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**Optimal Coverage Level and Producer Participation in Supplemental Coverage Option in  
Yield and Revenue Protection Crop Insurance**

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## **Optimal Coverage Level and Producer Participation in Supplemental Coverage Option**

### **Abstract**

*The 2014 Farm bill included a new supplementary coverage option (SCO) to provide additional protection against shallow losses not covered by the individual crop plans. SCO indemnification triggers off of county yields or revenues whereas individual plans trigger off of the individual farmers' yields or revenue. In this paper we examine the impact of supplementary coverage option on the optimum producer coverage level. Our findings indicate that the individual plan with SCO provides better protection but is distortionary to the current choice of coverage level. The new optimal coverage level choice is likely to differ and vary in counties depending upon the counties' respective yield variability.*

**Key Words:** Crop insurance, supplemental coverage option, optimum coverage level

*JEL codes:* G22, Q14, Q18

Crop Insurance is one of the main risk management tools available to U. S. farmers. The Federal Crop Insurance program has undergone several changes in order to accommodate the risk management requirements of farmers. The Agricultural Act of 2014 (commonly known as the 2014 Farm Bill) introduced various changes to the Federal Crop Insurance Program.

Supplemental Coverage Option (SCO) is one of the major changes that were introduced to be an endorsement to the most popular crop insurance plans: Yield Protection (YP), Revenue Protection (RP), and Revenue Protection with Harvest Price Exclusion (RP-HPE). SCO provides protection for losses of the underlying individual policies' deductible. Individual plans contribute

about 86 percent of gross premium and 81 percent of liability to the federally funded U.S. crop insurance program. RP is by far the most popular among all individual crop insurance plans with 80 percent of premium and 73 percent liability. Combining SCO with these individual plans is not only likely to increase the premium and liability amounts but also likely to increase the probability of the loss and magnitude of loss due to its design as a shallow-loss protection.

SCO is available with YP, RP, and RP-HPE, and it can cover the deductible above the underlying plan up to 86 percent. The crop insurance guarantee for YP is based on the individual yield risk while RP and RP-HPE coverage is based on the individual yield and price risk. SCO's guarantee, therefore, is also based on the underlying policy's source of risk. However, SCO loss trigger is based on the Area Risk Protection Insurance (ARPI). The yield or revenue guarantee for SCO is determined from the individual plans whereas indemnification is based on the ARPI. For instance, if a farmer elects a 75 percent coverage level, then SCO coverage level range is 86 percent minus 75 percent (11 percent). The guarantee for SCO is the coverage range times the guarantee under individual plans assuming 100 percent coverage.

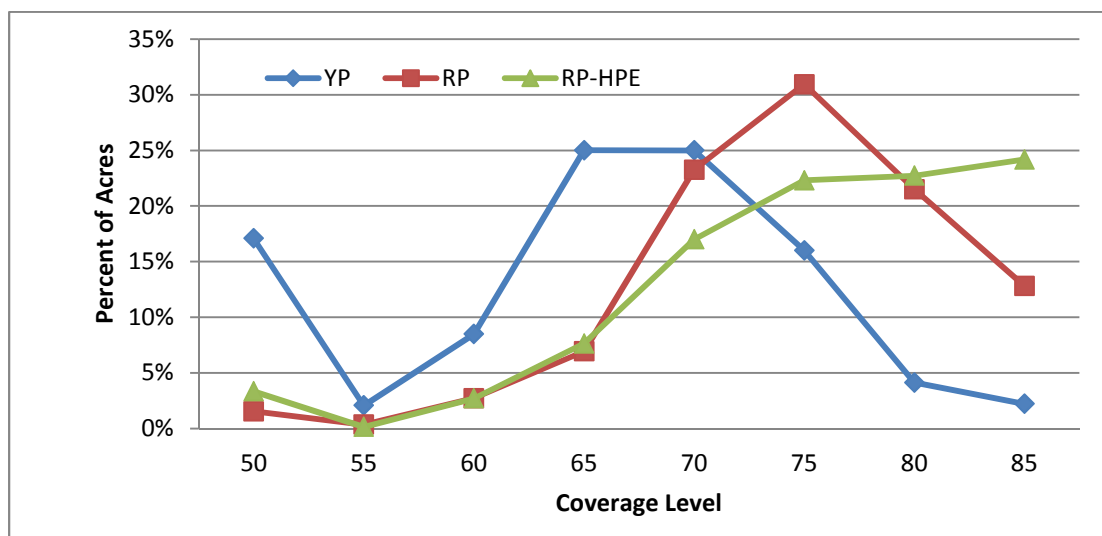
The individual plans have a regressive proportional subsidy where the subsidy is proportional to the premium charged to the farmer while the rate of subsidy declines as coverage level increases. SCO premium has a different subsidy structure from the underlying policy and is 65 percent flat regardless of the coverage range. Combining the subsidy of individual plans and SCO, then the net cost to farmers after applying subsidy varies by coverage level and substantially differs from individual plans alone. Relative cost and benefit of the insurance coverage is likely to induce switching from one coverage level to another. Average coverage selection by farmers across the U. S. for YP is more or less stable in the neighborhood of 60 percent. RP and RP-HPE coverage level averaged larger than YP and are not as stable as YP

