The Utility of Multiple Peril Crop Insurance for Irrigated, Multiple-Crop Agriculture

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The usefulness of FCIC multiple peril crop insurance on diversified, irrigated, high-yielding farms in the Imperial Valley is examined. Production data and expected price and yield distributions were collected from thirty-two farm managers in 1982. Individual whole-farm net income distributions then were used to elicit their risk preferences. Participation in FCIC crop insurance for cotton, wheat, and sugar beets under the existing program and under several alternatives was predicted. Predicted participation never exceeds 25% of eligible growers. Low maximum yield guarantees and premiums inconsistent with individual yield experience are identified as factors limiting participation.

Key words: crop insurance, diversification, irrigation, risk, utility.

Can a crop insurance program originally designed for dryland wheat production in 1938 provide coverage for a broad range of crops produced under widely varying conditions across the United States now? This question arose from the Federal Crop Insurance Act of 1980, which authorized the Federal Crop Insurance Corporation (FCIC) to provide multiple-peril crop insurance for more crops in more counties in conjunction with the phase-out of the Disaster Payments Program (DPP). The DPP had been providing crop insurance at no additional cost to farm operators who participated in the nonrecourse loan and set-aside programs.

FCIC has had a history of low participation. Only 16% of potential acreage (excluding PIK acres) was insured or reinsured by FCIC as recently as 1983 (AACI). Only 8% of U.S. harvested acreage was insured in 1980 (Kramer 1982). Participating acreage increased by 81% (U.S. GAO) in 1981, mainly from expansion to replace the DPP. Previous studies indicate that FCIC crop insurance can be an attractive risk-management option for risk-averse dryland monoculture farmers (King and Oamek 1981, 1983; Kramer 1981). This study addresses the current and potential value of multiple-peril crop insurance as a risk-management tool to farm operators in irrigated, multiple-crop agriculture. This study examines limitations to broader participation in the current FCIC crop insurance program and proposes some changes to allow expanded usefulness of the FCIC program.

The Study Area and 1982 Insurance Alternatives

The study was conducted in the Imperial Valley of California, where 460,000 acres of land are under cultivation. All crops are irrigated, and production continues throughout the year. A variety of crops including alfalfa, wheat, cotton, sugar beets, and a number of vegetable crops are produced there, giving farm operators ample opportunity to diversify. Mean as well as variance of yields are high relative to other areas in the country (see table 1). The 1982 FCIC crop insurance program in the Imperial Valley consisted of two methods

of calculating yield guarantees and premiums. Under the Area Coverage Program, operators could select yield guarantees of 50%, 65%, or 75% of the average yield assigned to their farm by FCIC. FCIC calculated average yield for each farm by adjusting historical county-average yields for soil type. Premiums were based on expected indemnity for the county adjusted for soil type. Individual operators could have their premiums reduced by up to 50% or increased by up to 300% by buying FCIC crop insurance over several years and incurring no indemnifiable losses or frequent, large indemnifiable losses, respectively. Area coverage premiums ranged from $10.30 to $39.45 per acre for cotton, $2.15 to $10.30 per acre for wheat, and $2.70 to $26.50 per acre for sugar beets.

Individual Yield Coverage (IYC) was the second method of calculating FCIC yield guarantees and premiums in 1982. Operators could submit proof of yields in the five years prior to 1982 to establish an average yield for their farm. Operators could select yield guarantees of 50%, 65%, or 75% of their average yields. Premiums were calculated by multiplying the guaranteed yield times the price election by FCIC's premium rate for the individual farm. FCIC's premium rate under IYC was based on the yield guarantee classification of the individual farm under the Area Coverage Program.

The operator could select one of three price elections under both the Area Coverage and IYC programs. The highest price election offered by FCIC was intended to be at least 90% of expected market price. For example, the three price elections for cotton in 1982 were $.50, $.65, and $.75 per pound.

