

INPUT DEMAND AND PRODUCER WELFARE EFFECTS OF CROP REVENUE INSURANCE SCHEMES*

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I. Introduction

In response to the U.S. Federal Crop Insurance Reform Act of 1994, a pilot crop revenue insurance program which is known as Income Protection (IP) was developed by the Federal Crop Insurance Corporation (FCIC).¹ Private sector programs have also been approved by the FCIC. These include Crop Revenue Coverage (CRC) developed by the American Agrisurance, and Revenue Assurance (RA) developed by the Iowa Farm Bureau Mutual Insurance Company (Hennessy et al. 1997)

All types of crop revenue insurance guarantee a minimum gross revenue that equals the insurable price times the yield election. The difference among them is choosing the price level to calculate the level of revenue guaranteed. Under CRC, the price level is based on 95% of the average Chicago futures market price in February. If prices reach a higher level by harvest time, the revenue guarantee is raised accordingly, but it will not be lowered. If the producer's actual gross revenue, based on the actual yield and 95% of the Chicago

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¹ The FCIC was reorganized and renamed to Risk Management Agency in 1996.

futures price at harvest, is below the insured level, an indemnity payment that equals to the difference is received (Edwards 1997).

The IP also uses February futures prices to set the level of revenue guaranteed, but does not increase the protection level even if the prices rise. The RA uses the average of the February Chicago futures price minus the historical differential between the futures price at harvest and the Farm Service Agency posted county price. The RA does not increase the revenue guarantee even when the prices rise, either.

Two issues concerning the crop revenue insurance schemes may receive attention. The first issue is input demand. Agricultural insurance program has generally been assumed to reduce chemical input use because of moral hazard effects (Babcock and Hennessy 1996; Chambers 1989; Feinerman et al. 1992; Nelson and Loehman 1987; Ramaswami 1993; Smith and Goodwin 1996).² Is there any difference among crop revenue insurance schemes in terms of input demand?

The second issue about crop revenue insurance is producer welfare. Turvey (1992) showed that the Canadian revenue insurance program was less costly than combined price and crop insurance to insure producers' income. Recently, in Hennessy, Babcock, and Hayes, the RA program was compared with the 1990 farm program, and was found to be less costly in achieving the goal of guaranteeing income. There might be a difference in producer welfare among the crop revenue insurance schemes.

The purpose of this paper is to analyze and compare the impact of two types of crop revenue insurance in terms of input demand and producer welfare. If the insurable prices are the same between RA and IP, the distribution of revenues and input uses are exactly the same. Thus this study compares input uses between CRC and RA (or IP). In order to analyze the input demand and producer welfare conceptually, this study extends to the expected utility model that is adopted by Babcock and Hennessy. A Monte Carlo simulation is also conducted to assist the results by assuming that prices follow log-normal

² This conventional view had been challenged by Horowitz and Lichtenberg (1993). They showed that corn producers purchasing insurance applied significantly more nitrogen per acre by 19% and spent more on pesticides by 21%. However, some recent studies (Babcock and Hennessy 1996; Smith and Goodwin 1996) have doubted their results.

distribution and yields follow beta distribution and that producer has a constant absolute risk-averse utility function.

II. The Model

1. Optimal Input Uses

Let us consider an individual producer who is confronted with both output price and yield uncertainty. The producer's profit $\Pi_3 = Py - P_x x$, where P and P_x are an output price and an input price, respectively. According to Babcock and Hennessy, the stochastic relationship between output, y , and input, x , is captured by the conditional probability density function, $g(y | x)$, $a \leq y \leq b$. And the stochastic output price is represented by marginal density function, $h(P)$, $P \geq 0$. Assuming output price and output are independent, without crop revenue insurance, the producer's problem is to decide level of input, x , so as to maximize expected utility of profits, EU_N , that can be written as

$$(1) \quad EU_N = \int_0^\infty \int_a^b U(\Pi_3) h(P) g(y | x) dy dP,$$

where $U(\cdot)$ is a producer's utility function that is assumed to be a constant absolute risk averse (CARA).

