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AN ANALYSIS OF WILLINGNESS-TO-PAY FOR CROP INSURANCE*

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In this paper a method for estimating a producer's willingness-to-pay for crop insurance is presented. The method includes formulae to capture the impact of crop insurance on the producer's expected income and variance of income. These impacts are evaluated in the context of a model of producer welfare which features both price and yield uncertainty, as well as risk aversion on the part of the producer. The method is applied to the Australian wheat industry and estimates of willingness-to-pay are shown to be relatively sensitive to the levels of coverage and yield variability.

Introduction

Developments in the world wheat trade suggest that wheat growers are exposed to an increased level of income variability. One method of managing increased income variability is the adoption of insurance policies.[1]

Miranda (1991) compared the current US individual-yield approach to crop insurance with area-yield crop insurance in the context of Kentucky soy-bean production and concluded 'that area-yield crop insurance should receive serious consideration as an alternative to the current crop insurance program' (p. 242). Patrick (1988) in a survey of Australian (Mallee) wheat growers found not only that a majority would be willing to participate in a crop insurance program, but also that a majority of these growers 'would be willing to pay approximately the estimated actuarial cost of the coverage or more' (p. 43).

The aim in this paper is to develop an indirect method for estimating producers' willingness-to-pay for crop insurance. One advantage of having such estimates is that they can be used to complement direct estimates provided by a survey of producers. In addition, the method uses numerical rather than econometric evaluation procedures and

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[1] Also, empirical evidence suggests that the adoption of modern cultivars has resulted in increased yield variability (see Anderson, *et al.* 1988). See Bardsley, *et al.* (1984) for a previous analysis of insurance in Australian agriculture.

therefore has the advantage of being applicable on the basis of a relatively small set of information.

The structure of the paper is as follows. In section one the method of estimating willingness-to-pay is developed. The method includes formulae to capture the impact of crop insurance on the producer's expected income and variability of income, as well as a simple model of producer welfare under uncertainty. In section two, this method is illustrated in the context of the Australian wheat industry. Although the estimates of willingness-to-pay are shown to be relatively sensitive to the levels of coverage and yield variability, they indicate that in general premiums may exceed actuarial cost by up to ten per cent and still prove attractive even to only moderately risk averse producers. A brief summary follows.

The Method

The producer is assumed to face yield uncertainty with an expected value of unity:

(1) $$x = \theta x_e$$

where:

θ = uncertain yield ($E(\theta) = 1$)

x = actual output

x_e = planned (expected) output.

An individual-yield crop insurance program is based on a deficiency of a producer's actual yield below some critical level where this critical level is defined by the level of coverage of the expected yield. By contrast, area-yield crop insurance is based on a deficiency of actual area yield below some critical level defined by the level of coverage of expected area yield. As shown by Miranda, for given yield variability, the two programs converge as the correlation between individual and area yield approaches unity. This correlation in turn depends on the homogeneity of soil and weather conditions in the area. In what follows, the distinction between individual and area yield is ignored by assuming that they are identically distributed and perfectly correlated. Miranda shows that for correlations less than one and for individual yield variability less than area yield variability, the desirability of area-yield relative to individual-yield crop insurance is reduced. Moreover, in the context of the problem of moral hazard such divergences can have major operational significance for an insurance scheme.[2]

[2] Patrick argues that the homogeneity of yields in the Mallee is sufficient to ignore the distinction between individual and area yields in estimating willingness-to-pay. However, see footnote 15 for further discussion of the moral hazard problem.

With the above specification, the producer will receive an insurance payment whenever output falls below the critical level:

(2) $$x_c = \alpha x_e$$

where:

x_c = critical output

α = level of coverage .

Although Miranda considers an 'in-kind' insurance payment (bushels per acre), typically the payment will be a monetary one and therefore will depend also on the nominated price for insured output.[3] In what follows, output price is assumed to be uncertain, although uncorrelated with yield.[4] This means that the nominated price needs to be specified in relation to the expected price. For reasons of simplicity this relationship is assumed to be one of equivalence. However, the implications of a divergence between nominated price and expected price for the estimation of willingness-to-pay are straightforward. In particular, the lower is the nominated price relative to the expected price, the lower is willingness-to-pay for crop insurance.

