the yield is fixed. The value of an option solely depends on the price move. With RP, because yield factors into the farmer's revenue, RP pays less frequently and pays less than CME options, which explains the difference in value.

Operational Issues with RMA's Volatility Method-Stability of Volatility Values:

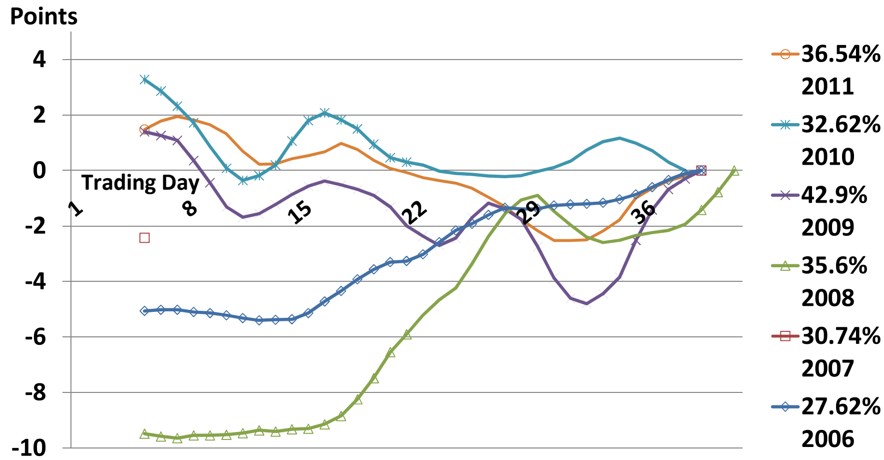
The root of the operational issues regarding volatility lies in the fact that crop insurance agents may be using company premium quoting systems that use the prior year's volatility factor by default until the price discovery period ends. With the large changes in volatility factors from year to year as shown in Fig. 2, this has the potential to seriously distort any premium quotes. In addition, agents have only about two weeks between the end of the price discovery period and the sales closing date. The short time frame, combined with the large number of policies with sales closing dates (e.g., March 15) creates a time and workload issue. The more time they have to prepare quotes and issue policies, the easier it is for the agents to get their work done. However, the time available for agents to meet with customers is reduced due to the fact that YP prices no longer come out earlier than RP prices now that Combo establishes a single price for both plans.

One issue is whether agents simply need better information or whether volatility factors needed to be determined at an earlier date. Some agents may prefer to change the period used to determine volatility to the last five days of the previous month. The government could potentially respond to this by noting that since volatility factors don’t vary much during the price discovery period, agents should be able to use the most recent average value to prepare reasonably accurate price quotes without waiting for the price discovery period to close. This is consistent with the claim that implied volatilities are less variable than the option price (Hull, page 297).

Because it seems unlikely that RMA will revise their price discovery period for projecting prices and locking-down volatilities, the relevant question is whether agents can prepare reasonably accurate quotes using the future prices and volatilities values provided by barchart.com a month earlier. For sales closing on March 15, that would mean using the information provided by barchart.com in January. If volatility is reasonably stable, this shouldn’t create a significant issue with regard to the premium calculation.

To investigate the stability of the volatility factor, Fig. 3 depicts the difference between a five-day rolling average of implied volatilities (obtained from put options linked to the December corn contract) in January and February from the average implied volatility in the last five days of February from 2011 to 2006, respectively. Note that the average implied volatility in the last five days of February varies year to year and is provided along with the corresponding year at the chart legend (see the right margin in the chart). On the chart, trading days in January and February are displayed on the horizontal axis and the point differences are on the vertical axis. In the last trading day of February (see the far right observation) all graphs touch to zero based on the way in which the chart has been constructed.

Fig. 3. Implied Volatilities: Comparison of Five-Day-Averages in January/February to the Final Five-Day- Average (2011-2006)*



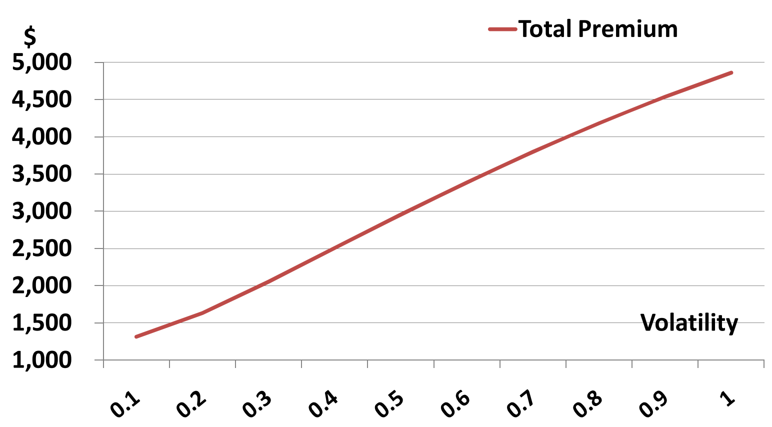
* Implied volatilities based on put option for the December corn futures price