The RA(or IP) uses an average February futures price, P_f , to calculate the level of revenue guaranteed, R_1 . Thus, R_1 can be represented as $R_1 = \alpha P_f \bar{y}$, where α is a coverage level and \bar{y} is the proven yield based on actual production history records. If an actual revenue falls below R_1 , the difference between R_1 and actual revenue will be paid to producer. Under RA (or IP), the producer's optimization problem is to choose input level in order to maximize

$$(2) \quad EU_R = \int_0^\infty \int_a^{R_1/P} U(\Pi_1) h(P) g(y | x) dy dP \\ + \int_0^\infty \int_{R_1/P}^b U(\Pi_3) h(P) g(y | x) dy dP,$$

where EU_R is the expected utility under RA, and $\Pi_1 = R_1 - P_x x$. Equation (2) is analogous to equation (6) in Babcock and Hennessy.

The first-order condition for expected utility maximization

under RA is

$$\begin{aligned}
 (3) \quad & \int_0^\infty \int_a^{R/P} U(\Pi_1)(-P_x)h(P)g(y|x)dydP \\
 & + \int_0^\infty \int_a^{R/P} U(\Pi_1)h(P)\frac{dg(y|x)}{dx} dydP \\
 & + \int_0^\infty \int_{R/P}^b U(\Pi_3)(-P_x)h(P)g(y|x)dydP \\
 & + \int_0^\infty \int_{R/P}^b U(\Pi_3)h(P)\frac{dg(y|x)}{dx} dydP = 0,
 \end{aligned}$$

where U' is the partial derivative of utility with respect to profit.

Under the CRC, the revenue guarantee is raised if prices reach a higher level by harvest time, but it will not be lowered. If the harvest price is less than P_f , the revenue guaranteed will be R_1 which is the same as RA. If the harvest price is higher than P_f , the revenue guaranteed is $R_2 = \alpha P \bar{y}$. The expected utility under CRC, EU_C , can be written as;

$$\begin{aligned}
 (4) \quad EU_C = & \int_0^{P_f} \int_a^{R/P} U(\Pi_1)h(P)g(y|x)dydP \\
 & + \int_{P_f}^\infty \int_a^{R/P} U(\Pi_2)h(P)g(y|x)dydP \\
 & + \int_0^{P_f} \int_{R/P}^b U(\Pi_3)h(P)g(y|x)dydP \\
 & + \int_{P_f}^\infty \int_{R/P}^b U(\Pi_3)h(P)g(y|x)dydP.
 \end{aligned}$$

Because $R_2 = \alpha P \bar{y}$, the boundary point R_2/P in equation (4) is equal to $\alpha \bar{y}$. The first term of right hand side explains that if the price is lower than P_f , and actual revenue, R , is less than R_1 , the producer will be paid by $R_1 - R$. The second term means that if P is higher than P_f and R is less than R_2 (y is less than $\alpha \bar{y}$), he will be paid by $R_2 - R$. The remaining terms represent the cases of no indemnity.

The first-order condition for expected utility maximization under CRC is derived as

$$\begin{aligned}
 (5) \quad & \int_0^{P_f} \int_a^{R/P} U(\Pi_1)(-P_x)h(P)g(y|x)dydP \\
 & + \int_0^{P_f} \int_a^{R/P} U(\Pi_1)h(P)\frac{dg(y|x)}{dx} dydP \\
 & + \int_{P_f}^\infty \int_a^{R/P} U(\Pi_2)(-P_x)h(P)g(y|x)dydP \\
 & + \int_{P_f}^\infty \int_a^{R/P} U(\Pi_2)h(P)\frac{dg(y|x)}{dx} dydP \\
 & + \int_0^{P_f} \int_{R/P}^b U(\Pi_3)(-P_x)h(P)g(y|x)dydP
 \end{aligned}$$

$$\begin{aligned}
& + \int_0^{P_f} \int_{R/P}^b U(\Pi_3) h(P) \frac{dg(y|x)}{dx} dy dP \\
& + \int_{P_f}^{\infty} \int_{R/P}^b U'(\Pi_3) (-Px) h(P) g(y|x) dy dP \\
& + \int_{P_f}^{\infty} \int_{R/P}^b U(\Pi_3) h(P) \frac{dg(y|x)}{dx} dy dP = 0.
\end{aligned}$$