On this basis, actual income (I) with crop insurance is given by:

(3) $$I = px \text{ for } x \geq x_c$$

$$I = px + p_e(x_c - x) \text{ for } x < x_c$$

where:

p = actual price

p_e = expected price .

Using (3), expected income (E(I)) is given by:

(4) $$E(I) = p_e x_e + p_e \int_0^{x_c} (xc - x) f(\theta)\, d\theta$$

where

$f(\theta)$ = probability distribution of yield .

The second term on the right-hand-side in (4) is the estimated actuarial cost of the program and is therefore the minimum possible premium level. Consequently, a producer's willingness-to-pay in excess of this level will be determined by the impact of the program on

[3] Patrick adopts this monetary approach so that willingness-to-pay is in dollar values.

[4] Both Miranda and Patrick ignore the possibility of a non-zero correlation between price and yield. Here this possibility is considered subsequently in footnote 9 where it is suggested that estimated willingness-to-pay for crop insurance is relatively insensitive to the value of the correlation coefficient between price and yield.

the variance of income ($Var(I)$). The variance of income with insurance ($Var(I_i)$) can be derived using the relationship:[5]

(5) $$Var(I_i) = Var(A+B) = Var(A) + Var(B) + 2Cov(A,B)$$

where:

$$A = px$$

$$B = p_e(x_c - x) \text{ for } x < x_c$$

(6) $$= o \text{ for } x \geq x_c.$$

Although the assumption of uncorrelated price and yield means that the variance of A is represented relatively simply by the formula:[6]

(7) $$Var(A) = x_e^2\, \sigma_p^2 + p_e^2\, \sigma_x^2 + \sigma_p^2\, \sigma_x^2$$

where:

σ_p^2 = variance of price

σ_x^2 = variance of output,

the distribution of the random insurance payment B is more complex because it involves a truncation at zero. Given this situation, further analysis of the distribution of B requires a specification of the actual distribution of yield. If it is assumed that the distribution of yield can be approximated by the normal distribution, then based on Fraser (1988) it can be shown that the variance of B is given by:

(8) $$\begin{aligned} Var(B) = {} & F(x_c)p_e^2\, \sigma_x^2\, (1-((x_c-x_e)/\sigma_x)(Z(x_c)/F(x_c)) \\ & - (-Z(x_c)/F(x_c))^2) \\ & + (1-F(x_c))(o - E(B))^2 \\ & + F(x_c)(E(B \mid x < x_c) - E(B))^2 \end{aligned}$$

where:

$F(x_c)$ = cumulative probability of $\theta x_e < x_c$

$Z(x_c)$ = $(1/\sqrt{2\pi}) \exp(-0.5((x_c-x)/\sigma_x)^2)$

σ_x = $\sigma_\theta x_e$ = standard deviation of output

σ_θ = standard deviation of yield

$\sigma_\theta{}^2$ = variance of yield

$E(B \mid x < x_c)$ = $p_e(x_c - (x_e - \sigma_x Z(x_c)/F(x_c)))$

E(B) = $F(x_c)\, E(B \mid x < x_c)$.

[5] See Mood, *et al.* (1974) p. 179.
[6] See Mood, *et al.*(1974) p. 180.

Moreover, since:

$$Cov(A,B) = \int_0^\infty \int_0^\infty (px - p_e x_e)(B - E(B)) f(p) f(x) dp dx \tag{9}$$

can be simplified to:

$$\begin{aligned} &= \int_0^\infty \int_0^{x_c} (px - p_e x_e)(p_e(x_c - x)) f(p) f(x) dp dx \\ &= p_e^2 x_c F(x_c)(E(x \mid x < x_c) - x_e) \\ &\quad + p_e^2 x_e F(x_c) E(x \mid x < x_c) \\ &\quad - p_e^2 F(x_c) E(x^2 \mid x < x_c) \end{aligned} \tag{10}$$

use of this assumption also means that:[7]

$$E(x \mid x < x_c) = x_e - \sigma_x Z(x_c)/F(x_c) \tag{11}$$

$$\begin{aligned} Var(x \mid x < x_c) = \sigma_x^2 (1 - ((x_c - x_e)/\sigma_x)(Z(x_c)/F(x_c)) \\ - (-Z(x_c)/F(x_c))^2) \end{aligned} \tag{12}$$

so that substituting (11) and (12) into (10) using the relationship:[8]

$$E(x^2 \mid x < x_c) = Var(x \mid x < x_c) + (E(x \mid x < x_c))^2$$

and simplifying gives:

$$\begin{aligned} Cov(A,B) = &-p_e^2 \sigma_x Z(x_c)(x_c - (x_e - \sigma_x Z(x_c)/F(x_c))) \\ &-p_e^2 F(x_c) \sigma_x^2 (1 - ((x_c - x_e)/\sigma_{x)(Z(x_c)}/F(x_c)) - (-Z(x_c)/F(x_c))^2) \end{aligned} \tag{13}$$

