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## **Risk Management Properties of the 2014 Farm Bill**

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## **Introduction**

Passage of the Agricultural Act of 2014 (i.e., the 2014 Farm Bill) requires producers to make a one-time enrollment decision on a variety of Farm Bill options for the next five years. Taxpayer cost is estimated at \$956 billion with about \$134 billion (or 14%) allocated to farm commodity and crop insurance programs (Congressional Budget Office 2014). The 2014 Farm Bill, specifically Crop Commodity Programs (Title 1, Commodities) deviate from recent and previous Farm Bills where the direct payment program was the central theme.<sup>1</sup> The payment trigger structure in the 2014 Farm Bill shifts focus from offering payments no matter the income outcome (i.e., direct payments) to payment levels being conditional yields and/or prices at different levels of aggregation, effectively making the 2014 Farm Bill a risk management program.

Risk management choices in the 2014 Farm Bill adds to producers' existing, risk management toolbox. These new subsidized choices are likely to interact with already present risk management tools but whether they interact as substitutes or complements is unclear. The presence of substitutes or complements is important to both the producer and taxpayers. Producers wish to find the efficient, best protection for the buck, combination risk management tools, implying the need to understand the relation between risk management options. Taxpayers care because offering programs that deter from using already available programs is an inefficient allocation of government resources, resulting in increases taxpayer cost.

In this paper, we examine how Farm Bill choices interact with other risk management programs, namely crop insurance, a publicly provided tool, and hedging, a privately provided

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<sup>1</sup> Both the Average Cop Revenue Election (ACRE) and Supplemental Revenue Assistance (SURE) programs were available in the 2008 Farm Bill offering payments based on revenue outcomes.

tool through a portfolio approach. Because the Farm Bill enrollment decision is set for five years, the optimal set of risk management choices is a mystery with many sub-plots. The dollar value of each Farm Bill choice is highly uncertain, because prices and yields over the next five years are highly uncertain. Instead of attempting a full solution over the five year life of the Farm Bill, we introduce a yearly snapshot method which essentially breaks the problem down into separate one year problems. This is a first order approximation, but it should provide insight into the risk reducing properties of the Farm Bill.

The Farm Bill (hereafter the Farm Bill) rules state that each producer must make his or her decision, and often a single producer who farms multiple farms can, and will, want to consider extending the portfolio approach down to the Farm Serial Number (FSN) unit and crop level to make risk management decision. As a result a producer could have different Farm Bill selection for between different FSN units and crop. We consider three of the four Farm Bill program options; Agricultural Risk Coverage County (ARC-CO), Price Loss Coverage (PLC) and Supplemental Coverage Option (SCO).<sup>2</sup> Because of data requirements and modeling complexities at the FSN level we do not consider the FSN level Farm Bill option, ARC Individual (ARC-IC) in the analysis. The producer's portfolio selection will be guided by the known variables such as the PLC reference price, the overall size of operation, percent base acres relative to planted, percent base per crop, percent base per farm, PLC yield per farm and unknown random variables that change each year such as farm's actual yield, the spring and fall price guarantee for his underlying crop insurance policy, the Marketing Year Average (MYA) price and inputs determining Farm Bill option expected revenues. For example, in ARC-CO, for

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<sup>2</sup> Because we focus on corn we do not consider Farm Bill options available for other crops. For example, Stacked Income Protection (STAX) for cotton.

a producer who selected Revenue Protection crop insurance, the ARC-CO expected revenue depends upon recently experienced MYA prices and county yields.<sup>3</sup>

The impact of the Farm Bill is unclear and important because of the number of new program choices, rules associated with program choices, and how program choices interacting with other, already available, risk management programs such as crop insurance and hedging. Understanding whether the Farm Bill is a substitute or complement to other existing risk management tools is important to society. If the Farm Bill offsets the need for crop insurance then the government is offering two programs protecting the same risk, indicating substitutes and perceived as an inefficient allocation of taxpayer resources.. The opposite is also possible, the Farm Bill may enhance the usefulness of other risk management options, making the Farm Bill a complement. For example, additional yield protection could enhance the usefulness of pre-harvest hedging.

Other risk management programs already exist to protect against income losses. Crop insurance, Title 9 in the Farm Bill, has expanded from a 2.7 billion program in 2002 to a 11.5 billion a year program in 2013 (USDA-RMA Summary of Business Report, 2014). The Farm Bill continues to expand crop insurance, for example a new area-based coverage that interacts with traditional crop insurance coverage.<sup>4</sup> Futures markets have existed for a long time. The Chicago Board of Trade (CBOT), which created the world's first futures market exchange started 167 years ago, in 1848 (CME Group). The futures market allows producers to transfer future price uncertainty to either commodity buyers or willing speculators.

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<sup>3</sup> ARC-CO expected revenue calculation contains other rules that must be taken into account in determining expected revenue. For example both prices and yields use the Olympic average to determine expected revenue.

<sup>4</sup> Other new programs exist but are outside the focus of this analysis.

The yearly snapshot model takes a portfolio approach. It treats crop income, crop insurance, hedging, and the farm bill safety net payments as different investments within the total income portfolio. The interplay and coupling between these different instruments determines the overall value and uncertainty of the total income portfolio for a given season (the yearly snapshot). For each year the portfolio is evaluated at two points in time-once before the crop is planted and once after it is harvested. Monte Carlo methods are employed with 30,000 samples for each portfolio. The financial benefit of the different portfolios can be determined by looking at the expected value-to determine central tendency, the variance-to determine the uncertainty, expected shortfall-to determine risk of rare but devastating financial events, and shape of the resulting cumulative distributions-to measure stochastic dominance (Chavas,2004).

The baseline income portfolio considers income from only crop sales. Other assets such as crop insurance, hedging, or Farm Bill safety net programs can be added to the baseline portfolio to reduce income risk and perhaps enhance expected income. An estimate of the value of the portfolio before the crop is planted is given by the expected value of the portfolio. This expected value represents a budget or income Performance statement. It is produced using the best information at hand on Mar 1st. The underlying futures price, farm yield, and county yield take a random walk as yield affecting weather events and price affecting events occur until they reach the end point, which in our case is Dec 1<sup>st</sup>. The calculation of our portfolio would normally yield a fixed income statement, but PLC and ARC-CO, are not finalized because they are based on the MYA. MYA price is not completely determined on Dec 1<sup>st</sup> because the MYA is the monthly national average cash price for the complete marketing year. For corn and soybeans there are still nine months to go. We estimate MYA on Dec 1<sup>st</sup> by using a two variable linear regression of the actual MYA national price with the December futures price on Dec 1<sup>st</sup> and the change in

December futures price from Mar 1<sup>st</sup> to Dec 1<sup>st</sup> as predictors using data over the last 28 years. A random sample is drawn from a normal distribution of the ratio of regression residuals and added to the prediction to simulate the remaining nine month uncertainty of MYA. Different assets in our portfolio are correlated because the variables used to calculate them are either correlated directly or indirectly through the regression relationship. Historical data over the last 35 years is used to identify the correlation among the futures price on Dec 1<sup>st</sup>, farm yield and the county yield. We use historical data to construct an empirical farm yield distribution and county yield distribution, while the Black-Scholes model, with the volatility estimated by option price data on Mar 1<sup>st</sup>, is used to model the futures price distribution. These three marginal distributions, with each containing 30,000 samples, are shuffled to reproduce the Spearman correlation matrix determined from 35 years of data using the classic technique of Iman and Conover (1982). We study 2015 in detail because information from Mar 1<sup>st</sup> is available. This model can be extended to any farm bill year by making assumptions about the Mar 1<sup>st</sup> conditions and conducting what if scenarios can be used to produce snapshots of the out years. It is important to note that ARC-CO payments are path dependent because the trigger price is figured from the Olympic average; therefore, the set of assumptions must include estimates of the past five years of MYA prices.