2. Effects of Coverage Level

The effect of increasing coverage level, α , on the optimal input use under the RA, x_R , can be derived from differentiating the first-order condition, equation (3), with respect to x_R and α . Using Leibnitz's rule, one may derive

$$\begin{aligned}
(6) \quad \frac{\partial x_R}{\partial \alpha} = & - \frac{1}{\Delta_1} P_f \bar{y} U'(\Pi_1) \int_0^{\infty} \int_a^{R/P} h(P) g(y|x) dy dP \\
& \times \left[P_x \lambda + \frac{d \log \int_0^{\infty} \int_a^{R/P} h(P) g(y|x) dy dP}{dx} \right],
\end{aligned}$$

where Δ_1 is the second-order condition for the objective function under the RA, equation (2), which is assumed to be negative and λ is an absolute risk aversion coefficient.

Equation (6) is similar to equation (7) in Babcock and Hennessy. Since the product of the terms outside the square brackets is positive, the sign of equation (6) depends on the sign of the square brackets. The first term inside the square brackets is positive under risk aversion. The second term inside the square brackets is the percentage change in the probability that a claim will be made due to a one unit increase in x (Babcock and Hennessy). If it is positive or if it is negative and the absolute value is smaller than the first term inside the square brackets, equation (6) is positive. That means an increase in the RA coverage level increases the optimal input use. If it is negative and the absolute value is larger than the first term inside the square brackets, an increase in the RA coverage level decreases the optimal input use. Babcock and Hennessy showed that an increase in the revenue insurance coverage level decreases the optimal fertilizer application using a Monte Carlo simulation. The results of a similar simulation is presented in the next section.

Similarly, the effect of increasing coverage level, α , on optimal input use under CRC, x_c , can also be derived from differentiating the first-order condition, equation (5), with respect to x_c and α .

$$\begin{aligned}
 (7) \quad \frac{\partial x_C}{\partial \alpha} = & -\frac{1}{\Delta_2} P_f \bar{y} U'(\Pi_1) \int_0^{P_f} \int_a^{R/P} h(P) g(y|x) dy dP \\
 & \times \left[P_x \lambda + \frac{d \log \int_0^{P_f} \int_a^{R/P} h(P) g(y|x) dy dP}{dx} \right] \\
 & - \frac{1}{\Delta_2} \left[\int_{P_f}^{\infty} \int_a^{\alpha \bar{y}} U''(\Pi_2) \times P \bar{y} (-P_x) h(P) g(y|x) dy dP \right. \\
 & \left. + \int_{P_f}^{\infty} \int_a^{\alpha \bar{y}} U'(\Pi_2) P \bar{y} h(P) \frac{dg(y|x)}{dx} dy dP \right],
 \end{aligned}$$

where Δ_2 is the second-order condition for the objective function under the CRC, equation (4), which is assumed to be negative. Equation (7) can be rearranged as

$$\begin{aligned}
 (8) \quad \frac{\partial x_C}{\partial \alpha} = & -\frac{1}{\Delta_2} P_f \bar{y} U'(\Pi_1) \int_0^{P_f} \int_a^{R/P} h(P) g(y|x) dy dP \\
 & \times \left[P_x \lambda + \frac{d \log \int_0^{P_f} \int_a^{R/P} h(P) g(y|x) dy dP}{dx} \right] \\
 & - \frac{1}{\Delta_2} \bar{y} \int_{P_f}^{\infty} U'(\Pi_2) P h(P) dP \\
 & \times \int_a^{\alpha \bar{y}} g(y|x) dy \left[P_x \lambda + \frac{d \log \int_a^{\alpha \bar{y}} g(y|x) dy}{dx} \right].
 \end{aligned}$$

Both terms outside two square brackets in equation (8) are positive. And the first terms inside two square brackets are also positive under risk aversion. The second term of the first square brackets is the percentage change in the probability that actual revenue is less than R_1 given lower price than P_f due to a one-unit increase in x . The second term of the second square brackets is the percentage change in the probability that actual yield is less than $\alpha \bar{y}$. If those second terms of two square brackets are positive, equation (8) is positive which means an increase in the CRC coverage level increases the optimal input demand. If they are highly negative, equation (8) is negative which indicates that an increase in coverage level decreases the optimal input use under the CRC. Actually, equation (8) can not be unambiguously signed. The results can be shown by a simulation that is also presented in the next section.