(Table 1). There was an increase in average coverage level in 2009, probably due to the increase in the subsidy in 2009 for enterprise units by about 20 percent point.

**Table 1. Historical Average Coverage Level for Corn**

Plan	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
YP	62	62	62	61	62	62	61	61	62	61
RP	72	73	74	73	73	76	75	76	76	77
RP-HPE	72	72	72	72	71	72	72	77	77	78

Regarding acreage participation by coverage level, in 2013 about 25 percent of corn insured acres is enrolled with 65 and 70 percent coverage level in YP (each equally popular). However, 75 percent coverage level in RP was popular among the corn producers in the U.S. About 31 percent of the total corn insured acres was enrolled in 75 percent coverage level (Figure 1). SCO subsidy combined with retrogressive subsidy of individual plan can make these coverage levels either more or less profitable.



**Figure 1. Percentage of Acreage by coverage level in 2013**

The interaction between the SCO and underlying individual policy should be understood in order to evaluate the farmer's decision on which crop insurance plan and coverage level to select. Past literature focused on the crop insurance plan choice between individual and area decisions (Miranda, 1991 and Mahul, 1999). Literature also explored the farmers' choice between yield vs. revenue plans (Sherrick et al. 2003, Shaikh et. al, 2008, Adhikari, Belasco, and Knight, 2010). However, the multiple available coverage level choices were not included in these studies. Bulut, Collins, and Zacharias (2012) studied the coverage choice with individual and area insurance plan. They have theoretically solved for the optimum coverage demanded for various scenarios of interaction between area and individual insurance. However, there has not been an attempt to evaluate the optimum coverage level demanded for the SCO and underlying individual crop insurance plans. Therefore, we attempt to provide an answer to the optimum coverage level for two crops and two individual crop insurance plans with the SCO endorsement. Our study further extends to evaluate the changes in the optimum coverage level relative to the yield risk and risk taking behavior of the farmers.

### **Conceptual Framework**

A farmer chooses a coverage level for individual plans that maximizes their expected net return from the insurance. A farmer's decision on the coverage level is based on maximizing the net return of the individual plan and SCO endorsement. The indemnity function of the individual plan is:

$$I_i = \text{Max}(0, x\bar{Y}_i - Y_i) \quad (1)$$

where  $x$  is the coverage level and for YP, and  $\bar{Y}_i$  is the expected yield. In the case of RP,  $\bar{Y}_i$  is the expected revenue with a maximum of harvest and projected price, and for RP-HPE, it is the

expected revenue with project price for RP-HPE. For YP,  $Y_i$  is the realized yield and for both RP and RP-HPE, it is the realized revenue. The indemnity function for SCO is written as:

$$I_{sco} = \text{Min} \left( 1, \text{Max} \left( 0, \frac{0.86 - \frac{Y_{ci}}{Y_c}}{0.86 - x} \right) \right) * \bar{Y}_i \quad (2)$$

where,  $Y_c$  and  $Y_{ci}$  is the county expected yield and realized county yield for YP, expected and realized county revenue with maximum of projected or harvest price for RP, and expected and realized revenue with projected price for RP-HPE.