### *Producer Risk*

We examine the consequences of different decisions that may be reached using these tools to help individual producers craft risk management plans that best support their objectives. We model farm survival using the expected shortfall (ES) risk measure.<sup>5</sup> The ES risk measure represents the loss expectation once a loss occurs and is preferred over the value-at-risk measure

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<sup>5</sup> The ES risk measure has been used by Woodard, Sherrick and Schnitkey (2010)

in cases where the net income distribution is characterized by a long tail.<sup>6</sup> We define a loss as a 1% and 5% probability because it is a semi-rare event (1 in 100 years and 1 in 20 years, respectively). In the next 20 years, the producer who worries about protecting 1% ES has an 82% probability of success, or an 18% probability of experiencing a 1% ES. For the 5% ES over the next 20 years, the producer has a 36% probability of success, or a 64% probability of experiencing a 5% ES.

We investigate futures price risk through the use of commodity market option prices within the framework of the Black-Scholes-Merton model of futures market behavior. This approach incorporates what the commodity market views as price risk and has been used in other crop insurance research (Woodard, Sherrick, and Schnitkey, 2010; and Schnitkey, Sherrick and Irwin, 2003). One reason commodity markets exist is to provide the best information to help make spring predictions about fall prices. We use producer-level historical yields to capture farm yield risks – risks that could deviate substantially from those based on county, state or national level aggregate data (Miller and Kahl, 1987). We use NASS county yield data to display county yield behavior needed in both ARC-CO and SCO calculations. The Spearman correlation structure-based on 35 years of observations-between ln ratio of futures on Dec 1<sup>st</sup> and Mar 1<sup>st</sup>, the ratio of deviation of the farm yield from the farm yield trend divided by the trend and for the ratio of deviation of the county yield from the county trend divided by trend, is reproduced using methods from Iman and Conover (1982). This technique produces a 3D joint probability distribution from which we can draw samples.

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<sup>6</sup> Expected shortfall provides the average of all bad outcomes below a predetermined probability level. This method provides a clearer picture of downside risk over value-at-risk which defines loss at exactly the probability level, thereby ignoring all risks below this point.



We link futures prices to MYA prices using regression. This is an essential step because Farm Bill program options use MYA in calculating payments whereas crop insurance and hedging use futures markets. Regression allows us to identify the relation between futures and MYA prices. Because about 31% of the MYA has been determined by the path the futures price takes between September 1<sup>st</sup> and Nov 30 and the endpoint selected on December 1<sup>st</sup> by random draw from the joint probably distribution is the end point for this path, it is expected that using the March 1<sup>st</sup> value of the December futures, which is the starting point of the path, and using the randomly selected December 1<sup>st</sup> value of the December futures, which is the endpoint of the sample path will explain much of the behavior of MYA. We use The December 1<sup>st</sup> value as one predictor and a linear combination of the March 1<sup>st</sup> value and December 1<sup>st</sup> value which represents the change in the futures value as a second to predict MYA.

#### *Net income model*

Per-acre net income ( $\pi$ ), without insurance or hedging, is given by

$$(1) \quad \pi = p * y - c - c(y)$$

Where  $p$  represents output price,  $y$  is actual yield,  $c$  is the fixed cost of production, and the function  $c(y)$  represents the per-bushel harvest cost. Purchasing insurance adds the term  $I(r, r^*, z) - u(z)$  to equation (1), where  $I(.)$  represents the insurance indemnity or payment from the insurance company to the producer;  $r$  represents actual revenue ( $y * p_{harvest}$ ), where  $p_{harvest}$  represents the insurance “harvest price”;  $r^*$  is guaranteed revenue, calculated as  $(y_{aph} * p_{projected} * CL)$ , where  $y_{aph}$  represents the yield guarantee or Actual Production History (APH),  $p_{projected}$  represents the insurance projected price and  $CL$  represents the percent insured,  $z$

represents the insurance contract (i.e., coverage level, unit type, and insurance type)<sup>7</sup> and  $u(z)$  represents the Risk Management Agency calculated insurance contract premium.<sup>8</sup> Pre-harvest futures price hedging, through the use of futures markets, adds the term  $p_h * y_h$ , where  $p_h$  represents the hedged production price,  $y_h$  represents the number of bushels hedged and the sub index  $h$  represents the amount hedged between zero and 110% of Actual Production History (APH) bushels. Including hedging reduces the number of bushels to be sold at harvest; therefore, we replace yield in equation (2) with  $y_r$ , which is the remainder of  $y - y_h$ . With unknown yields, it is possible for  $y_h$  to be greater than  $y$ . Enrolling in the Farm Bill adds the term  $FB(PC, Base, Planted, SCOPrem)$  to equation (1), where PC represents the three program choices; *ARC-CO*, *PCL*, *SCO*, base represents the percent of base acres on the farm, planted represents the number of planted acres to a crop, *SCOPrem* represents the insurance premium paid by the producer.<sup>9</sup>

When given the option of purchasing insurance, enrolling the Farm Bill and hedging, the producer's net income per acre becomes

$$(2) \quad \pi = p * (y - y_h) - c - c(y) - z(y) + I(r, r^*, z) - u(z) + p_h * y_h + FB(PC, Base, Planted, SCOPrem)$$

## Farm Bill

The Farm Bill contains a variety of program options with different parameters and constraints.

*ARC-CO* protects revenue in a narrow band between 86% and 76% of the Olympic average of

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<sup>7</sup> Insurance contract components are discussed in more detail in the Monte Carlo Simulation section.

<sup>8</sup> Under a RP policy  $p_{projected}$  in the revenue guarantee calculation could be replaced with  $p_{harvest}$  if  $p_{harvest} > p_{projected}$ . For a yield protection policy,  $p_{harvest}$  is replaced with  $p_{projected}$  in the actual revenue calculation.

<sup>9</sup> *ARC-CO* and *PCL* premiums are zero.

the area (usually county) revenue.<sup>10</sup> PLC protects price, not revenue, over a band between the actual MYA price and the \$3.70 reference price if the price is less than the reference price. The price protection in PLC is capped at the loan rate which is \$1.75 per bushel. Both ARC-CO and PLC are capped at \$125,000 total payment per year per person or \$250,000 per year per married couple. ARC-CO and PLC are only paid on 85% of the farm's base acres. Producers enrolled in PLC can also enroll in SCO on a yearly basis. SCO is a supplemental crop insurance policy sold and administered by the RMA, covering planted acres and has no payment limitation (RMA 2014). The Federal Government subsidizes 65% of the premium cost for SCO. SCO payment is based on an area loss at the county level. SCO uses the same crop insurance policy type that the producer chose. For example if the producer selected RP then the SCO policy is revenue based. If the producer selected yield protection then the SCO policy is yield based. County revenue is based upon county yields and crop insurance prices. SCO begins to pay when the county revenue falls below 86% of the expected level and quits paying when the payment equals the difference between 86% and the producer selected coverage level. For example, if the producer selected an 80% coverage level then SCO payment would be limited to 6% of the expected value.

### *Yield Distributions*

It is difficult to get a sufficiently long time series of farm-level yield data that adequately describe farm yield risk. As a result, researchers often use county level data to describe farm yield variation. Aggregation to the county level could average out poor or excellent outcomes, thereby underestimating farm yield variability. To accurately describe farm level yield

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<sup>10</sup> ARC-IC, is another available option that acts similar to ARC-CO but uses different parameters.

variability we use yearly farm average yield from our representative producer. Our representative producer has 35 years of annual corn production yield history from multiple fields scattered throughout Hardin County Kentucky.