As a consequence, combining (7), (8) and (13) means that the variance of income with insurance can be represented by:

$$\begin{aligned} Var(I_i) = &x_e^2 \sigma_p^2 + p_e^2 \sigma_x^2 + \sigma_p^2 \sigma_x^2 \\ &+ (1 - F(x_c))(E(B))^2 + F(x_c)(E(B \mid x < x_c) - E(B))^2 \\ &- p_e^2 F(x_c) \sigma_x^2 (1 - ((x_c - x_e)/\sigma_x)(Z(x_c)/F(x_c)) - (-Z(x_c)/F(x_c))^2) \\ &- 2p_e^2 \sigma_x Z(x_c)(x_c - (x_e - \sigma_x Z(x_c)/F(x_c))). \end{aligned} \tag{14}$$

The impact of insurance on the variance of income will be given by the difference between (14) and the variance of income without insurance ($Var(I_o)$), which is given simply by:

$$Var(I_o) = Var(A) = x_e^2 \sigma_p^2 + p_e^2 \sigma_x^2 + \sigma_p^2 \sigma_x^2 . \tag{15}$$

A comparison of (14) and (15) shows that the magnitude of the sum of the last four terms on the right-hand-side of (14) (which must be negative to reflect the stabilising impact of insurance on the variance

[7] See Johnson and Kotz (1970) pp. 81-83.
[8] See Mood, *et al.*(1974) p. 159.

of income) will be an important determinant of a producer's willingness-to-pay for crop insurance.

However, this willingness-to-pay will also depend on the attitude to risk of the producer. The approach taken here to allow for risk aversion is to represent the producer's valuation of crop insurance by the mean-variance framework. Miranda argues for this approach as a reasonable approximation. In addition, Hanson and Ladd (1991) provide simulation evidence to support the use of the mean-variance framework even in the presence of truncated probability distributions, as is the case with crop insurance.[9] With this framework expected utility of income (E(U(I))) is given by:

$$E(U(I)) = U(E(I)) + \tfrac{1}{2}\, U''(E(I))\, Var(I)\,. \tag{16}$$

On the basis of (4), (14) and (15), the producer's willingness-to-pay for crop insurance can be estimated by evaluating (16) in the presence and absence of crop insurance and comparing their certainty equivalents.

For this estimation procedure the information requirements are limited to:

(i) coefficient of variation of price (CV_p)
(ii) coefficient of variation of yield (CV_θ)
(iii) level of coverage of crop insurance (α).

In addition, a precise form for the producer's utility function needs to be specified.

In the next section this method is illustrated in the context of willingness-to-pay for crop insurance in the Australian wheat industry.

The Application

The procedure adopted in this section is to estimate willingness-to-pay for crop insurance on the basis of a 'base case' set of industry parameter values, and then to test the sensitivity of the results to these values.[10] In each case results will be provided for a range of attitudes

[9] See also Leathers and Quiggin (1991) for a discussion of this issue.

[10] Although not considered formally here, some indication of the impact on estimated willingness-to-pay of a non-zero correlation between price and yield can be gained by substituting for $\sigma_p^2\,\sigma_x^2$ in (14) and (15) the approximation (see Mood, *et al.* (1974) p. 181):

$$2p_e x_e \rho \sigma_p \sigma_x$$

where ρ = the correlation coefficient between price and yield and σ_p = the standard deviation of price, and treating the presence of crop insurance as a reduction in σ_x, where this reduction is approximated from (12) by the square root of:

$$\sigma_x^2(1 - ((x_c - x_e)/\sigma_x)(Z(x_c))/F(x_c)) - (-Z(x_c)/F(x_c))^2)$$

Such an approach captures the self-insuring quality of a negative covariance between price and yield, and the associated reduction in willingness-to-pay for crop insurance, as well as the added attraction of crop insurance in the case of a positive covariance. However, results based on a range of values of ρ between 0.5 an –0.5 suggest estimated willingness-to-pay is relatively insensitive to this parameter with divergences from base case results of less than 10% in all cases.