A government subsidy allowed operators who chose not to participate in the Disaster Payment Program to have premiums reduced by 30% in 1982 on crop insurance with yield guarantees of 50% or 65% of their average yield. The subsidy reduced the premium on the 75% yield guarantee by a cash amount equal to the 30% reduction in the premium for the 65% yield guarantee.

Procedure

First Interview

A stratified random sample of Imperial Valley growers of insurable crops was selected from several farm size strata. Farms in the sample ranged from 130 to 9,500 acres in size. Thirty-two Imperial Valley growers were interviewed during the summer of 1982 to obtain detailed data on production practices, price and yield expectations for the 1982–83 crop year, and farm firm characteristics.

Price and yield expectations for the 1982–83 crop year were elicited by asking producers to distribute ten equally probable outcomes across a range of yields (e.g., fig. 1) or prices according to their expectations. The range of possible yields or prices and the "width" of categories within the range were based on prior evaluation of the questionnaire by Imperial Valley producers.[1] The probability elicitation method selected falls into the nonmotivating classification (e.g., Bessler 1984) because no monetary or other motivation was given to producers to provide accurate subjective probability distributions.[2]

Elicited probability distributions of prices and yields are summarized in table 2. *Ceteris paribus,* larger variance and more negative third moments of the elicited yield distributions are expected to increase the value of crop insurance.

Second Interview

In the summer of 1983, a modified version of King and Robison's interval approach to the measurement of decision maker preferences was used to elicit risk preferences from thirty of the operators in the sample. The assumption of constant bands of absolute risk aversion across the whole range of net income allowed use of whole-farm net income distributions in elicitation of risk preferences. This modification allowed the choices presented to the operator to be more realistic. Whole-farm net income distributions were collapsed from twenty to six observations to allow ease of examination by operators.[3]

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[1] Ten equally probable outcomes generally were adequate for producers to describe distributions, although they occasionally left gaps in a distribution to include outlying prices or yield outcomes.

[2] The lack of resources to provide substantial payoffs and the large amount of producers' time required for the other parts of the questionnaire were reasons for not selecting the proper scoring rule approach. Producers may or may not have been motivated by the knowledge that the accuracy of enterprise and farm net income and risk analysis subsequently provided to them depended on the accuracy of the probability distributions they provided.

[3] The definition and derivation of the whole-farm net income distributions appear in following sections.

Table 1. A Comparison of Average Yield Statistics for Imperial County and Selected States for Cotton, Sugar Beets, and Wheat for the period 1974-78

Crop and Place	Five-Year Average Yield	Standard Deviation of Annual Average Yields	Coefficient of Variation[a]	25% of Mean Yield	Value of One Standard Deviation[b]	Value of 25% of Mean Yield[b]
Cotton (500 lb. bales/acre)					($)	
Imperial County	2.03	.47	.23	.57	175.50	190.05
California	1.90	.32	.17	.48	119.60	177.97
Mississippi	.97	.15	.15	.24	57.30	90.75
Texas	.65	.10	.15	.16	37.70	60.60
Sugar beets (tons/acre)						
Imperial County	24.80	1.69	.07	6.20	58.98	217.00
California	26.48	1.38	.05	6.62	48.42	231.70
Colorado	18.40	.80	.04	4.60	27.91	161.00
Wheat (tons/acre)						
Imperial County	2.48	.152	.06	.619	22.87	92.93
California	1.79	.150	.08	.449	22.50	67.28
Colorado	.684	.036	.05	.171	5.44	25.65
Kansas	.870	.029	.03	.218	4.27	32.62
Texas	.636	.092	.14	.159	13.77	23.85

Sources: Imperial County yield statistics are calculated from data in "Imperial County Agriculture," from the Office of the Agricultural Commissioner, El Centro, California, 1979. Selected states' statistics are calculated from data found in USDA Crop Reporting Board. Note: Individual farms may have experienced higher or lower mean yields and standard deviations than are suggested by aggregate averages. Similarly, aggregation over greater acreage tends to result in variance of state-average yields being less than variance of county-average yields.