Yields have increased steadily from 1979. To determine the amount of yield risk, we first remove the yield trend. Failure to remove the trend will result in an overestimate of farm yield risk. To calculate the yield trend, we regress current yield on previous yield employing Linear Least Squares using historical farm data from 1979 to 2014.<sup>11</sup> The farm residual ratio distribution,  $R_f$ , which we use as the sampling distribution, is calculated as

$$(3) \quad R_f = \frac{y - ytr}{ytr}$$

where  $y$  represents yield, and  $ytr$  represents the estimated yield trend. We can express the unknown next-year's yield as

$$(4) \quad y = ytr + ytr * R_f$$

We assume  $R_f$  can be used as a stationary sampling distribution, i.e., that the distribution of ratios of difference from the trend divided by the trend does not change over time.

The 35 years of producer yield data are a sample drawn from an existing population distribution.<sup>12</sup> With a representative producer and a relatively short time frame, results could lead to an inaccurate assessment of linkages between crop insurance and hedging. Specifically, the data could suggest a yield risk that is not representative of either the county or state yield risk. As a result, we calculate yield risk histograms at the farm (our representative producer,

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<sup>11</sup> We found evidence of homoskedasticity using the Breush-Pagan test for heteroskedasticity.

<sup>12</sup> The 34 years represent the number of historical yield observations the producer has had, and therefore represents the number of years in business.

FmCn), county (CtCn), state (StCn), and national (NtCn) levels over the same data period as our farm data, Figure 1. Shown graphically in Figure 1, aggregation from the farm to the county slightly lowers the level of yield risk and aggregation from the farm to the state or even national level substantially reduces the amount of yield risk. Consequently, one would expect the county to slightly underestimate farm risk for this farm operation, and state or national to substantially underestimate farm yield risk for this farm operation. While the detailed shape of the histograms in Figure 1 is approximate, the kurtosis is negative across all levels of aggregation (Coble, Barnett and Riley, 2013).

We want the  $R_f$  distribution to adequately describe the probability of any major yield impacting event; therefore, using a nonparametric approach we develop an empirical distribution by plotting the cumulative distribution and drawing a smooth line through the points, with the additional constraint that the line must pass through a point with 1/30 probability that the yield will be at least as bad as the worst yield in the distribution. This constraint, added to model the extreme low yield events which have previously occurred, leads to a fat low yield tail. This fat tail behavior was predicted before the major Kentucky drought event of 2012. The major 2012 yield shortfall is easily explained within the  $R_f$  model proposed for this farm. We add the constraint that distribution must be uni-modal. After an empirical distribution is constructed its mean, standard deviation, and kurtosis is compared to the data sample moments. If agreement is not satisfactory the distribution is adjusted and the comparison repeated. This recursion produces a uni-modal distribution is obtained with its first three moments in reasonable agreement with the sample that has very low yields occurring at least once in 30 years.

### *Price Distributions*

We are interested in the change in December futures price from March 1<sup>st</sup> to December 1<sup>st</sup>. We build an approximately stationary sampling distribution by taking the logarithm of the December futures price on December 1<sup>st</sup> divided by the December futures price on March 1<sup>st</sup> and designating this distribution as  $\text{LnP}_h$ . Assuming the data resulted from sampling of a lognormal price distribution, we can use this data set to estimate the parameters of  $\text{LnP}_h$ , which leads to an estimate of a lognormal historical distribution of prices (Sherrick, Garcia, and Tirupattur, 1996). In the next section, we investigate the coupling between the price sampling distribution,  $\text{LnP}_h$ , and the yield sampling distribution,  $R_f$ .

Instead of using  $\text{LnP}_h$  directly as a sampling distribution, we chose to use the new crop futures contract market information on March 1<sup>st</sup> to produce a forward looking distribution to account for the possible increase or decrease in price volatility. The goal is still to focus on price change, but we construct  $\text{LnP}_b$  by using an implied volatility estimate to relate a starting point on March 1<sup>st</sup> to a distribution on December 1<sup>st</sup>.

To determine the price probability distribution we first need a calculation of implied volatility. We use 'Barchart.com' to obtain an implied volatility estimate. The Risk Management Agency uses Barchart.com to get the implied volatility which is central to generating premiums for Revenue Protection contracts. We calculate the price probability distribution in the spring on March 1<sup>st</sup>, just after determination of the crop insurance projected price.<sup>13</sup> December option prices expire approximately one week before futures contracts enter the delivery period.

### *National Price Discovery and Distributions*

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<sup>13</sup> For Kentucky the projected price is the average of December corn futures market during the month of February.

We use regression analysis to determine the relation between futures and MYA prices. We regress historical MYA price on December 1<sup>st</sup> futures prices between 1979 and 2013. December 1<sup>st</sup> is used because it represents the fall price, providing an indication of crop size. We include an additional regressor representing the change between futures prices on March 1<sup>st</sup> and December 1<sup>st</sup>. This regressor termed ‘Change’ is intended to capture large deviations in prices that signal changes in the following years production demand. A large positive change may indicate a low yield and thus the need for additional production the following year. A large negative change may signal the opposite, plenty of stocks and less need for production the following year.

$$(5) \quad MYA = \alpha + \beta F_{Dec} + \gamma Change + \varepsilon$$

where MYA is the USDA marketing year average price;  $F_{Dec}$  is a vector of futures prices on December 1<sup>st</sup>; Change is a vector indicating the change in the December futures contract price between March 1<sup>st</sup> and December 1<sup>st</sup>;  $\alpha, \beta, \gamma$  are estimated parameters and  $\varepsilon$  represents the error term.

Estimated regression parameters are used to obtain the predicted value for the MYA variable. The national price residual ratio distribution,  $R_{np}$ , which we use as the sampling distribution, is calculated as

$$(6) \quad R_{np} = \frac{MYA - MYA_{est}}{MYA_{est}}$$

where  $MYA$  represents the sample value for MYA, and  $MYA_{est}$  represents the predicted national average price using equation (5) regression.

We assume  $R_{np}$  can be used as a stationary sampling distribution, i.e., that the distribution of ratios of difference from the trend divided by the trend does not change over time.

## **Joint Dependence**

The instruments in our portfolio are not independent. They have a dependency structure because the variables (farm yield, county yield, farm price, MYA) used to calculate them are dependent. We use a divide and conquer strategy to model the dependency of; farm yield, county yield, farm price and MYA. The dependence of farm yield, county yield and farm price are characterized directly by using historical data between 1979 and 2014 on farm yield, county NASS yield, and futures prices on December 1<sup>st</sup>, table 1. The 3D joint distribution is formed using ANALYTICA's adaption of the classic Iman and Conover (1982) procedure. The dependence of MYA on the other variables is determined indirectly by using regression containing Pf. Because farm price is correlated to county yield and farm yield, MYA is correlated to county yield and farm yield.

## **Monte Carlo Simulation**

We construct a Monte Carlo simulation model with 30,000 iterations using ANALYTICA decision support software. We analyze risks faced by our representative farm in which we calculate the distribution of net income coming from yield and price distributions, combined with an estimate of the farm yield, county yield, and farm price correlation. From this calculation, we can assess the level of net income risk (1% and 5% ES) and impact from crop insurance, Farm Bill and hedging risk management tools. Risk management variables include: crop insurance (no insurance, revenue protection [RP], and revenue protection with harvest price



exclusion [RP-HPE] at six coverage levels ranging from 60 to 85% in 5% increments); Farm Bill options ARC-CO, PLC, and SCO; and hedging (futures market, 0 to 110% of Actual Production History [APH]). For the crop insurance unit choice, we limit the analysis only to enterprise units because the producer is trying to manage farm net income; fields entering and exiting production over time make it difficult to obtain field level yield probability distributions.<sup>14</sup> We limit hedging to cash contracts with the local elevator. With cash contracts the producer can hedge any amount of bushels between 0 to 110% of APH. Grain is to be valued on December 1<sup>st</sup> harvest using the historical basis on December 1<sup>st</sup>. The historical basis is estimated as the average over the previous 20 years at the elevator the producer traditionally delivers to.<sup>15</sup>

We calculate farm production costs in two parts: costs that are independent of yield and costs dependent upon yield. This calculation method accurately reflects farmer costs. With a crop insurance contract, not incurring costs dependent upon yield, such as harvest costs results in the producer being financially better off with a zero yield compared to a yield one bushel below the insurance guarantee.<sup>16</sup> Items used to calculate costs are the same as those found in a land grant university extension budget. Costs dependent upon yield are calculated using historical per acre harvest costs. Costs included are combine costs, trucking costs (both from the field to the bin and from the bin to the elevator), and drying costs. The cost per acre including land costs is \$606 for this farm, while the estimated harvesting cost is \$0.48 per bushel. The farm average yield is 149 bushel per acre, resulting in total production costs of \$678 per acre. Average

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<sup>14</sup> Enterprise units limits losses to sources impacting the entire farm such as those stemming from drought and heat. Losses stemming from sources like localized wind storms and hail, for example, would be internalized by the producer.