to risk and for the two levels of insurance coverage ($\alpha = 0.5, 0.75$) examined by Patrick.[11]

Hazell, Jaramillo and Williamson (1990) estimate the coefficient of variation of world wheat prices for the period 1978-87 to be 0.205. It is estimated in Fraser (1992) that the combined effect of pooling and the guaranteed minimum price scheme reduced this level of price variation for Australian wheat growers to 0.082. In what follows 0.082 will be taken as the base case level of producer price variability, but the sensitivity of the results to deregulation will be tested by substituting 0.205 for this level.

Anderson *et al.* (1988) estimate the coefficient of variation of (detrended) wheat yield for Australia for the period 1975-85 to be 0.25. However, they also show considerable divergence from this value both across time and between states. For example, the value for Australia for the period 1955-75 is estimated to be 0.17, while for the latter period the value between states ranges from 0.20 for Western Australia to 0.42 for Tasmania.[12]

In what follows 0.25 will be taken as the base case level of yield variability, but the sensitivity of the results will be examined for a range of values between 0.17 and 0.41.

Finally, it is assumed for the base case evaluation that the producer's attitude to income risk can be represented by the constant relative risk aversion function:

$$U(px) = px^{1-R}/(1-R) \tag{17}$$

where:

$$R = -U''(px)px/U'(px) .$$

However, the sensitivity of the results to this specification will be tested by substituting the alternative specifications:

(i) $U(px) = -e^{-Apx}$

(ii) $U(px) = -(m - kpx)^2$.

Specification (i) is known as the constant absolute risk aversion form and (ii) is known as the quadratic form.[13]

On the basis of the above industry data, the specification of the utility function and the method outlined in section one, Table 1 contains the base case results of willingness-to-pay for a range of attitudes to risk and the two levels of crop insurance coverage.[14]

[11] Miranda cites 65% as an additonal possibility in the current US program.

[12] Patrick uses an estimate of 0.41 for Mallee wheat growers and indicates that his yield data were consistent with yields being normally distributed.

[13] See Newbery and Stiglitz (1981, p. 74). Note that $A = -U''(px)/U'(px)$ and that $m > kp_x$.

[14] Note that the results have been calculated using positioning values of $p_e = 10$ and $x_e = 1$. The range of attitudes to risk in Table 1 is consistent with empirical evidence. See Bond and Wonder (1980), Newbery and Stiglitz (1981), Bardsley and Harris (1987).

Reflecting the stabilising impact of insurance on the variance of income, more risk averse producers have a higher willingness-to-pay. However, while the increase in willingness-to-pay is not particularly sensitive to the level of risk aversion in the case of 75% coverage (a doubling of the level of R from 0.3 to 0.6 increases willingness-to-pay by less than 12%), willingness-to-pay is somewhat more sensitive for 50% coverage (almost 17% increase in this case). Nevertheless, the results in Table 1 give some indication of the extent to which premiums may exceed the estimated actuarial cost and still be attractive to a majority of producers. For example, if most producers are believed to have a level of risk aversion in excess of $R = 0.3$, then premiums may exceed the estimated actuarial cost by up to 20% in the case of 50% coverage, and by up to 13% in the case of 75% coverage.

Patrick (1988) identifies 'the costs of risk bearing, operating costs and administrative expenses' (p. 39) as adding to estimated actuarial costs in determining premiums, and as a result suggests premiums may be 50% higher than estimated actuarial costs. If this is the case, then only relatively risk averse producers ($R = 0.9$) would be willing to pay such premiums for the 50% coverage scheme, while the 75% coverage scheme would be of little interest even to producers with these high levels of risk aversion. Alternatively, Quiggin (1986) has argued that if the scheme represents a small and uncorrelated component of the insurer's overall portfolio, then the costs of risk bearing are effectively zero. In addition, Quiggin (1986) and Bardsley (1986) suggest administrative costs of crop insurance are likely to be between 2% and 10% of premiums. In this alternative case, premiums could be such that most producers would also be willing to pay for 75% coverage.[15]

Finally in relation to Table 1, willingness-to-pay is clearly extremely sensitive to the level of coverage. Nevertheless, the ratio of willingness-to-pay to estimated actuarial costs is lower for a higher level of coverage (for $R = 0.3$ it falls from 1.20 to 1.13). Consequently, if administrative costs increase proportionately with estimated actuarial costs then the premiums associated with a higher level of coverage will be attractive to a smaller proportion of producers than those associated with a lower level of coverage.