To compare optimal input uses and estimate the effect of increasing coverage level on the difference in optimal input uses

between the RA and CRC, one may use equation (9) which can be derived from subtracting equation (8) from (6).

$$\begin{aligned}
 (9) \quad \frac{\partial(x_R - x_C)}{\partial\alpha} = & -\frac{1}{\Delta_1} P_f \bar{y} U'(\Pi_1) \int_0^\infty \int_a^{R/P} h(P) g(y|x) dy dP \\
 & \times \left[P_x \lambda + \frac{d \log \int_0^\infty \int_a^{R/P} h(P) g(y|x) dy dP}{dx} \right] + \frac{1}{\Delta_2} P_f \bar{y} U'(\Pi_1) \\
 & \times \int_0^{P_f} \int_a^{R/P} h(P) g(y|x) dy dP \\
 & \left[P_x \lambda + \frac{d \log \int_0^{P_f} \int_a^{R/P} h(P) g(y|x) dy dP}{dx} \right] \\
 & + \frac{1}{\Delta_2} \bar{y} \int_{P_f}^\infty U'(\Pi_2) P h(P) dP \int_a^{\alpha \bar{y}} g(y|x) dy \\
 & \left[P_x \lambda + \frac{d \log \int_a^{\alpha \bar{y}} g(y|x) dy}{dx} \right].
 \end{aligned}$$

If equation (9) is positive, the optimal input use under the RA is larger than that under the CRC and an increase in coverage level increases the difference in input uses between the RA and CRC. And reverse is true for negative. Equation (9) can not be unambiguously signed, either. The sign can be determined by a simulation that is presented in the next section.

3. Welfare Effects

To derive and compare welfare effects of crop revenue insurance, objective functions for RA and CRC may be differently represented. To get similar form to equation (4), equation (2) can be written as

$$\begin{aligned}
 (10) \quad EU_R = & \int_0^{P_f} \int_a^{R/P} U(\Pi_1) h(P) g(y|x) dy dP \\
 & + \int_{P_f}^\infty \int_a^{R/P} U(\Pi_1) h(P) g(y|x) dy dP \\
 & + \int_0^{P_f} \int_{R/P}^b U(\Pi_3) h(P) g(y|x) dy dP \\
 & + \int_{P_f}^\infty \int_{R/P}^{R/P} U(\Pi_3) h(P) g(y|x) dy dP \\
 & + \int_{P_f}^\infty \int_{R/P}^b U(\Pi_3) h(P) g(y|x) dy dP.
 \end{aligned}$$

Similarly, the objective function for the CRC, equation (4), can be

represented as

$$\begin{aligned}
 (11) \quad EU_C = & \int_0^{P_f} \int_a^{R_1/P} U(\Pi_1)h(P)g(y|x)dydP \\
 & + \int_{P_f}^{\infty} \int_a^{R_1/P} U(\Pi_2)h(P)g(y|x)dydP \\
 & + \int_0^{P_f} \int_{R_1/P}^b U(\Pi_3)h(P)g(y|x)dydP \\
 & + \int_{P_f}^{\infty} \int_{R_1/P}^{R_2/P} U(\Pi_2)h(P)g(y|x)dydP \\
 & + \int_{P_f}^{\infty} \int_{R_2/P}^b U(\Pi_3)h(P)g(y|x)dydP.
 \end{aligned}$$

Let us define the optimal input uses under the RA and CRC at a certain coverage level as x'_R and x'_C , respectively. By substituting x'_R into equation (10) and (11), and manipulating those equations, one can derive

$$\begin{aligned}
 (12) \quad EU_C(x'_R) - EU_R(x'_R) = & \int_{P_f}^{\infty} \int_a^{R_1/P} [U(\Pi_2) - U(\Pi_1)]h(P)g(y|x)dydP \\
 & + \int_{P_f}^{\infty} \int_{R_1/P}^{R_2/P} [U(\Pi_2) - U(\Pi_3)]h(P)g(y|x)dydP.
 \end{aligned}$$

Since $\Pi_2 > \Pi_1$ in the relevant range of $P > P_f$ and $a < y < (R_1/P)$ and $\Pi_2 > \Pi_3$ in the relevant range of $P > P_f$ and $(R_1/P) < y < (R_2/P)$, equation (12) is positive and thus $EU_C(x'_R) > EU_R(x'_R)$. Note that $EU_C(x'_C) > EU_C(x'_R)$ conceptually. Thus $EU_C(x'_C) > EU_R(x'_R)$ states that the maximized expected utility under the CRC is larger than that under the RA. The same results may be drawn in a numerical simulation.