<sup>15</sup> To focus our analysis on the relationship between hedging and crop insurance we did not consider possibility that basis risk is correlated with prices and yields. The twenty year average basis is found to be \$0.06/bu.

<sup>16</sup> For example, say the guarantee is 150 bu per acre and the harvest price equals the base price and local cash price. Harvest cost for 149 bushels per acre is \$86.42 (149\*\$0.58). Incurring a complete loss implies the producer saves over \$86 per acre in cost vs. harvesting on bushel below the guarantee.

production per-acre costs are similar to the average costs found in the University of Kentucky no-till corn budgets (Halich, 2015).

We analyze the farm net income portfolio at two distinct points in time. The first point is in the spring, right after the crop insurance projected price is determined, corresponding to the time when the producer is making investment decisions on which crop or how many acres of a crop to plant. The second point is in the fall, just before December when futures go into delivery. Harvest is completed, so crop size, as well as crop insurance harvest price have been determined. For simplicity, the crop insurance harvest price is set equal to the futures price on December 1.<sup>17</sup> These points in time are noteworthy because of their relationship to spring planting investments and how crop insurance functions to protect prices. For hedging, crops can be pre-sold only at the first point (March 1<sup>st</sup>) in the spring. Any remaining unsold bushels must be sold at the second point (December 1<sup>st</sup>), and oversold bushels are bought back at the second point. We do not consider storage past December 1<sup>st</sup> because it is outside the crop insurance price protection window. Any net income or loss incurred by storing un-priced crop past December 1<sup>st</sup> can be credited to a separate storage enterprise and estimated using a different model; therefore, post-harvest price decisions are separated from pre-harvest decisions. MYA price is calculated monthly as an average price weighted by the quantity of grain sold that month. As a result the fall price on December 1<sup>st</sup> will be representative of the final fall price because of the large volume of grain being sold to the elevator off the field. At the second point we

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<sup>17</sup> The fall price guarantee for KY is the December futures averaged over the month of October. Under the Black-Scholes-Merton assumptions of a stochastic process following geometric Brownian motion, this is a path-dependent quantity (Glassman 2004). We have modeled this quantity, and its distribution has a slightly smaller spread and the same average (zero drift) as the December 1<sup>st</sup> futures price distribution.

calculate the expected MYA price and therefore any potential payments stemming from the Farm Bill programs.

## **Results**

Farm and county yield distributions are presented in figure 2. Farm yield distribution comes from the producers 35-year historical, de-trended corn yield. County yield distribution comes from the county 35-year historical, de-trended NASS corn yield. Both farm and county yield distributions display a strong presence of ‘tail risk’, indicating the probability exists of experiencing catastrophic low yield events. The farm yield distribution is not as skewed to the left as the county distribution, indicating lower probability of incurring a low yield than the county. Farm yield distribution contains higher yields than those found at the county, a result indicating the farm can produce higher yields than the average county farm.

Figure 3 presents the December 2015 corn futures price and the 2015 MYA price probability distribution functions. December 2015 corn futures prices were evaluated on March 3, 2015, the first trading day after the crop insurance projected price was set. Implied volatility from ‘Barchart.com’ was found to be 18.4%. December futures prices on March 1<sup>st</sup> were found to be \$4.137 with an estimated standard deviation of 0.92. Table 2 reports estimated coefficients from the regression equation (5) describing the relation between futures price and MYA. The R<sup>2</sup> value was 0.92, indicating a strong relation in the estimated equation. The regression predicted MYA price is \$4.016. Estimated standard deviation for MYA price was found to be 0.77. Both MYA price and standard deviation were found to be smaller than those in the futures market. As a result the MYA price distribution is contained within the December corn futures distribution.

Payment bands for both ARC-CO and PLC are presented in Figure 4. Results indicate ARC-Co payment trigger starts and max payment is hit before payments in PLC start. This result highlights the ‘shallow loss’ function of ARC-CO, in that it pays early but only over a small band ranging from 0 to \$59.4 per acre. Further declines in prices are not covered under ARC-CO. PLC payment trigger starts at a lower price than ARC-CO and continues to pay until the loan rate is reached. Potential payments vary from 0 to about \$188 per acre. Constraints on payment bands limit usefulness as a risk management tool because very low probability events, having the most substantial impact on income, will only be covered up to a point.

Net income uncertainty results, with crop insurance, PLC, and ARC-CO and without any are presented or hedging in Figure 5. Results indicate that PLC stochastically dominates being without. ARC-CO second order stochastically dominates PLC. Crop insurance, with a RP contract at 80% coverage level second order stochastically dominates ARC-CO.

Net income uncertainty results, with hedging and no insurance are presented in Figure 6. Results indicate hedging reduces uncertainty by placing more probability in a narrower band of income. Risk reduction gains from hedging are negligible. Hedging reduces the probability of receiving a high price.

Net income uncertainty results, with hedging and RP-80% are presented in Figure 7. Results indicate that hedging with insurance provides further reductions in risk. Hedging also reduces the probability of receiving a higher price when used in conjunction with crop insurance.

Net income results, with crop insurance (RP-80%), ARC-CO, PLC, and SCO across different hedging levels are presented in figure 8. Results indicate that RP-80% plus ARC-CO provides the highest net income across all levels of hedging. RP-80% plus PLC and SCO

provide the second best net income. At no level of hedging does the portfolio offering the highest net income change. Increases in hedging slowly reduces income.

Expected Shortfall at the 1% level results are presented in Figure 9. Results indicate 1%ES is minimized with RP-80%, ARC-CO, and 40% hedging. Because our analysis is only a yearly snapshot results are specific to 2015. ARC-CO payments in 2015 will lower the 2016 ARC-CO revenue level. Crop insurance represents the foundation to risk management by reducing 1%ES risk more than any other risk management option. Hedging and crop insurance plus ARC-CO appear to be complements because 1%ES measure declines as hedging increases from 0 to 40%. Hedging with crop insurance and PLC or PLC plus SCO does not reduce 1%ES measure by much, indicating weak complements. It is unclear whether hedging and ARC-CO are complements. Visually it appears ARC-CO induces additional hedging over crop insurance alone because the crop insurance curve flattens, indicating a maximum, at a hedging point lower than crop insurance plus ARC-CO.

## **Conclusions**

In this paper, we examined how Farm Bill choices interact with other risk management programs, namely crop insurance and hedging, a privately provided tool through a portfolio approach. Our main contribution is that our model accounts for farm yield, county yield, and farm price correlation while connecting the fall price to MYA price. The fall price to MYA connection allows us to evaluate Farm Bill choices while facing crop insurance and hedging choices. Our approach of incorporating uncertainty into the whole risk management decision making process, improves risk management decision making when the producer faces multiple programs each containing multiple choices.

This research provides risk management insights to the relation between the 2014 Farm Bill relation and relation with other currently existing risk management tools. Focusing on risks faced by our representative producer allows us to accurately describe his risks and correlations with aggregate variables. However, there are shortcomings to this approach. First, different results may be found when modelling producers in different locations with different risks and correlations. Second, our ‘yearly snap shot’ approach does not evaluate the long term impact of the Farm Bill decision. Identifying long term risks is difficult, the December 2018 CME corn contract is thinly traded, indicating traders are not even willing to make decisions that far out in time. Nevertheless, our approach provides a baseline on how to identify the efficient portfolio of risk management tools.