[a] Coefficient of variation is calculated as standard deviation divided by average yield.

[b] Values are calculated with the following prices: cotton, $375 per 500 lb. bale; sugar beets, $35 per ton; wheat $150 per ton.

Efficient strategies in various risk aversion categories that satisfied the following criterion were selected for use in the risk-preference-elicitation procedure:

Strategies 1, 2, 3, ..., n were considered suitable for risk preference elicitation if

$$E[U_{i=K}] > \max(E[U_{i \neq K}]) \quad \text{if } R_{LK} < R_K(Y) < R_{UK}$$
$$\text{for all } Y \qquad\qquad i = 1, 2, \ldots, n$$
$$R_{U(K-1)} < R_{LK} < R_{UK} < R_{L(K+1)},$$

where $E[U_i]$ is expected utility of strategy i, R_{LK} and R_{UK} are the lower and upper bounds on the absolute risk aversion coefficients defining risk aversion category K, and $R_K(Y)$ is the absolute risk aversion function of net income (Y) for any decision maker in risk aversion category K.

For any set of strategies $i = 1, 2, \ldots, n$ such as that defined above, preference for strategy $i = K$ was taken as indication that the operator's absolute risk aversion coefficient took a value between $R_{U(K-1)}$ and $R_{L(K+1)}$ for all levels of net income simulated for his farm. It is possible that both strategy $i = K$ and strategy $i = K - 1$ are efficient for operators with risk aversion coefficients that lie between $R_{U(K-1)}$ and

R_{LK}. Therefore, preference for strategy $i = K$ cannot be taken as evidence that the operator's risk aversion coefficient clearly exceeds R_{LK}, but that it does exceed $R_{U(K-1)}$.

Each strategy selected for the elicitation procedure was printed on a separate card for presentation to operators. The six equally probable net income results as well as their mean and standard deviation were printed on one side of the card.[4] The acreage of each crop and the level of FCIC crop insurance on each insurable crop were printed on the back of the card. Operators were allowed to look at both sides of the card and asked to select the strategy that they preferred for their farms. The opportunity to associate crop mix and insurance

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[4] A question has arisen as to whether producers used the six equally probable outcomes to evaluate the net income distribution (as is intended in the interval method) or just the mean and standard deviation. Our reasoning was that the sample mean and standard deviation were simply summary statistics of the six data points already presented on the cards. If producers chose to ignore the additional information provided and selected a strategy solely on a mean-variance criterion, the elicitation method remained valid. In practice, producers tended to focus on the six equally probable outcomes and the mean when discussing their alternatives.

Cotton Prices and Yields

Indicate what you believe are the chances of different cotton lint yields occurring on your fields in 1982 (bales/acre).

1	1.5	2	2.5	3	3.5	4	4.5	5

Indicate what you believe are the chances of different cotton lint prices being received by you in 1982 ($lb.).

.50−.55	.55−.60	.60−.65	.65−.70	.70−.75	.75−.80	.80−.85	.85−.90	.90−.95	.95−1.00

Figure 1.   An example of the format used to elicit probability distributions of prices and yields from Imperial Valley producers

strategy directly with the whole-farm net income distribution was well received by most operators in the sample. This feature of the elicitation procedure made identified risk preferences more realistic to the extent that operators discussed options in the context of their own farming situations. Operators' interest in the relationship between various strategies and the probability distribution of whole-farm net income indicates a strong potential for development of farm-level risk management and teaching aids.

Risk preferences of thirty producers were elicited with stochastically efficient whole-farm net income distributions. Seventeen producers were classified as risk averse while thirteen were risk neutral. Absolute risk aversion coefficients ranged in scale from .0000002 to .0001. By comparison, King and Oamek (1983) reported absolute risk aversion coefficients ranging in scale from .00001 to .00007 using their interval method. The magnitude of absolute risk aversion coefficients tended to decrease as the magnitude of the whole-farm net income distribution increased.

