An Empirical Assessment of Adverse Selection in U.S. Crop Insurance

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July, 1993

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Agricultural crop insurance has been the subject of much economic analysis over the last decade. However, most of the work has been theoretical rather than empirical. Conceptual papers have attempted to explain why private multiple peril crop insurance markets do not emerge (e.g., Nelson and Loehman) or have suggested new insurance schemes that eliminate market failures or impediments (e.g., Quiggin). While several papers have explained the failure of private markets to provide multiple peril crop insurance by moral hazard (e.g., Chambers), most have focused on the role of adverse selection (Ahsan, Ali, and Kurian; King and Oamek; Skees and Reed). To date, however, empirical analyses that demonstrate significance and magnitude of adverse selection have been lacking. The limited empirical analyses available are more in the nature of simulation analyses of selected farms (e.g., King and Oamek) or are based on county-level data where the contribution of interfarm variation within counties to adverse selection is overlooked (Gardner and Kramer). This paper reports on a nation-wide statistical comparison of individual participating and non-participating farms and demonstrates that adverse selection is, in fact, a serious problem in offering multiple peril crop insurance. Adverse selection is shown empirically to explain a large part of the persistent losses incurred by the Federal Crop Insurance Corporation (FCIC).

Failure of Federal Crop Insurance in the United States

Federal multiple peril crop insurance and the FCIC was introduced with the Federal Crop Insurance Act of 1938. However, federal crop insurance was not an important part of the U.S. farm program until the Federal Crop Insurance Act of 1980. With the 1980 Act, coverage of both crops and counties was increased and a 30 percent subsidy of premiums was undertaken to encourage participation. Nevertheless, participation rates remained below 25 percent compared to a goal of 50 percent (until 1989 when participation was required as a condition for receiving drought assistance in 1988). Also, beginning with the 1980 Act, the delivery of federal crop insurance was shifted to the private sector although the FCIC continues to set all the parameters of the insurance contract. In 1988, for example, about 85 percent of insurance sales was through private insurance companies which handled all aspects of sales, service, and loss adjustment on their own with the FCIC reinsuring these companies against extraordinary losses (e.g., in excess of 15.375 percent of premiums in 1989). In the last few years, this has resulted in FCIC compensation to reinsured companies equal to about one-third of collected premiums. The remainder of insurance sales are through master marketers who sell on commission for the FCIC (e.g., 20 percent of premiums in 1989) with the FCIC servicing policies and overseeing loss adjustments.

In spite of the disappointing participation levels, the FCIC has incurred heavy and persistent losses even in years with good crops. Government outlays for crop insurance exceeded $4.2 billion between 1980 and 1988 with a loss ratio (indemnities divided by premiums) averaging 2.05 (U.S. General Accounting Office 1989). (A loss ratio less than about .95 is generally regarded as necessary for private insurance viability.) This high loss ratio is particularly disturbing given the program goal of gradually privatizing crop insurance and eliminating government subsidization.

The Federal Crop Insurance Contract

For most crops, farmers who purchase insurance choose one of three yield levels and one of three price levels at which to insure. The insurable yield levels are 50, 65, and 75 percent of the farmer's Approved Production History (APH) yield. The APH yield is a ten-year average of yields obtained on the farm if a verified history is available. Otherwise, an ASCS yield is used or the FCIC assigns a yield. Generally, the FCIC sets the highest insurable price at approximately the expected market price with two other insurable prices somewhat lower. The insurance premium depends on the farmer's selected yield and price levels, the APH yield, and the county level premium rate which reflects local risk conditions. The federal government subsidizes 30 percent of the premium at the 50 or 65 percent levels. At the 75 percent level, the premium is subsidized by 30 percent of the 65 percent level premium.

Farmers receive an insurance indemnity payment if the average yield on their entire farm falls below the insured yield level. The indemnity payment is equal to the insured yield less the actual yield evaluated at the insured price. Total revenue per acre may be smaller than normal if the insured percentage of APH yield is small, the APH yield is smaller than the farmer's true normal yield, or the insured price is below the normal market price.