Results indicate that expected income is the highest when selecting a RP crop insurance policy and ARC-CO. The next highest expected income occurs when selecting RP with PLC and SCO. It is not surprising that government provided risk management tools increase expected income because all are subsidized. ARC-CO and PLC premiums are subsidized at 100% where SCO is subsidized at 65%. Risk management results indicate the 1%ES is minimized with RP-80% crop insurance policy, ARC-CO and 40% of expected production hedged. Crop insurance is the foundation of the risk management platform. ARC-CO, PLC, and SCO provides additional risk management protection but this protection is small in comparison to crop insurance. Crop insurance plus ARC-CO appear to complement hedging because 1%ES declines as hedging increases. Farm Bill options appear to complement currently offered risk management choices, a result indicating the Farm Bill may be an efficient tool to reduce producer risk.

## Literature

Chavas, J. 2004. *Risk Analysis in Theory and Practice*. Burlington, MA: Elsevier Inc.

CME Group. 2015. Timeline of CME Achievements. Available online at: <http://www.cmegroup.com/company/history/timeline-of-achievements.html> (accessed May 2015).

Coble, K. H., Barnett, B. J., & Riley, J. M. 2013. Challenging Belief in the Law of Small Numbers. In *Agricultural and Applied Economics Association 2013 Crop Insurance and the Farm Bill Symposium, Louisville Oct.*

Congressional Budget Office. 2014. Letter from Elmendorf, director, Congressional Budget Office, to the Honorable Frank Lucas, on estimated costs of HR 262, January 28. <http://www.cbo.gov/sites/default/files/cbofiles/attachments/hr2642LucasLtr.pdf>.

Halich, G. 2015. Corn and Soybean Budgets (Central KY 2015). Retrieved spring 2015 from <http://www2.ca.uky.edu/AgEcon/index.php?p=150>

Iman, R. L., & Conover, W. J. 1982. A distribution-free approach to inducing rank correlation among input variables. *Communications in Statistics-Simulation and Computation*, 11(3), 311-334.

Miller, S.E., & Kahl, K. H. 1987. Forward pricing when yields are uncertain. *Review of Futures Markets*, 6, 21-39.

Schnitkey, G. D., Sherrick, B. J., & Irwin, S. H. 2003. Evaluation of risk reductions associated with multi-peril crop insurance products. *Agricultural Finance Review*, 63(1), 1-21.

Sherrick, B. J., Garcia, P., & Tirupattur, V. 1996. Recovering probabilistic information from option markets: Tests of distributional assumptions. *Journal of Futures Markets*, 16(5), 545-560.

U.S Department of Agriculture, Risk Management Agency. 2015. Summary of Business. Available online at: <http://www.rma.usda.gov/data/sob.html> (accessed May 2015).

U.S Department of Agriculture, Risk Management Agency. 2015. Supplemental Coverage Option for Federal Crop Insurance. Available online at: <http://www.rma.usda.gov/news/currentissues/farmbill/2014NationalSupplementalCoverageOption.pdf> (accessed May 2015).

Woodard, J. D., Sherrick, B. J., & Schmitkey, G. D. 2010. Revenue Risk-Reduction Impacts of Crop Insurance in a Multicrop Framework. *Applied Economic Perspectives and Policy*, 32(3), 472-487.



Table 1. Correlation Coefficients

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	Farm yield	County yield	Farm price
Farm yield	1.0	0.87	-0.27
County yield	0.87	1.0	-0.31
Farm price	-0.27	-0.31	1.0

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Figure 1, Farm, County (Hardin County), State (Kentucky), and National Yield Distributions.

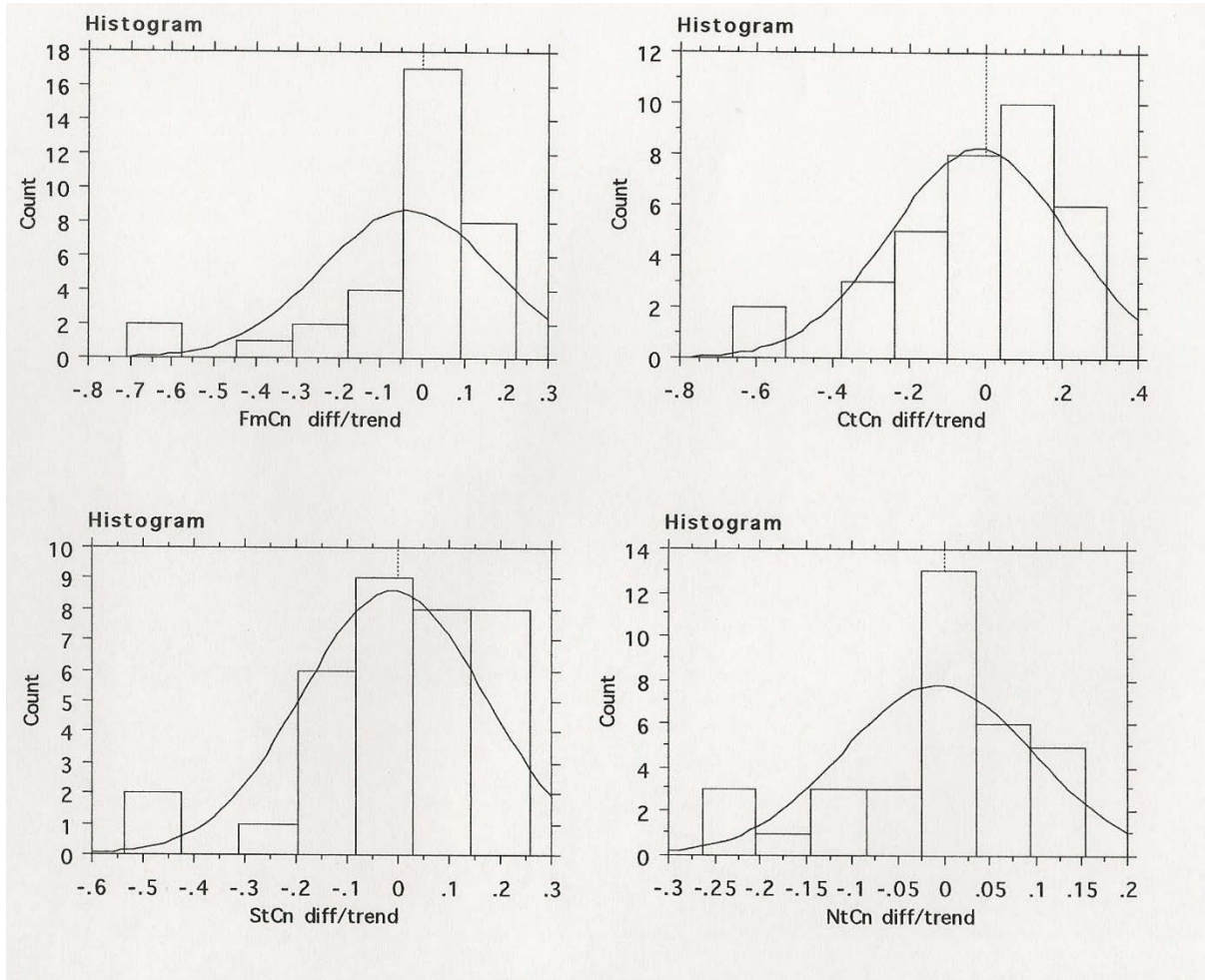


Figure 2. Farm and County Yield Probability Distribution Functions.