What is apparent from Fig. 3 is that the relationship is quite different in early years (2006 to 2008) versus later years (2009 to 2011). Particularly, from 2006 to 2008, the rolling average of volatilities throughout January and February remained lower than the average volatility in the last five days of February, therefore, their differences are negative. That relationship was even more prominent in the month of January. Nevertheless that pattern changed in the last three years. The rolling average appears to oscillate within five basis points around the average in the last five days of February; therefore, the horizontal axis is crossed several times in these years. Taking this to the bottom line, the usefulness of using an earlier time period all depends on the degree of sensitivity of premium calculation to the possible errors in estimating volatilities.

Elasticity (Sensitivity) of Premiums with Respect to Volatility:

Using RMA's Cost Estimator–premium calculation tool for Combo policies, we prepared premium estimates for major crops (corn, soybeans, grain sorghum, cotton, and spring wheat) to investigate the sensitivity of total premium calculations to volatility. These calculations were prepared on November 19, 2010. At that time, RMA's volatility factor was set only for winter wheat. For remaining crops, RMA's Cost Estimator allowed us to enter our own selected values for volatilities and calculate premiums. Fig. 4 presents the results for Iowa soybeans for the 2011 crop year. This example is for a 38 acre farm in Kossuth County with 85% coverage level, optional units, approved yield of 38 bushels per acre, and rate yield of 36 bushels per acre. The projected price is assumed to be $11.63 per bushel, which was also the 2010 harvest price. From Fig. 4, for Iowa soybeans, we found a nearly linear increasing relationship between volatility and total premium. A similar

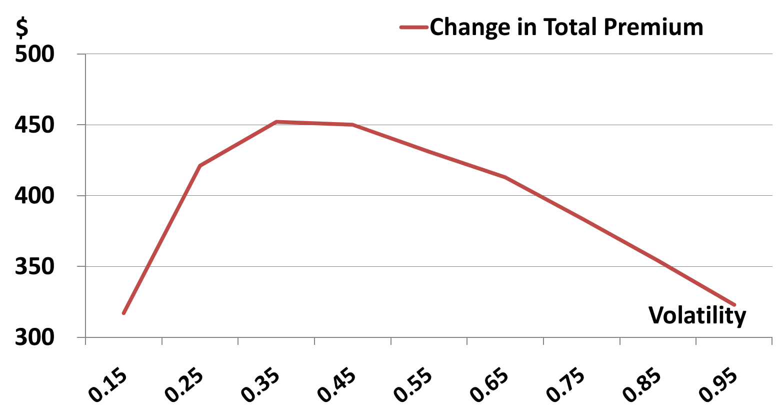
Fig. 4. Total Premium Related to Volatility
(Iowa Soybeans Farm with $11.63/bu Base Price)



relationship was observed for other crops. If volatility increases, we would expect the premium to go up. But, given the complexity of the Combo rating procedure, the resulting nearly linear relationship was unexpected.

Based on information in Fig. 4, Fig. 5 further depicts the change in total premium as volatility increases 10 basis points (e.g., going from 0.3 to 0.4 or 30% to 40%; represented by middle point 0.35 in the Figure). What is striking is that the change in premium is positive and steeper as volatility increases in range below 45%, which turned out to be the observed range of volatility from 2011 to 2006 (see Fig. 2). Furthermore, one can come up with a preliminary estimate of sensitivity based on this example for Iowa soybeans farm: going from 0.3 to 0.4, a 10 basis point increase, results in a $452 increase in total premium. Because the total premium amount is $2,053 at 0.3, a one basis point increase in the volatility factor would increase total

Fig. 5. Change in Total Premium per 10 Point Change in Volatility (Iowa Soybeans Farm with $11.63/bu Base Price)



premium by approximately 2.2%, which can be verified from the following

$\frac{1}{2053} \times \left(\frac{(2505 - 2053)}{(0.4 - 0.3)} \right) = 2.2\%$ at this range of volatility values. If instead the projected price increased by 1%, the total premium would go up by 1% because the premium is the liability times the premium rate, and the liability is the price times the rate yield. That means, at least in this example, total premium is more sensitive with respect to the one point increase in volatility factor compared to the one percent increase in price.

Conclusion:

With the arrival of Combo policies, the concept of volatility will play a more significant role in the crop insurance program. This article has explored the concept and reviewed its role within Combo rating. Our treatment of the topic amounts to scratching the surface and by no means is definitive. This very preliminary analysis pointed out that volatility could be critical in determining premiums and A&O compensation. What is needed is quantification of the impact of variation in volatility. This is especially important as the way RMA uses volatility in premium rates is unclear. More transparency on how this concept is computed and used in ratemaking is needed and future research on this area is warranted.

References:

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