III. A Numerical Simulation

Because the theoretical analysis is inconclusive in the previous section, a Monte Carlo simulation is conducted to obtain insights. This study uses the same data and procedures as Babcock and Hennessy. It is assumed that yields follow beta distribution and prices follow log-normal distribution. For the conditional probability density function, $g(y|x)$, this study uses the estimation result for Site 12, Table 1 in Babcock and Hennessy.³ The Johnson and Tenenbein (1981) method is

³ The p and q functions for beta distribution that are used in this study are $p = 3.14 - 0.0921X^{0.5} + 0.00603X$, and $q = 12.30 - 1.3530X^{0.5} + 0.04560X$.

also used to capture the level of dependence between yields and prices by Spearman's rank correlation coefficient, ρ_s . Two levels of Spearman's rank correlation coefficient used are 0 and -0.3. Though the number of deviates used in Babcock and Hennessy was 1,000, this study employs the number 5,000 to achieve higher precision. A constant absolute risk-averse utility function is also assumed. The risk aversion coefficients used are 0.0046 and 0.0100 to represent low and moderate levels of risk aversion, respectively.

In equation (6), (8), and (9), the effects of input use on revenue and yield distributions are critical factors to determine the signs. Those are

$$\frac{d \log \int_0^\infty \int_a^{R/P} h(P)g(y|x)dydP}{dx}, \quad \frac{d \log \int_0^{P_f} \int_a^{R/P} h(P)g(y|x)dydP}{dx},$$

and $\frac{d \log \int_a^{\alpha \bar{y}} g(y|x)dy}{dx}.$

The first term is the percentage change in the probability that actual revenue is less than $R_1[\Pr(R < R_1)]$, the second term is the percentage change in the probability that actual revenue is less than R_1 and price is less than $P_f[\Pr(R < R_1 \text{ and } P < P_f)]$, and the third term is the percentage change in the probability that actual yield is less than $\alpha \bar{y}[\Pr(y < \alpha \bar{y})]$. Thus this study first turns to estimating those relevant probabilities. Table 1 shows how the estimated probabilities change as nitrogen fertilizer application increases from 100 lbs/ac to 250 lbs/ac.⁴ As can be seen, increased fertilizer use decreases the relevant probabilities. These results state that the above three terms are negative.

Table 2 presents the simulations results for 65% and 75% coverage levels under the assumption of uncorrelated yields and prices. The first conclusion from these results is that an increase in the RA coverage level decreases the optimal fertilizer rate. For example, at the 75% coverage level, optimal fertilizer applications decrease from their optimal levels under no insurance by 6.00% under low risk aversion and 9.09% under moderate risk aversion. This means that the square brackets in equation (6) is negative and the

⁴ Babcock and Hennessy show how the estimated yield distribution changes as nitrogen fertilizer increases using figures.

second term is negative while the absolute value is larger than the first term inside the square brackets. That is, the percentage change in the probability where a claim will be made due to one unit increase in x is negative and the absolute is large.

The second finding is that an increase in the CRC coverage level also decreases the optimal fertilizer rate which means that equation (8) is negative. The largest reduction is 11.11% under moderate risk aversion. The third finding is that the optimal fertilizer rates under the RA are larger than those under the CRC and the differences increase as coverage levels increase. These results indicated that equation (9) is positive.

The corresponding results when yields and prices are negatively correlated with $\rho_s = -0.3$ are presented in Table 3. The conclusions regarding input uses are the same as those of the uncorrelated prices and yields. But one may find that the percentage reductions are smaller than when yields and prices are uncorrelated. For example, the reduction for the low risk aversion under the 75% RA is 4.48% as compared to a 6.00% reduction under no correlation. This finding stems from the fact that a negative correlation can decrease the degree of risk the producer faces.