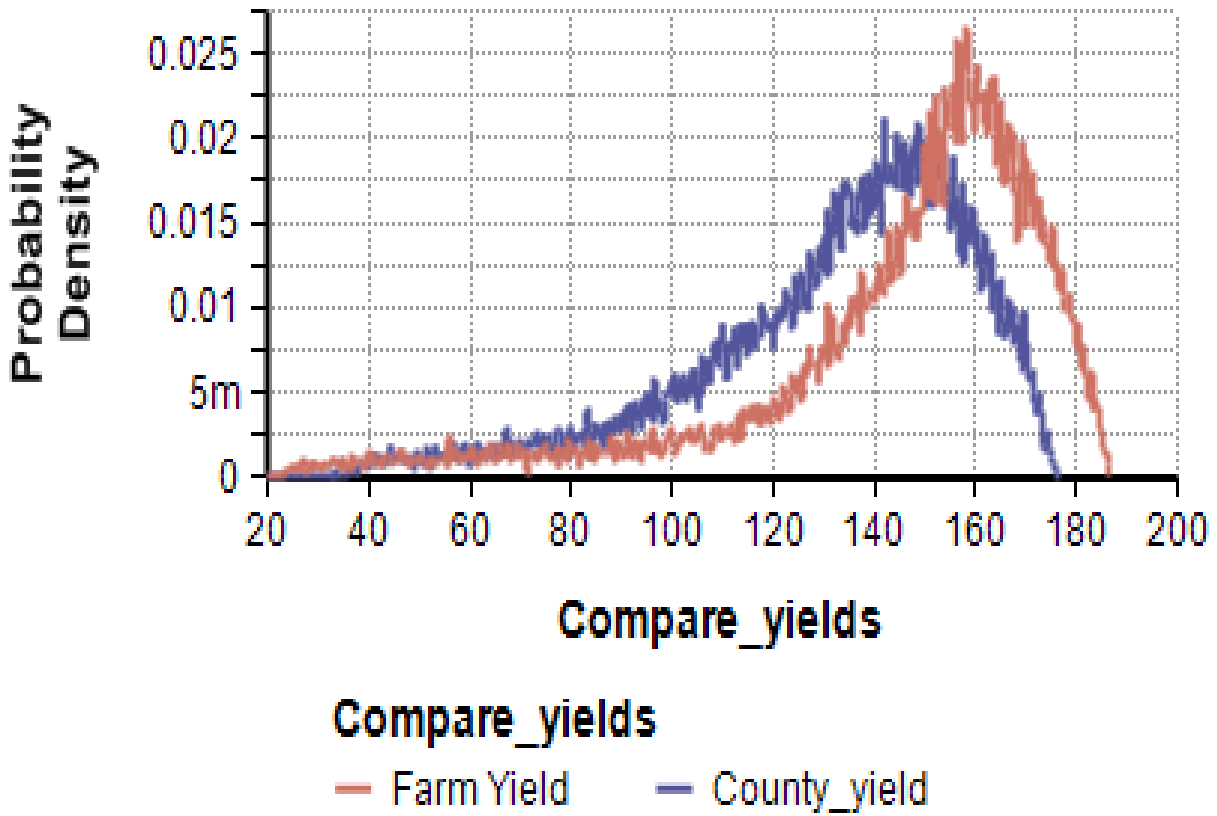


Figure 3, December Futures and Marketing Year Average Probability Distribution Functions.

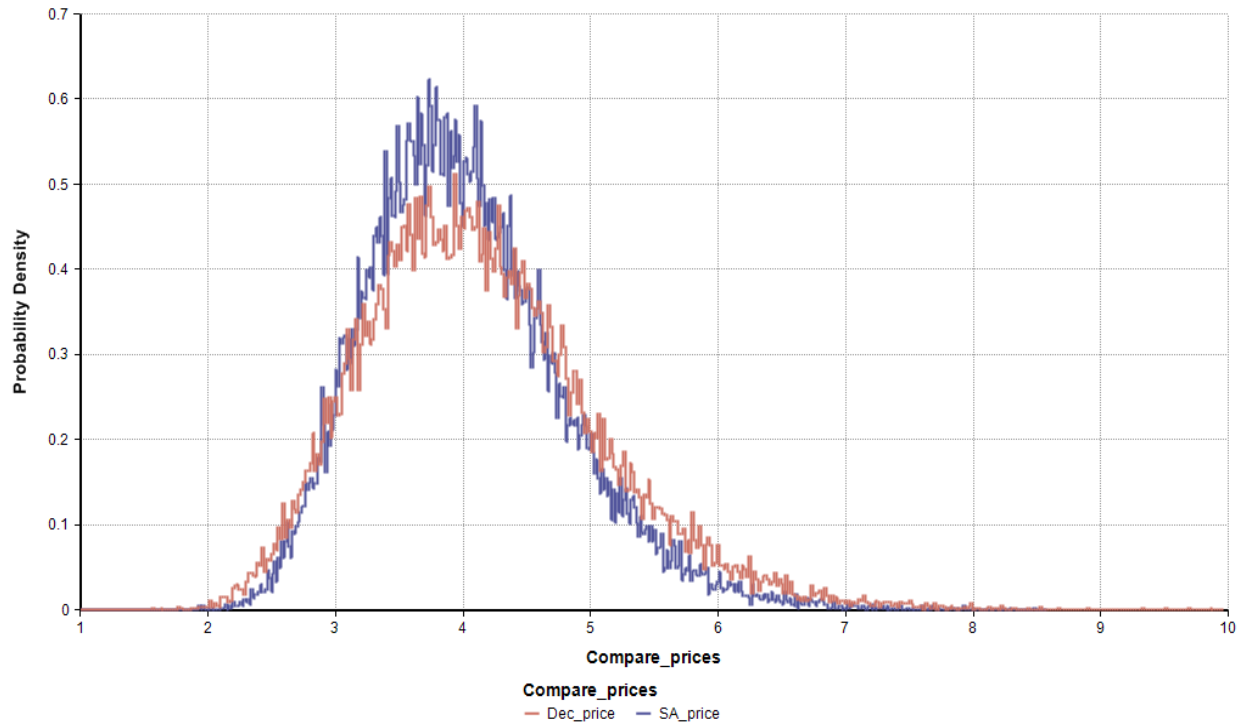


Table 2. Relation of Futures price on MYA

Parameter	Coefficient
December 1 <sup>st</sup> Futures Price	1.015* (0.030)
Change <sup>#</sup>	-0.246* (0.064)
Constant	-0.180 (0.093)

Notes: Standard errors are in parenthesis. Asterisk (\*) indicates significance at the 5% level. # indicates the difference in futures price between March 1<sup>st</sup> and December 1<sup>st</sup>.

Table 4. ARC-CO and PLC Payment Bands for Hardin County Kentucky in 2015.