SCO indemnification is based on the area yield and the guarantee is based on the individual plan. When a farmer selects the SCO endorsement with the individual plan, the indemnity is the sum of indemnity from both the individual plan and the SCO endorsement.

$$I = I_i + I_{sco} \quad (3)$$

There are four different cases of losses under the SCO endorsement; a farmer can experience a loss on the individual plan but not on SCO endorsement, a loss on SCO but not on the individual plan, a loss on both or on neither. In these loss scenarios  $I_i$  and  $I_{sco}$  can have value of zero or nonzero. The variance of loss is the sum of variances from the individual plan, SCO, and covariance of the loss from individual plan and SCO. The covariance is the function of correlation between individual farm and county yield.

Though SCO is an endorsement on underlying individual policies, it is priced as a separate insurance plan. We assume the individual and SCO are priced with actuarially fair premium rates. The government subsidy for the SCO is fixed at 65 percent of the premium while for individual plans it is variable with coverage level. Producer premium is the cost to the

producer after deducting the subsidy. Let  $\gamma_p$  be the producer premium,  $\gamma_i$  be the premium on the individual plan,  $\delta_x$  be the subsidy rate by coverage level ( $x$ ), and  $\gamma_{sco}$  be the premium for SCO, then producer premium is:

$$\gamma_p = \gamma_i * (1 - \delta_x) + \gamma_{sco} * (1 - 0.65) \quad (4)$$

Producers' net benefit with the individual insurance is:

$$\pi_i = I_i - \gamma_i * (1 - \delta_x) \quad (5a)$$

and with individual and SCO endorsement it is:

$$\pi_{i+sco} = I - \gamma_i * (1 - \delta_x) - \gamma_{sco} * (1 - 0.65) \quad (5b)$$

We assume farmers choose the coverage level that maximizes their net profit ( $\pi_{i+sco}$ ). By definition, actuarially fair premium is the premium that equals expected indemnity. Net profit from the individual and SCO depend on expected indemnity and the associated premium subsidies. SCO has 65 percent subsidy that results in smaller producer premium regardless of the coverage level while subsidy for individual plan declines as coverage level increases. The total cost to the producer for the individual plan and SCO endorsement is larger than it would be for just the individual plan. Expected indemnity is higher from the larger coverage for individual plan and lower for SCO. Conversely, lower coverage level has larger expected indemnity from SCO but smaller from individual plan. Given the scenario of indemnity expectation with and without SCO and subsidy structure with respect to the coverage level, the coverage choice can be different with SCO from that without SCO.



## **Analytical Procedure**

This research takes the case of two sample counties; one for non-irrigated corn and the other for upland cotton. We have selected McLean county of Illinois for corn and Lubbock county of Texas for cotton. Both of these counties are the largest producing counties for corn and cotton, respectively. County and farm yields are important aspects in this analysis. An additive model of county and farm yield, as proposed by Miranda (1991), is a popular method to separate idiosyncratic random and deterministic yield from county yield. The same model has been used in various other crop insurance research papers (Carriquiry, Babcock, and Hart, 2005, Adhikari, Knight, and Belasco, 2013). However, there is a multiplicative model that assumes farm yield is a random proportion of the county yield (Deng, Barnett, and Vedenov, 2007). The multiplicative model determines the mean farm yield relative to county yield while the variance of the random proportion partly determines the proportion of the farm yield variability (Mitchell and Knight, 2008). For this study actual farm yield is not available. We assumed the county average yield to be the farm average yield and used Risk Management Agency's premium rate of 65 percent coverage level and backward iteratively solved for the implied yield variance for the given premium rate. This method assumes that RMA's premium rate is actuarially fair rate and estimates the yield risk associated with the rate. We have calculated county average yield and standard deviation from the detrended National Agricultural Statistical Service (NASS) yield series. Now we assumed the correlation between county and farm is 0.8. For the revenue products, we obtained projected and harvest price information from various extension publications and RMA's website source.

In order to conduct the analysis for individual plan and SCO, we have to construct a portfolio with county yields, farm yields, and prices. We use correlation among county and farm yields and yield price correlations to draw the marginal distribution of the county yields, farm yields, and harvest prices. We assumed yield and price correlation the same between county yield and price and farm yield and price. A multivariate simulation approach developed by Phoon, Quek, and Huang (PQH) is used to draw 10,000 correlated county yield, producer yield, and price series. PQH presents a very flexible technique for simulating correlated random variables that have mixed marginal distributions by using a priori spearman rank correlation and offer the benefit over traditional Iman and Conover process (Phoon, Quek, and Huang, 2002; Anderson, Harri, and Coble, 2009) . We assumed that county and farm yields have truncated normal distribution, and that prices have log normal distribution. The projected price and volatility factor estimated by the RMA for 2015 are used as yield parameters. Parameters of yield and price used in simulation are given in the table 2.