[15] Recalling the problem of moral hazard referred to in section one, note that if as protection against this problem the insurer instead bases premiums on a mean yield which is 20% below the area average, then the estimated actuarial cost for the two levels of coverage (of average yield) increases to 0.586% and 5.726% of expected income respectively. On the basis of the willingness-to-pay results in Table 1, premiums of this magnitude would clearly be unattractive to even the most risk averse farmers producing with area-average yield. Consequently, protection of this sort against the moral hazard problem is effectively incompatible with the operation of an insurance scheme which has broad appeal to farmers.

TABLE 1
Willingness-to-Pay for Crop Insurance: Base Case Results
(% of expected income)

		R		
Coverage	EAC[a]	0.3	0.6	0.9
50%	0.210	0.251	0.293	0.334
75%	2.081	2.355	2.630	2.901

[a] EAC = Estimated Actuarial Cost as a percentage of expected income.

TABLE 2
Sensitivity Analysis of Willingness-to-Pay: Alternative Price Variability (CV_p = 0.205)
(% of expected income)

		R		
Coverage	EAC	0.3	0.6	0.9
50%	0.210	0.254	0.298	0.342
75%	2.081	2.379	2.679	2.973

TABLE 3
Sensitivity Analysis of Willingness-to-Pay: Alternative Forms of Utility Function
(% of expected income)

		R		
U(px)[a]	Coverage	0.3	0.6	0.9
$-e^{-Apx}$	50%	0.245	0.281	0.320
	75%	2.310	2.540	2.763
$-(m-kpx)^2$	50%	0.246	0.281	0.313
	75%	2.309	2.522	2.719

[a] The values of A, m and K in equation (16) are adjusted so that R is equal to the specified value.

TABLE 4
Sensitivity Analysis of Willingness-to-Pay: Alternative Values of Yield Variability
(% of expected income)

			R		
CV_x	Coverage	EAC	0.3	0.6	0.9
0.17[a]	50%	0.010	0.011	0.013	0.014
	75%	0.532	0.589	0.646	0.702
0.33	50%	0.982	1.197	1.412	1.623
	75%	4.272	4.959	5.652	6.333
0.41	50%	2.210	2.780	3.336	3.914
	75%	6.805	8.124	9.464	10.776

[a] Because output has a positioning value of unity, the coefficient of variation of output (CV_x) is equal to that of yield.

In order to examine further the sensitivity of willingness-to-pay to various parameter values consider first the variability of price. Table 2 contains details of the results of this sensitivity analysis using alternative parameter values for the coefficient of variation of price (CV_p = 0.205 instead of 0.082). In general, Table 2 shows that the estimates of willingness-to-pay in Table 1 are relatively insensitive to the level of price variation — in all cases there is less than 3% difference between corresponding values in the two tables. This general result suggests that both domestic deregulation of wheat marketing and recent instability in the world wheat market due to the US-EEC trade war are unlikely to have significantly altered the willingness-to-pay for crop insurance of Australian wheat growers.[16]

Consider next the sensitivity of the results in Table 1 to the specification of the utility function in equation (16). Table 3 contains estimates of willingness-to-pay based on the constant absolute risk aversion and quadratic forms. As shown in Table 3 , the results in Table 1 are relatively insensitive to the specification of the utility function, differing by 6% or less in all cases.