Costs and Net Income

The University of California Budget Generator was used to estimate cost of production per acre based on elicited production practices for each crop grown by each grower in the sample. The measure used in comparing alternative strategies was net income after cash costs. The term "net income" refers to net income after cash costs which excludes the opportunity cost of unpaid labor and equity financed assets.

Estimated cash costs include per acre costs and yield-dependent costs that affect both the mean and the shape of the calculated net income distribution. Interest and depreciation on owned machinery and equipment and rent on land owned by the operator were multiplied by the operator's debt-to-asset ratio to estimate their cash cost. Higher per acre cash costs tend to reduce mean net income for a crop but do not affect the shape of the income distribution; higher yield-dependent cash costs reduce the mean and affect the shape of the income distribution according to the relationship of yield and gross income; and higher share rent reduces both the mean and the dispersion of the net income distribution.

Efficient Crop Mix and Insurance Strategies

A modified version of King's generalized risk efficient monte-carlo programming (GREMP) model was used to identify risk-efficient crop mix and crop insurance coverage strategies in several ranges of absolute risk aversion for each operator. The level of crop insurance coverage on each insurable crop and the number of acres of each crop to be produced were stochastically generated. Acres of each crop were selected in increments of minimum field size for each farm. Crop insurance coverage was selected from the nine possible combinations of price elections and yield guarantees or no insurance for each insurable crop. Total acres of all crops on a farm and acres of selected crops were constrained to reflect actual total acres farmed in 1982 and certain biological and market constraints.

The GREMP model employs Meyer's stochastic dominance with respect to a function efficiency criterion to rank alternative strate-

Table 2. Sample Mean Values for the Mean and Second, Third, and Fourth Moments About the Mean of Elicited Probability Distributions for the 1982-83 Crop Year

Variable	Number in Sample	Mean	Variance	Third Moment	Fourth Moment
Alfalfa hay prices	18	80.47	49.85	−74.17	9,342
Alfalfa hay yields	18	8.38	.49	−.08	1.18
Alfalfa seed prices	2	97.15	122	−115	48,393
Alfalfa seed yields	2	3.6	.93	−.50	1.78
Cotton prices	23	363	498	413	907,498
Cotton yields	24	3.09	.28	−.065	.329
Lettuce prices	2	6.02	5.55	32.29	276
Lettuce yields	2	666	8,556	−1,531,391	450,221,024
Sugar beet prices	10	39.9	39.85	97.012	8,492
Sugar beet yields	13	27.1	5.33	−9.75	148.15
Wheat prices	27	132.13	106	870	74,600
Wheat yields	27	3.04	.11	−.03	.076

gies according to their net income probability distributions. Efficiency criteria identify efficient sets of strategies so that more than one strategy may be efficient for a decision maker. According to Meyer's criterion, a strategy is efficient for operators with absolute risk aversion coefficients that lie within specified bounds if no other strategy considered provides greater expected utility for all possible utility functions within the specified bounds.[5]

The modified GREMP model was used to identify efficient strategies in the risk aversion category containing the operator's elicited risk preferences. An operator was predicted as "should buy" crop insurance if all efficient strategies in his risk aversion category include crop insurance. If an operator's efficient set included some strategies with crop insurance and others without, he was predicted as "may buy." Finally, if no efficient strategy included crop insurance, the operator was predicted as "should not" purchase crop insurance.

A substantial modification was made to the GREMP program to allow less expensive analysis of multiple-crop farms. An important characteristic of multiple-crop farms is the interrelationship between prices and yields of the various crops. A twenty-observation joint probability distribution of prices and yields for each operator in the sample was used to evaluate alternative strategies instead of the ran-

domly selected set of prices and yields that the GREMP model's generalized multivariate process generator would have produced.