**Table 2. Yield and Price Parameters**

County/ Crop	County Yield			Farm Yield			Price	
	Avg.	Stdev	CV	Avg.	Stdev.	CV	Proj. Price	Volatility Factor
McLean, IL/Corn	179.37	23.78	0.13	179.37	42.90	0.24	4.15	0.21
Lubbock, TX/Cotton	435.95	233.21	0.53	435.95	470.47	0.86	0.61	0.15

Using simulated farm yields, county yields and price series, we estimate the indemnity, expected indemnity, and the actuarially fair premium rate for the individual plan and SCO endorsement. Indemnity, premium, and subsidy structure for each of the coverage levels is

applied to estimate the net gain from the individual plan, SCO separately and then jointly with SCO endorsement as per the equations 5a and 5b. The optimum coverage level is the one that generates the largest net gain. We compare the net gain at different coverage levels with individual and SCO combined versus the individual plans alone.

For this analysis, we assume farmers are risk averse and buy insurance. We use the power utility function, which is the constant relative risk aversion (CRRA). The CRRA utility function per acre net return ( $\pi_p$ ) for farmers is represented as:

$$U_p(\alpha) = -\pi_p(x)^{1-R} \quad (6)$$

where,  $R > 1$ .

Producer  $p$  has a choice to select the individual plan only or combined individual plan with the SCO endorsement. Net return is the net of the farm revenue, insurance indemnities received, premium paid and initial wealth and is dependent upon the producers' choice of the plan and coverage level. We assume  $R = 2$  to represent a moderate level of risk aversion. Producers' expected utility from the equation (6) is:

$$E[U_p(\alpha)] = E[-\pi_p(x)^{1-R}] \quad (7)$$

The producer maximizes the expected utility by changing the coverage level. Mathematically, the producer's problem is:

$$\max_x EU_i(x) = \max_x \int_{\pi} -\pi_p(x)^{1-R} dF(\pi_p | x) \quad (8)$$

where,  $x \in \{0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85\}$ . The producer faces the choice of two plans; individual plan without SCO and individual plan with SCO, and eight different coverage level

options. These optimal utilities for each of option are converted into the associated certainty equivalent in terms of dollar/acre:

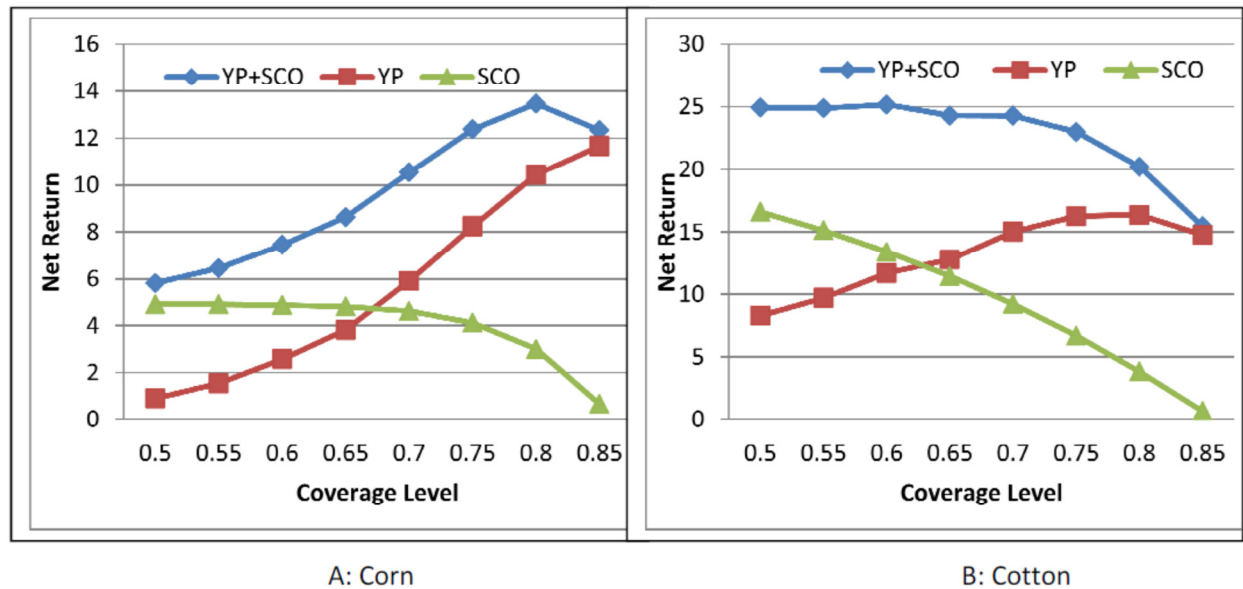
$$CE^* = (-EU_i^*)^{1/(1-R)} \quad (9)$$