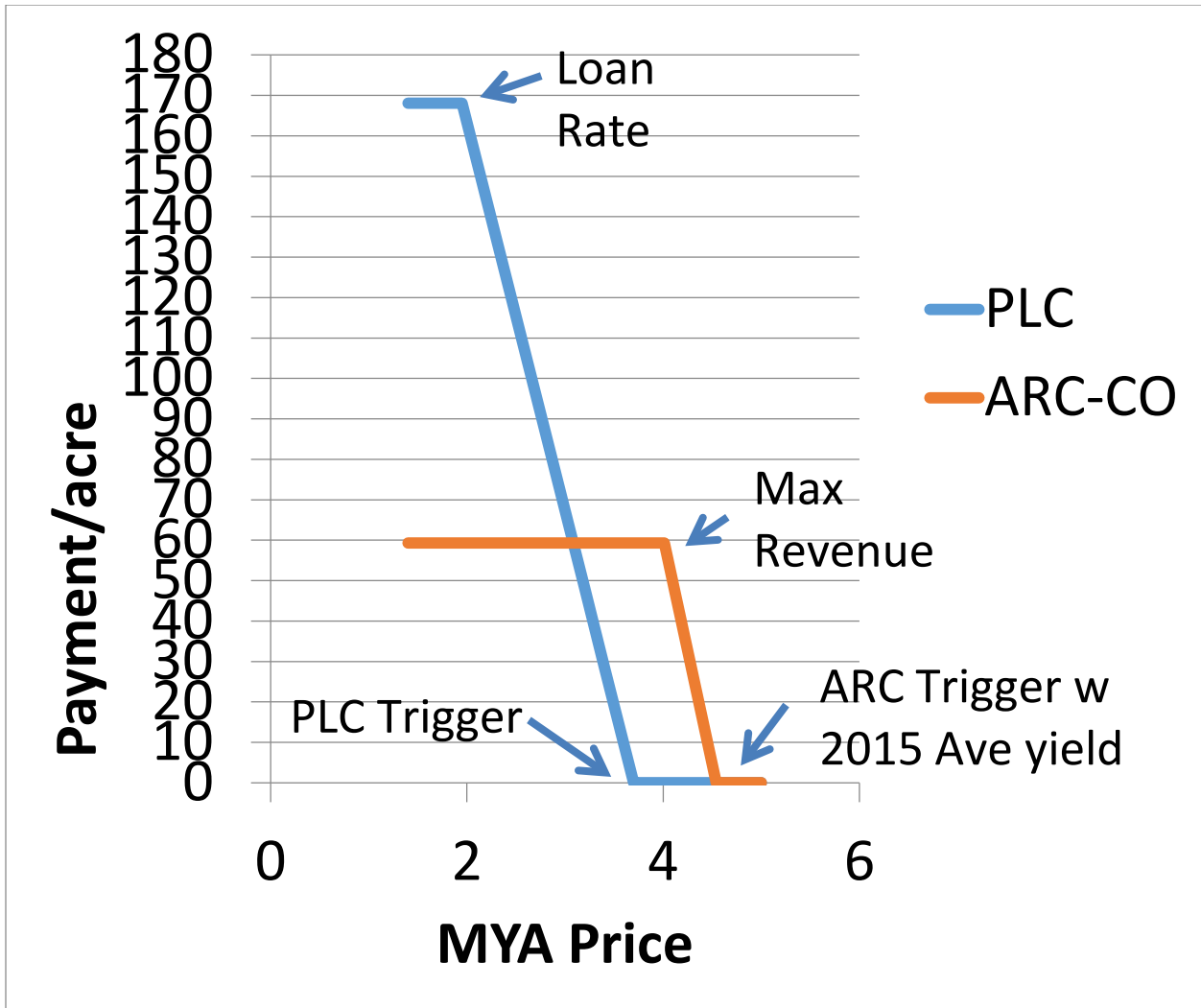


Figure 5. Farm Net Income Risk Cumulative Distribution Function with Crop Insurance, ARC-CO, PLC, and without.

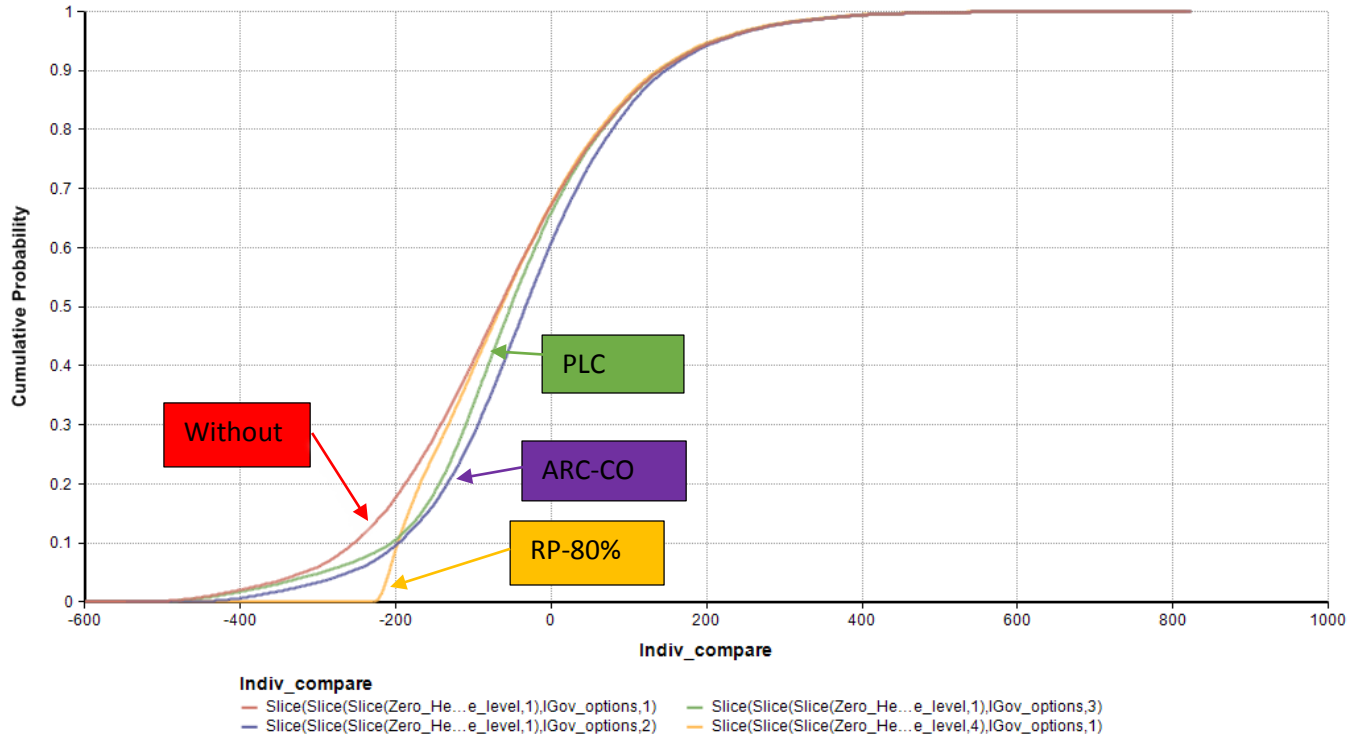


Figure 6. Farm Net Income Risk Cumulative Distribution Function with and without hedging.

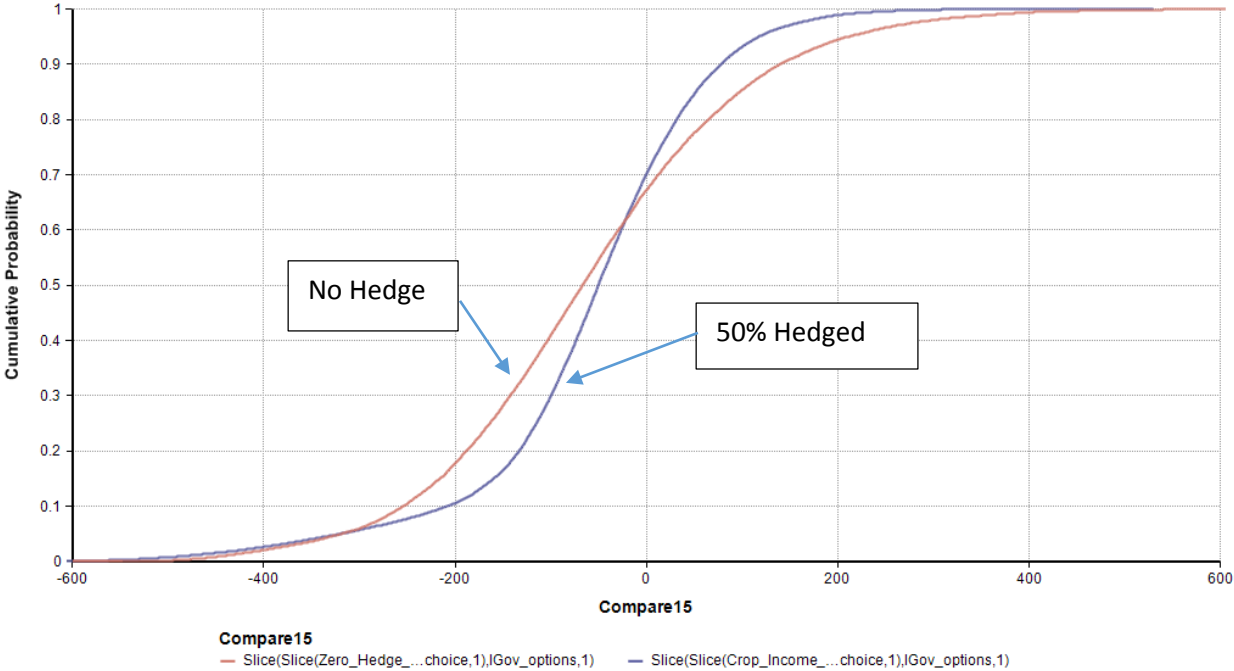




Figure 7. Farm Net Income Risk Cumulative Distribution Function with Crop Insurance and with and without hedging.