The joint price and yield probability distributions were constructed from historical data on county-average prices and yields and from the probability distributions for prices and yields elicited from each operator in the sample. Following Bessler (1977), autoregressive integrated moving-average (ARIMA) models were estimated for the price and yield of each crop using twenty years of county-average data. The deviations from the best-fitting ARIMA models were assumed to represent unanticipated fluctuations in prices and yields.[6] It was assumed that the lowest yield (price) in each operator's elicited probability distribution occurred in the year that the largest negative unanticipated fluctuation in county-average yields (prices) occurred. Similarly, each successively higher yield (price) in the elicited distribution was assigned to the year in which the next most negative deviation occurred. These assumptions allow construction of a joint price and yield probability distribution which incorporates interdependence information from observation of the past twenty years while preserving the marginal probability distributions of prices and yields elicited from individual operators for the current crop year.

This method of calculating interdependence of forecasted prices and yields resulted in different covariances for each operator. All but

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[5] The absolute risk aversion functions that define the bounds of each risk preference category were assumed constant across all levels of net income in this study. This assumption was made to facilitate the risk preference elicitation procedure described above. Some flexibility in specification of risk preferences is lost as a result.

[6] Lin estimated enterprise income interdependence using a similar method.

five of twenty-four cotton producers had negative covariances between cotton prices and yields. All eighteen alfalfa hay producers, thirteen sugar beet producers, and twenty-seven wheat producers had positive covariances between prices and yields for those crops. One of two alfalfa seed producers and one of two lettuce growers had positive covariances, while the others had negative covariances. Negative covariance of prices and yields is expected to reduce the value of crop insurance for that crop for a risk averter.

The combined data from elicited probability distributions, estimated costs, and interdependence relationships results in a probability distribution of net income for each crop for each producer (table 3). Some sampled producers of each crop, except lettuce and alfalfa seed, had negative mean net income after cash costs on owned and rented land.

Interdependence of net income from different crops is also implicit in this model. Net income per acre of cotton was positively correlated with net income per acre of sugar beets, alfalfa hay, and alfalfa seed but negatively correlated with net income from lettuce for all cotton producers in the sample. Net income from cotton was positively correlated with wheat income for twelve producers. Net income from sugar beets, wheat, and alfalfa hay tended to be positively correlated. Positive covariances of net income between crops are thought to reduce the effectiveness of diversification as a method of reducing risk. The relationship between diversification and predicted purchase of crop insurance is examined below.

Crop Insurance Alternatives Analyzed

An insurance option is described by the method of calculating yield guarantee and premium. Three methods of calculating yield guarantees were used in this study:

(A) The yield guarantee offered to operators under FCIC's actual 1982 Area Coverage Program was used to evaluate participation under that existing program. Area Coverage yield guarantees generally are based on county-average yields adjusted for soil types.

(B) Yield guarantees were calculated as the selected percent coverage (50%, 65%, or 75%) times the mean of yield probability distribu-

tions elicited from each producer. This yield guarantee was used to simulate producer insurance decisions when the average yield used by FCIC to establish yield guarantees exactly equalled producers' expected yield. Yield guarantees based on the mean of producers' historical yields were approximated under FCIC's Individual Yield Coverage (IYC) Program. The IYC program has recently been replaced with Actual Production History (APH), which uses up to ten years of historical yields excluding the highest and lowest to establish yield guarantees. Producers' yield expectations in any one year may vary from their yield history.

(C) Yield guarantees were calculated as 1.1 times FCIC's actual Area Coverage yield guarantees to simulate effects of the 10% increase in yield guarantees offered in conjunction with the 1983 PIK program.

Six methods of premium calculation were used.

(1) The premiums actually charged to producers under Area Coverage were used with yield guarantee (A) above to predict participation under FCIC's Area Coverage Program in 1982 (option 1 for cotton and wheat in table 4). These premiums were also used with yield guarantee (C) to evaluate participation under the PIK program (option 6 for cotton and option 3 for wheat).