Certainty equivalent differences with and without insurance is compared for each of the option and coverage level choice. This is done for YP, RP, and associated SCO endorsement to determine the optimal coverage level for each of the cases.

## **Results and Discussion**

The insurance payout depends on the coverage level elected by a farmer. A higher coverage level provides a higher indemnity payout. A higher coverage level also requires a higher premium rate. Based on the current subsidy structure of the RMA, a higher coverage level has a smaller subsidy while the lower coverage level has a larger subsidy for individual plans. The net return is the indemnity minus the producers' cost (producers' cost is the actuarially fair premium rate – subsidy). In the case of YP corn, the net return of the individual plan is increasing with the increase in coverage level. In case of upland cotton, the net return is increasing but with smaller marginal increments than Corn in McLean County, Illinois. The net benefit from YP crop insurance is greater for the crop that has larger yield variance than for the one with smaller yield variance. However, the marginal incremental net benefit of an increase in coverage level is smaller with larger yield variability. For corn, the largest coverage level, 85%, yields the largest net gain whereas for upland cotton, an 80 percent coverage level provides the largest net gain. When a farmer selects the SCO endorsement, a smaller coverage level provides the largest net gain from SCO both for corn and cotton while the rate of decline in net benefit is smaller for

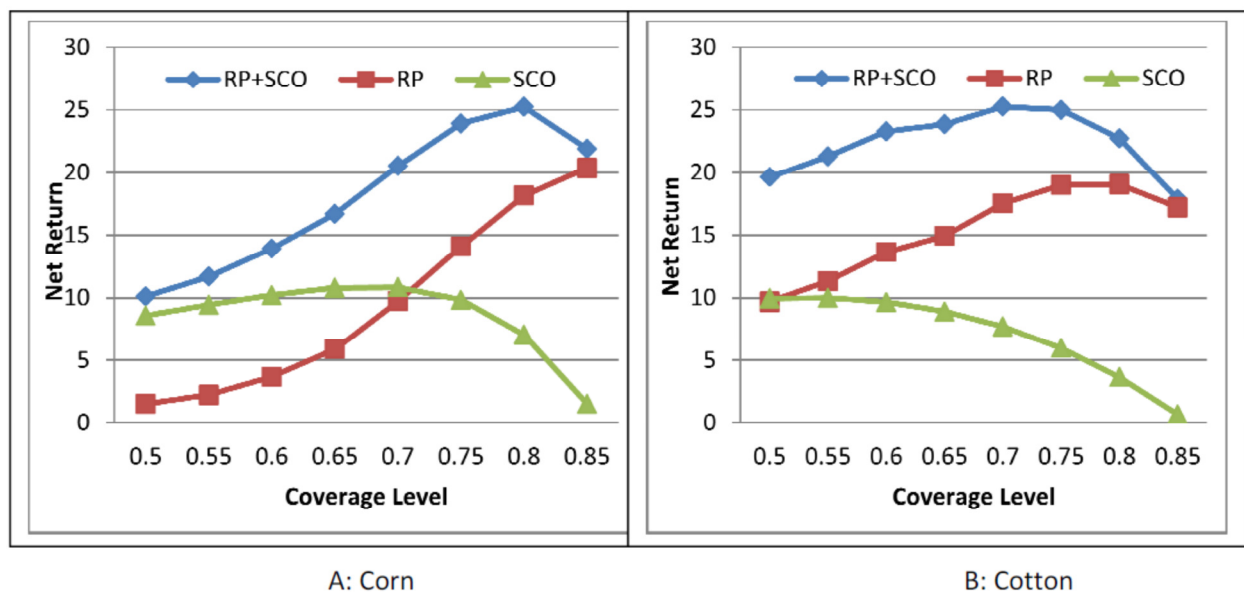
corn than for upland cotton. The optimum coverage level when maximizing the combined net gains from YP and SCO, will be different: an 80 percent coverage level for corn generates the largest net benefit while a 50 percent coverage level (lowest coverage level available) generates the largest net benefit (Figure 2).