TABLE 1 Effects of Nitrogen Fertilizer Rates on the Relevant Probabilities

Coverage Level(%)	Fertilizer Rate (lbs/ac)	$\rho_s = 0.0$		$\rho_s = -0.3$		
		Pr ($R < R_i$) ^a	Pr ($R < R_i, P < P_i$) ^b	Pr ($R < R_i$) ^a	Pr ($R < R_i, P < P_i$) ^b	Pr ($y < \bar{y}$) ^c
65	100	0.2224	0.1880	0.1806	0.1376	0.1614
	150	0.1458	0.1282	0.1110	0.0856	0.0924
	200	0.1138	0.1002	0.0788	0.0626	0.0674
	250	0.1060	0.0946	0.0716	0.0576	0.0576
75	100	0.3722	0.2934	0.3518	0.2466	0.3130
	150	0.2654	0.2188	0.2286	0.1684	0.1988
	200	0.2134	0.1802	0.1714	0.1308	0.1478
	250	0.1992	0.1702	0.1622	0.1248	0.1348

$$a) \Pr(R < R_i) = \int_0^\infty \int_a^{R_i/P} h(P)g(y|x)dydP.$$

$$b) \Pr(R < R_i, P < P_i) = \int_0^{P_i} \int_a^{R_i/P} h(P)g(y|x)dydP.$$

$$c) \Pr(y < \bar{y}) = \int_a^{\bar{y}} g(y|x)dy.$$

TABLE 2 Input Uses for Crop Revenue Insurance for Uncorrelated Yields and Prices ($\rho_s = 0.0$)

Risk Preference	Coverage Level (%)	<u>Revenue Assurance</u>		<u>Crop Revenue Coverage</u>	
		Fertilizer rate (lbs/ac)	Percentage reduction	Fertilizer rate (lbs/ac)	Percentage reduction
Risk Neutrality	0	202	0.00	202	0.00
	65	198	1.98	197	2.48
	75	194	3.96	192	4.95
Low Risk Aversion ^{a)}	0	200	0.00	200	0.00
	65	195	2.50	194	3.00
	75	188	6.00	185	7.50
Moderate Risk Aversion ^{b)}	0	198	0.00	198	0.00
	65	189	4.55	188	5.05
	75	180	9.09	176	11.11

a) Absolute risk aversion coefficient equals 0.0046.

b) Absolute risk aversion coefficient equals 0.0100.

TABLE 3 Input Uses for Crop Revenue Insurance for Correlated Yields and Prices ($\rho_s = -0.3$)

Risk Preference	Coverage Level (%)	<u>Revenue Assurance</u>		<u>Crop Revenue Coverage</u>	
		Fertilizer rate (lbs/ac)	Percentage reduction	Fertilizer rate (lbs/ac)	Percentage reduction
Risk Neutrality	0	202	0.00	202	0.00
	65	199	1.49	198	1.98
	75	196	2.97	192	4.95
Low Risk Aversion ^{a)}	0	201	0.00	201	0.00
	65	197	1.99	195	2.99
	75	192	4.48	187	6.97
Moderate Risk Aversion ^{b)}	0	200	0.00	200	0.00
	65	193	3.50	191	4.50
	75	186	7.00	181	9.50

a) Absolute risk aversion coefficient equals 0.0046.

b) Absolute risk aversion coefficient equals 0.0100.

A value often used in studies regarding welfare effects under risk and uncertainty is the certainty equivalent return (CER). Since the CERs bear a monotonically increasing relationship with expected utility and are measured in monetary units, they allow us to draw inferences about the expected utility (Lence and Hayes 1995). The CERs measured at the optimal fertilizer rates are presented in Table 4 and Table 5. The first to note from those tables is that the CERs under CRC are larger than those under the RA. As risk aversion level increases or coverage level increases the difference between them becomes larger.