(2) Premiums actually charged under Area Coverage in 1982 for specified yield guarantees were combined with yield guarantee (B) to evaluate the effect of calculating yield guarantees from average yields equal to producers' expected yield under the current Area Coverage Program (cotton option 3 and wheat option 2 in table 4). The premium rate (dollar per unit of yield guaranteed) for coverage based on producers' expected yields may differ from the premium rate for coverage based on their assigned area yield.

(3) Insurance premium rates (percent) specified for each operator by FCIC in 1982 under the IYC program were multiplied by the product of the yield guarantee and the price election to calculate premiums. This method combined with yield guarantee (B) was used to evaluate participation under the 1982 IYC program when yield guarantees are consistent with producers' yield expectations (option 2 for cotton in table 4).

(4) Actual 1982 Area Coverage premiums were multiplied by .7 to examine the effect of the 30% subsidy offered by FCIC in 1982. The

Table 3. Sample Average Estimated Mean and Variance of Net Income per Acre after Cash Costs by Crop in 1982/83

Crop	Number in Sample	Net Income per Rented Acre		Net Income per Owned Acre	
		Mean	Variance	Mean	Variance
		($)		($)	
Alfalfa hay	19	80	5,581	184	6,904
Alfalfa seed	2	46	8,030	121	9,855
Cotton	24	130	28,030	242	31,226
Lettuce	2	550	506,815	627	507,914
Sugar beets	13	112	32,365	205	40,188
Wheat	27	14	3,223	89	3,592

actual subsidy was between 19% and 22% at the 75% yield guarantee. This premium was combined with yield guarantee (B) to examine the effects of a subsidy when yield guarantees are consistent with producers' expectations (option 4 for cotton and wheat and option 1 for sugar beets in table 4).

(5) Premiums were also calculated as premium (4) above multiplied by .7 to examine the effects of a 51% subsidy $(1 - (.7)^2)$ on participation (option 5 for cotton).

(6) Premiums were calculated as expected indemnity divided by .9 to examine the effects of a .9 target loss ratio on participation. This premium combined with yield guarantee (B) was used to predict participation when both yield guarantees and premiums were calculated from yield distributions identical to producers' probability distributions of yields (cotton option 7, wheat option 5, and sugar beets option 2).

Results

Predicted Participation

The predicted number of buyers of FCIC crop insurance (table 4) is low for programs available in 1982 such as Area Coverage (cotton and wheat option 1) and IYC (cotton option 2). Making yield guarantees consistent with producers' yield expectations resulted in little or no increase in predicted number of buyers under Area Coverage (cotton option 3, wheat option 2), Area Coverage with 30% subsidy (cotton option 4, sugar beet option 1, wheat option 4) or IYC (cotton option 2). Increasing the subsidy to 51% from 30% had no effect on the predicted number of buyers of cotton in-

surance (cotton option 5). A flat 10% increase in yield guarantees as stipulated under the PIK program doubled the number of predicted buyers of cotton insurance under the Area Coverage Program (cotton option 6) but had little effect for wheat (wheat option 3). The largest predicted number of buyers for each crop occurred when premiums were calculated as expected indemnity divided by .9 (cotton option 7, sugar beet option 2, wheat option 5). These results are consistent with King and Oamek (1981). Unlike that study, however, maximum predicted participation in this study never exceeds 25% of cotton growers, 0% sugar beet growers, and 18.5% of wheat growers. Some insight into the cause of these low predicted numbers of buyers is gained by examining expected loss ratios.