**Figure 2. Net Gain from Yield Protection and SCO**

RP is the most popular crop insurance plan amongst US farmers. The net benefit of RP is larger than YP. Farmers in the corn-belt choose very high coverage levels. The results from our study support the farmers' decision to elect higher coverage levels because they can harness greater benefit by selecting higher coverage levels. The marginal rate of increase in net benefit is increasing with the increase in coverage level. In the case of RP that is combined with SCO, the net payout increases with greater magnitude with lower coverage levels. As coverage level increases, the net payout increases, but the rate of increment is smaller than with RP alone. However, the net payout reaches its maximum with 80 percent coverage level and declines with

85 percent coverage level (Figure 3, Panel A). Upland cotton has different insurance payouts than those of dryland corn. The net gain from RP is larger than YP in cotton but the magnitude of increment of insurance benefit is smaller than in case of corn. Both YP and RP provide the largest benefit under the 75 percent coverage level (Figure 3, Panel B). Combined with SCO endorsement in upland cotton, the optimum coverage level is 70 percent. The SCO net payout declines with the increase in coverage level for cotton, but increases from 50 to 70 percent coverage and declines rapidly afterwards for corn.



**Figure 3. Net Gain from Revenue Protection and SCO**

We measure the farmers' welfare with crop insurance by using a certainty equivalent and comparing it with the case of having no insurance. The difference in certainty equivalent is the increase in the farmers' welfare. We assumed both farmers who grow corn and upland cotton exhibit similar levels of risk aversion and opt to insure. Table 3 presents the certainty equivalent differences with all eight available coverage levels and under the cases of individual plans separately and individual plans combined with the SCO endorsement. The result resembles a

similar pattern to those of the net benefit analysis presented earlier in Figures 2 and 3. For Corn, YP provides smaller welfare gain than does RP. The optimum coverage level for YP and RP are 85 percent but after adding the SCO endorsement, the optimum coverage level for both becomes 80 percent. The highest coverage level is no longer the optimum. For upland cotton, 80 percent is the optimum coverage level for both YP and RP. However, 60 and 70 percent are the optimum coverage levels for YP and RP, respectively. Variability in the crop yield plays a vital role in determining the maximum welfare gain with different coverage levels. Cotton has higher yield variance than corn which has resulted that smaller coverage level produced the larger welfare gain as compared with corn. Incremental premium with larger coverage level results in the smaller welfare gain and make smaller coverage level as optimum coverage level.

**Table 3. Certainty Equivalent Differences with Individual and Combined Plan**

	Coverage Level							
	50	55	60	65	70	75	80	85
McLean, IL	Corn							
YP	1.0	1.7	2.8	4.1	6.3	8.8	11.1	12.5
YP+SCO	6.2	6.9	8.0	9.2	11.2	13.2	14.4	13.2
RP	1.6	2.4	3.9	6.3	10.3	14.9	19.2	21.6
RP+SCO	10.7	12.4	14.7	17.7	21.8	25.3	26.7	23.2
Lubbock, TX	Upland Cotton							
YP	11.2	13.1	15.7	17.2	20.1	21.7	21.8	19.8
YP+SCO	32.9	32.9	33.2	32.1	32.1	30.5	26.9	20.7
RP	13.0	15.2	18.3	20.0	23.4	25.3	25.4	23.0
RP+SCO	26.1	28.3	30.9	31.6	33.4	33.1	30.2	23.9