TABLE 4 CERs for Crop Revenue Insurance for Uncorrelated Yields and Prices ($\rho_s = 0.0$)

Risk Preference	Coverage Level (%)	<u>Revenue Assurance</u>				<u>Crop Revenue Coverage</u>			
		CER (\$/ac)	PR (\$/ac)	CER-PR (\$/ac)	ER ^{a)}	CER (\$/ac)	PR (\$/ac)	CER-PR (\$/ac)	ER ^{a)}
Risk Neutrality	0	268.73	-	-	-	268.73	-	-	-
	65	272.26	3.55	268.71	0.99	272.81	4.13	268.68	0.99
	75	277.10	8.50	268.60	0.98	278.79	10.25	268.54	0.98
Low Risk Aversion ^{b)}	0	251.20	-	-	-	251.20	-	-	-
	65	257.22	3.60	253.62	1.67	257.98	4.18	253.80	1.62
	75	264.29	8.70	255.59	1.50	266.32	10.57	255.75	1.43
Moderate Risk Aversion ^{c)}	0	233.56	-	-	-	233.56	-	-	-
	65	243.29	3.70	239.59	2.63	244.25	4.31	239.94	2.48
	75	252.99	9.02	243.97	2.15	255.30	11.05	244.25	1.97

a) The increase in producer welfare per dollar of premium ($ER = \Delta CER / \Delta PR$).

b) Absolute risk aversion coefficient equals 0.0046.

c) Absolute risk aversion coefficient equals 0.0100.

Note that above equations do not include the insurance premiums (PR). One needs information about insurance premiums to compare producer welfare effects. In the simulation, they were set equal to the averages of claims in order to be a fair insurance. The results are also presented in Table 4 and Table 5. As one may expect, the PRs under CRC are larger than those under the RA. Using values of (CER-PR), one may conclude that the welfare increases under the CRC are slightly larger than those under the RA for risk-averse producer.

An efficiency can be measured by the increase in producer welfare per dollar of cost (Hennessy et al. 1997). Efficiency ratios (ER) were calculated by $\Delta CER / \Delta PR$. Table 4 and 5 show that the efficiency of crop revenue insurance increases as the coverage level

TABLE 5 CERs for Crop Revenue Insurance for Correlated Yields and Prices ($\rho_s = -0.3$)

Risk Preference	Coverage Level (%)	<u>Revenue Assurance</u>				<u>Crop Revenue Coverage</u>			
		CER (\$/ac)	PR (\$/ac)	CER-PR (\$/ac)	ER ^{a)}	CER (\$/ac)	PR (\$/ac)	CER-PR (\$/ac)	ER ^{a)}
Risk Neutrality	0	264.59	-	-	-	264.59	-	-	-
	65	266.51	1.94	264.57	0.99	267.56	3.00	264.56	0.99
	75	270.24	5.72	264.52	0.99	273.07	8.69	264.38	0.98
Low Risk Aversion ^b	0	252.26	-	-	-	252.26	-	-	-
	65	255.48	1.96	253.52	1.64	256.82	3.05	253.77	1.50
	75	260.83	5.83	255.00	1.47	264.07	8.91	255.16	1.33
Moderate Risk Aversion ^c	0	239.26	-	-	-	239.26	-	-	-
	65	244.50	2.01	242.49	2.61	246.16	3.12	243.04	2.21
	75	251.92	6.01	245.91	2.11	255.48	9.20	246.28	1.76

a) The increase in producer welfare per dollar of premium ($ER = \Delta CER / \Delta PR$).

b) Absolute risk aversion coefficient equals 0.0046.

c) Absolute risk aversion coefficient equals 0.0100.

decreases and as risk aversion increases. And the efficiency of RA is somewhat greater than that of CRC for risk-averse producer. This result implies that the government spending for RA is more effective than that for CRC. At 75% coverage levels, each dollar of expected government spending for RA provides \$ 1.50 for low risk-averse producer and \$ 2.15 for moderate risk-averse producer.

IV. Concluding Remarks

In this paper, RA was compared with CRC in terms of input demand and producer welfare. Because the theoretical analysis is inconclusive, a Monte Carlo simulation was conducted to obtain insights.

The general conclusion regarding optimal input demand is that crop revenue program decreases the input demand. And input uses under the CRC are less than those under RA. For welfare effects, it is shown that welfare increases under the CRC are slightly larger than those under the RA for risk-averse producer. However, it is also shown that the efficiency of RA is somewhat greater than that of CRC.

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