Expected Loss Ratios

Expected loss ratios were determined by dividing the expected crop insurance indemnity by the premium for each producer under each of the FCIC programs simulated (table 5). Expected loss ratios larger than 1.0 indicate that FCIC may expect to pay out more in indemnities than it receives in premiums. Conversely, expected loss ratios less than 1.0 indicate that the producer may expect to pay more in premiums than will be received in indemnities. In general, subsidies and arbitrary increases in yield guarantees increase loss ratios. Yield guarantees consistent with producers' expected yields may also cause high expected loss ratios (e.g., cotton option 3 versus option 1) when premiums do not reflect the producer's yield distribution. When the producer's yield distribution is used not only to calculate yield guarantees but also to calculate expected

Table 4. Number of Operators Predicted to Purchase FCIC Crop Insurance under Various Methods of Yield Guarantee and Premium Calculation

Crop and Option Number	Yield Guarantee	Premium	Predicted Number of Operators Should Buy	May Buy	Should Not Buy
Cotton					
1	A. 1982 actual area coverage	1. 1982 actual area coverage	1	1	22
2	B. Mean of elicited yields	3. 1982 actual IYC rates	2	0	22
3	B. Mean of elicited yields	2. 1982 area coverage premiums	1	1	22
4	B. Mean of elicited yields	4. .7 × 1982 area coverage	2	1	21
5	B. Mean of elicited yields	5. .49 × 1982 area coverage	2	1	21
6	C. 110% × 1982 area coverage	1. 1982 actual area coverage	4	0	20
7	B. Mean of elicited yields	6. Expected indemnity/.9	2	4	18
Sugar beets					
1	B. Mean of elicited yields	4. .7 × 1982 area coverage	0	0	13
2	B. Mean of elicited yields	6. Expected indemnity/.9	0	0	13
Wheat					
1	A. 1982 actual area coverage	1. 1982 actual area coverage	1	1	25
2	B. Mean of elicited yields	2. 1982 area coverage premiums	1	2	24
3	C. 110% × 1982 area coverage	1. 1982 actual area coverage	2	0	25
4	B. Mean of elicited yields	4. .7 × 1982 area coverage	1	3	23
5	B. Mean of elicited yields	6. Expected indemnity/.9	1	4	22

indemnity, premiums can be calculated which meet target loss ratios (e.g., cotton option 7, sugar beet option 2, wheat option 5). This method not only results in increased predicted participation but also results in an aggregate expected loss ratio less than 1.0 for FCIC.

A problem still exists, however, because eleven of twenty-four cotton growers, twelve

Table 5. Number of Operators with Selected Expected Loss Ratios under Various Methods of Yield Guarantee and Premium Calculation

Crop and Option Number[b]	Loss Ratio[a] ≥1.0	.7–1.0	.5–.7	.3–.5	.1–.3	.01–.1	.0	Total
Cotton								
1	1	1	0	3	0	1	18	24
2	2	2	0	0	6	3	11	24
3	3	1	0	1	6	2	11	24
4	4	0	1	3	4	1	11	24
5	4	0	2	5	2	0	11	24
6	3	0	1	1	3	1	15	24
7	0	13	0	0	0	0	11	24
Sugar beets								
1	0	0	0	1	0	0	12	13
2	0	1	0	0	0	0	12	13
Wheat								
1	1	0	1	0	0	0	25	27
2	1	1	1	1	1	3	19	27
3	2	0	0	1	4	0	20	27
4	2	1	1	1	2	2	19	27
5	0	8	0	0	0	0	19	27

[a] Expected loss ratio is defined as expected indemnity divided by the premium.

[b] See table 4 for yield guarantees and premiums associated with each option number.

of thirteen sugar beet growers, and nineteen of twenty-seven wheat growers have expected loss ratios and expected indemnities of zero. Expected indemnities of zero result when there is no probability of yields occurring below the yield guarantee. While a probability of zero of low yields may be impossible, examination of actual yield records over the period 1978–81 for twenty-three cotton growers in the sample reveals that eleven of them did not achieve yields below 75% of their expected yield. Furthermore, nineteen producers did not achieve yields less than 75% of their average yield calculated over that period. The low probability of indemnifiable loss discourages purchase of crop insurance. This is particularly true when premiums that are large relative to expected indemnity result in expected loss ratios near zero for individual producers.