We have discussed that the SCO payment is triggered by the county yield. The optimum coverage level for the individual plan is affected by the SCO endorsement. Yield variance is one of the most important parameters in determining the welfare from crop insurance. Each of the producing counties has different averages and standard deviation of crop yield. We attempt to

look at the differences in the optimum coverage level by varying county yield variability for corn. We assumed that the average yield and relationship of yield variance among county and producer yields remains constant. We have estimated the certainty equivalent for the actual yield coefficient of variation (CV) and then we change it to 20 to 70 percent with 10 percent increments. It is obvious that the increase in the county yield CV increases the producers' certainty equivalent in crop insurance. As per our expectation, it also changes the optimum coverage level for the individual plan combined with the SCO. The current county yield CV for the example county is 13 percent. The optimum coverage level for an estimated county yield CV (13%) is 80 percent. When we increase the county yield CV to 20 percent, the optimum coverage level decreases to 75 percent. When we increase the county yield CV to 70 percent, the optimum coverage level decreases to the lowest allowable coverage level of 50 percent. CV and optimum coverage level are inversely related. But the same is not true for RP. RP protects risk against yield shortfall and price movements. Our analysis assumed that the price risk is constant while varying the yield risk. The impact on optimum coverage level is not as large as YP. With the increase in county yield CV from an estimated 13 percent to 20, 30, and 40 percent, the optimum coverage level changes to 75 percent. When we change yield CV to 50, 60, and 70 percent, the coverage level of 70 percent becomes the optimum.



**Table 4. Certainty Equivalent Differences of Individual Plan with SCO**

Coverage level	County Yield Coefficient of Variation						
	13	20	30	40	50	60	70
<b>Yield Protection</b>							
50	6.2	25.8	65.8	94.9	112.2	121.3	128.0
55	6.9	28.0	68.6	96.3	112.3	121.3	126.3
60	8.0	31.2	72.6	99.2	113.9	121.8	125.9
65	9.2	33.2	73.2	97.6	110.5	117.2	120.4
70	11.2	36.8	76.4	99.2	110.7	116.2	118.6
75	13.2	38.4	75.5	95.8	105.4	109.6	111.2
80	14.4	37.0	69.4	86.2	93.6	96.5	97.3
85	13.2	30.8	55.6	68.0	72.9	74.5	74.5
<b>Revenue Protection</b>							
50	10.7	25.4	55.5	76.1	87.3	93.2	96.2
55	12.4	29.6	62.6	83.6	94.7	100.2	102.8
60	14.7	35.2	71.0	92.3	103.1	108.3	110.4
65	17.7	39.7	75.5	95.9	105.8	110.2	111.8
70	21.8	45.9	82.6	102.5	111.6	115.3	116.3
75	25.3	49.3	84.5	102.7	110.5	113.3	113.8
80	26.7	48.3	79.6	95.0	101.2	103.1	103.0
85	23.2	40.1	64.7	76.4	80.6	81.6	81.0

Assuming ratio of farm and county yield coefficient is constant (1.8)

## Conclusion

Establishing the optimum coverage level is an important decision for producers to make based on their cost and potential benefit. On the other hand, crop insurance providers' benefits for estimating the premium before producers actually make the decision. We take a reasonable approach to and use valid statistical methods to estimate the cost and benefit of the crop insurance with individual plan and also with the SCO endorsement. As a shallow coverage level option, SCO is likely to play a vital role in the US crop insurance program. Combining SCO with underlying YP and RP increases the net benefit of the crop insurance to the producer, however, larger marginal benefit to the smaller coverage level than the larger coverage level. This is true

because of the declining coverage by SCO with larger coverage level for the individual plan.

This eventually impacts in the optimum coverage level. The major finding of this study can be summarized as:

- RP provides larger welfare gain for the producer both for corn and cotton producing counties. The marginal benefit is smaller for cotton than for corn due its larger yield variability.
- SCO combined with individual plan changes the optimum coverage level than individual plan alone.
- SCO with YP have different optimum coverage levels than SCO with RP. RP with very high coverage level being very popular in the US corn-belt, the coverage choice of the producer is likely to decline with the SCO endorsement.
- The county yield coefficient of variation is a very strong driver of the optimality of the coverage level for YP. It also has an impact in RP but with a lesser extent than YP.

These results reveal that there is a potential shift in the producers' coverage level choice of the YP and RP crop insurance products after introduction of SCO endorsement. However, shift in the coverage level choice is not uniform due to differences in the county yield variability. This research does not include producer characteristics that lead them to select the crop insurance coverage level. Extending this research in crops other than corn and cotton including producers' choice and plan attributes will compliment to this research.

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