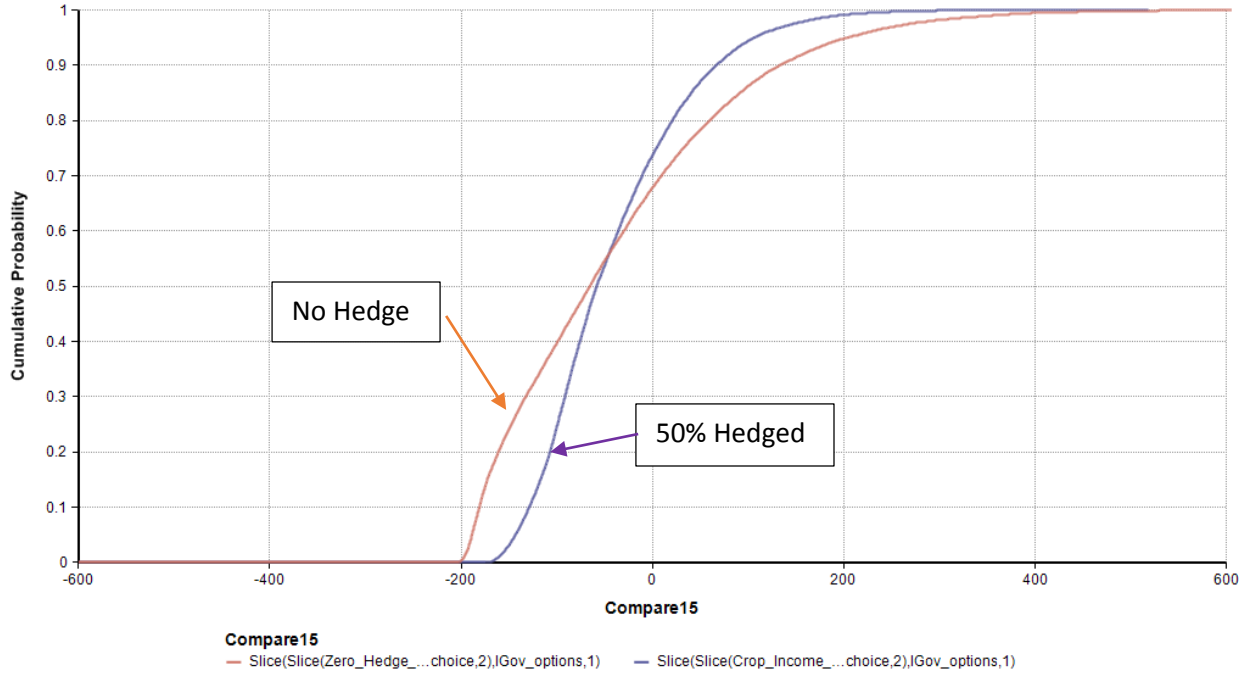


Figure 8. Average Income with Crop Insurance, ARC-CO, PLC, and SCO across Different Hedging Levels

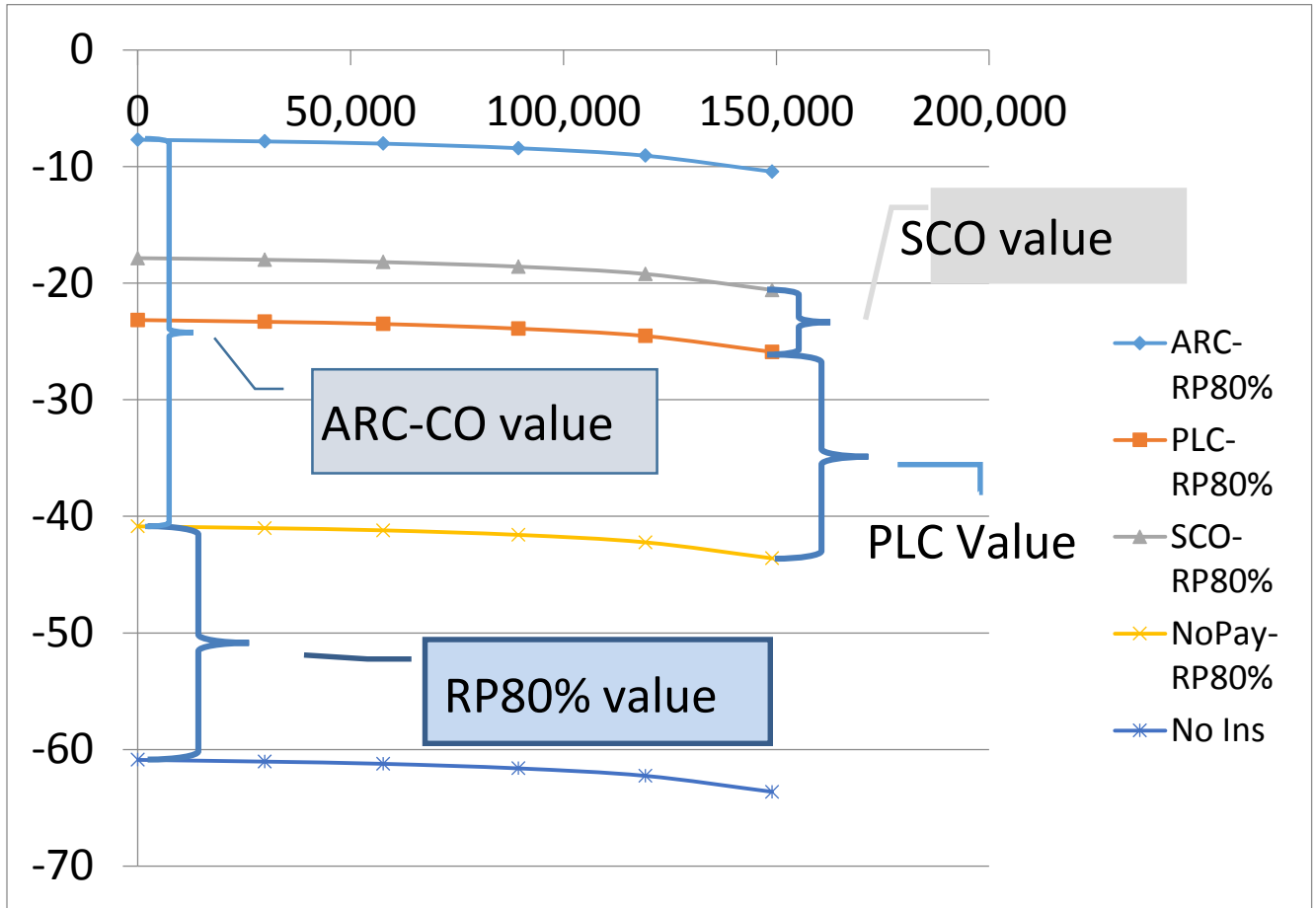


Figure 9. 1% Expected Shortfall for 2015.