Characteristics of Predicted Buyers of Crop Insurance

Characteristics of producers predicted to buy crop insurance were compared to sample averages to identify marketing opportunities for FCIC. There is some evidence that diversification substitutes for insurance. All farms predicted to buy either cotton or wheat insurance produced four crops or fewer. The nine farms with five or more crops were never predicted to buy crop insurance.

There is also evidence that the insurance programs considered do not attract larger farms. All farms predicted to buy either wheat or cotton insurance under 1982 FCIC programs were less than 1,300 acres in size; the sample average was 1,925 acres. When premiums were calculated to set the expected loss ratio to .9, the average size of farms predicted to insure rose to 1,450 acres for cotton insurers and 1,600 acres for wheat insurers. Smaller producers' yield distributions tended to have larger variances, making existing area coverage programs more attractive to them. Smaller variance of average yields on larger farms is consistent with some independence between yields on different fields which results in self-insurance through geographic diversification.

Three of five share-rent producers of cotton in the sample were predicted to insure under option 7. Only one of seven share-rent producers of wheat were predicted to insure. Share rent tends to reduce the effect of yield variation on the operator's net income variation. Share-

rent operators may use crop insurance to further stabilize net income for crops with high cash costs such as cotton.

Discussion

The IYC and APH options alone will not be sufficient to attract more insurance buyers if premiums are not also tailored to individual yield history to achieve more efficient expected loss ratios. There is a substantial difference between yield distributions elicited from operators and the average yield distributions used by FCIC to calculate insurance premiums. The IYC and APH programs allow operators to submit proof of past yield performance to obtain higher yield guarantees. Under the IYC program, premiums were increased in proportion to the yield guarantee without consideration of the operator's actual history of indemnifiable yields. The APH program applies lower premium rates as average yields increase but fails to consider the producer's past frequency of indemnifiable losses in determining premiums. Furthermore, premium adjustments for FCIC insured producers with exceptionally low or high frequency of indemnifiable losses are being phased out in conjunction with APH. If operators perceive premiums to be too high relative to the yield risk that they perceive for their farms, they may never buy crop insurance.

The presence of substantial uninsurable yield risk indicates that the current crop insurance program is not providing an effective risk-management tool for farmers in areas with high average yields. To expand crop insurance utilization, FCIC's current legislated maximum yield guarantee of 75% of mean yield should be amended. High mean yields in areas such as the Imperial Valley result in proportionately higher value of the uninsurable 25% of mean yield. Consequently, substantial financial losses can occur before any indemnity can be collected. An examination of state-average yields over the period 1974–78 shows that the uninsurable 25% of California average cotton yields is equal in amount and value to 50% of the Mississippi average cotton yield and 70% of the Texas average cotton yield (U.S. Crop Reporting Board).

An alternative criterion for calculating maximum yield guarantees is to legislate a minimum deductible in dollar value or in absolute

units of yield per acre. The amount of the minimum deductible would limit the uninsurable financial loss per acre regardless of mean yield.

Higher yield guarantees could lead to increased moral hazard, i.e., increased incentive to achieve low yields to collect indemnities. Increased coinsurance in the form of a decrease in the maximum price election may be required. Higher yield guarantees would increase the probability of operators receiving an indemnity while increased coinsurance would allow lower premiums and reduce indemnity payments.

FCIC crop insurance can be an effective risk management tool for farm operators across the country. Current legislative limits on yield guarantees restrict participation in the insurance program in high-yielding, diversified areas of the country. Our simulation suggests that the current move by FCIC to individualize yield guarantees must be accompanied by increased "tailoring" of premiums to individual historical yield performance if new crop insurance buyers are to be attracted.

The 1980 Federal Crop Insurance Act reflected general government policy to replace various disaster protection programs supported by government appropriations with a more self-supporting program of actuarially sound multiple-peril crop insurance. In order to provide an effective disaster protection alternative to farm operators, crop insurance must be available with yield guarantees large enough to afford minimal financial protection. Crop insurance also must be available with premiums that accurately reflect individual operators' expected indemnity so that crop insurance is a feasible purchase.

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