Finally, consider the sensitivity of willingness-to-pay for crop insurance to the variability of yield. Table 4 contains details of the results of this sensitivity analysis using the range of alternative values of the coefficient of variation of yield indicated previously. A comparison of the results shown in Tables 1 and 4 shows that willingness-to-pay for

[16] Note, however, that by unambiguously increasing the ratio of willingness-to-pay to estimated actuarial costs at relatively low levels of risk aversion, deregulation will have increased the scope for attractive premiums to be established for a majority of producers (for R = 0.3 and 75% coverage this ratio is 1.14 for CV_p = 0.205 compared with 1.13 for CV_p = 0.082).

crop insurance is relatively sensitive to the variability of yield. For example, a one-third increase in the coefficient of variation of yield from 0.25 to 0.33 results in a doubling of willingness-to-pay for 75% coverage and a four-fold increase for 50% coverage, while a one-third decrease to 0.17 sees willingness-to-pay reduced by about 75% for 75% coverage and by over 90% for 50% coverage. Since the results of Anderson *et al.* (1988) indicate considerable divergence between Australian states in the variability of wheat yield, this combined with the results in Tables 1 and 4 suggests there is also likely to be considerable divergence between the willingness-to-pay for crop insurance of producers in different states.[17] For example, with a coefficient of variation of yield of 0.20, relatively risk averse producers (R = 0.9) in Western Australia would be unwilling to pay more than about 2% of expected income even for 75% coverage, whereas similarly risk averse producers in other states would be willing to pay more than 6% of expected income for the same coverage (and over 10% in Tasmania).[18]

Finally, the results in Table 4 show that the proportional difference between the estimated actuarial cost of a scheme and the willingness-to-pay of producers for that scheme is a monotonic function of the coefficient of variation of yield. For example, for R = 0.3 and 75% coverage, with $CV_x = 0.17$, the ratio of willingness-to-pay to estimated actuarial cost is 1.11, whereas with $CV_x = 0.33$ this ratio is 1.16 and with $CV_x = 0.41$ this ratio is 1.19. Consequently, if administrative costs increase proportionately with estimated actuarial costs, there is an indication that the premiums of a particular scheme will be attractive to a larger proportion of producers the higher is their level of yield variability.

Conclusion

In this paper a method for estimating a producer's willingness-to-pay for crop insurance has been presented. The method was developed in section one and includes formulae to capture the impact of crop

[17] For the period 1975-85 Anderson *et al.* (1988) estimate the following coefficients of variation of wheat yield by state: NSW, 0.36; Victoria, 0.37; Queensland, 0.40; South Australia, 0.37; Western Australia, 0.20; Tasmania, 0.42.

[18] Patrick's (1988) results of an interview study of Mallee farmers suggest that 20% of farmers would be willing to pay 12% or more of expected income for 75% coverage and that 50% of farmers would be unwilling to pay even the estimated actuarial cost of this coverage. On the basis of the estimates in Table 4, Patrick's interview results suggest 20% of Mallee farmers ($CV_x = 0.41$) have a level of risk aversion well in excess of R = 0.9 and that 50% of Mallee farmers are risk-preferring. Given the results of Bond and Wonder (1980) and Bardsley and Harris (1987), both these proportions seem excessive. Note also that Patrick finds the average willingness-to-pay for 75% coverage is only 70% more than that for 50% coverage. By contrast, the results in Table 4 suggest that for $CV_x = 0.41$ both estimated actuarial cost and willingness-to-pay for 75% coverage are over two and a half times the respective values for 50% coverage.

insurance on the producer's expected income and variance of income. These impacts were evaluated in the context of a model of producer welfare which features both price and yield uncertainty, as well as risk aversion on the part of the producer. It was shown in section one that willingness-to-pay for crop insurance is a function of the level of coverage, the levels of price and yield uncertainty, and the attitude to risk of the producer.

In section two the method was illustrated in the context of crop insurance in the Australian wheat industry. Estimates of willingness-to-pay were made for two levels of coverage and a range of attitudes to risk on the basis of a base case set of parameter values and a specific form of utility function. It was shown that willingness-to-pay is strongly positively related to the level of coverage. The sensitivity of these estimates to the parameter values and the utility function was then examined. It was shown that the estimates of willingness-to-pay are relatively insensitive to the level of price variability, and the specific form of the utility function. However, willingness-to-pay was shown to be strongly positively related to the level of yield variability.

Finally, although willingness-to-pay was shown to be strongly positively related to both the level of coverage and the level of yield variability, the ratio of willingness-to-pay to estimated actuarial costs was shown to be increasing with yield variability but decreasing with coverage. Consequently, if administrative costs increase proportionately with estimated actuarial costs, only in the case of increased yield variability and decreased coverage will the proportion of producers who find the premiums of the particular crop insurance scheme attractive be increased unambiguously.

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