Heterogeneity and Adverse Selection

The problem of adverse selection occurs when agents (farmers) differ in characteristics that affect the probability and size of indemnity payments but these characteristics are not reflected appropriately in the premium structure. This gives some farmers a better than average chance to profit from purchasing insurance. If only such farmers participate, the insurers thus tend to lose. Farms and farmers are apparently highly heterogeneous. Fertility of land varies substantially from farm to farm and farmers differ in management skills. Furthermore, data reflecting this heterogeneity to insurers is unavailable or imperfect.

If farmers can assess their own expected returns from insurance (e.g., know the productivity of their own farm) better than insurers, then the agents who have larger expected indemnities per dollar of premium are more likely to participate. This is the problem of asymmetric information that gives rise to adverse selection. As a result of asymmetric information, the insurer must either set the premium structure to reflect the higher risk associated with the individuals who choose to participate (thus offering less-fair insurance to others) or a loss will be incurred by the insurer (for example, if the premiums reflect the average characteristics of all farmers).

To reduce this problem, the FCIC must account better for the factors that explain heterogeneity among farms in setting premiums. This paper attempts to assess the extent to which the FCIC currently accounts for heterogeneity among farms.

Heterogeneity of Risk

One type of adverse selection is when only high risk farmers participate in the program. Panels (a), (b), and (c) of Figure 1 represent three farmers with different risk levels but the same normal yield level, μ. In case (a), the risk is low enough that an indemnity payment can never be collected. In case (b), the risk is low enough that an indemnity payment cannot be collected if the farmer is insured at the 50 percent level. If the farmer is insured at the 75 percent level, the probability of collecting an indemnity payment is equal to the shaded area. However, the expected amount of the indemnity payment will be small if most of the probability density below $.75\mu$ is near $.75\mu$ (because the indemnity payment is based on the difference between $.75\mu$ and the actual yield). Case (c) represents a high risk farmer. In this case, much of the probability is far below the $.75\mu$ level so the expected size of the indemnity payment is substantial if insured at the 75 percent level. Figure 1 demonstrates how farmers with the same normal yield level may have quite different expected indemnities.

The only farm specific information used by the FCIC to determine the parameters of individual insurance contracts is the APH yield (an assessment of normal yield). The FCIC, in effect, assumes constant relative risk among farms facing the same premiums (Driscoll).

Heterogeneity of relative risk among farms is taken into account only by setting premium rates according to loss experience at county or regional levels. Thus, heterogeneity of risk is reflected only to the extent that risk is uniform within the counties or regions used to determine premium rates. With little doubt, farms with higher average yields do not necessarily have proportionally higher variability even within counties. For example, in a sample of Western Kentucky farmers Skees and Reed (1986) found that this adjustment is insufficient and favors farmers with lower average yields.

Heterogeneity of Average Yields

Another reason for adverse selection is that farmers' expected yields may not be well reflected in the insurable yields. For example, when a sufficient verified production history does not exist, county ASCS yields are used to establish insurable yields or the FCIC uses area-wide experience to assign a yield. Nevertheless, average yields may vary considerably among farmers in the same county because of land quality, managerial ability, production practices, etc. Thus, farmers with high quality land have an incentive to establish an approved production history while farmers with poor land do not. Alternatively, farmers with both good and poor land can rotate two crops with each crop raised on good land when uninsured and on poor land when insured. Thus, the APH yield for both crops will inappropriately partially reflect the poor land quality even though an insured crop is never grown on poor land.

Suppose two farmers have the same yield $\bar{\mu}$ for insurance purposes. Then, as in Figure 2 (a), the farmer using low quality soil will have an actual average yield μ below the insurance yield whereas in Figure 2 (b) the farmer using high quality soil will have an actual average yield μ above the insurance yield. Suppose the yield distributions differ only by location. Then the farmer in panel (a) will have a higher probability of collecting an indemnity payment. With sufficient heterogeneity among farmers, the farmer using low quality land may have a substantial probability of collecting indemnity payments while the farmer using high quality land has no chance of collecting indemnity payments and therefore does not participate. Again, participation may be low with high indemnities among those who participate. The applicability of this explanation has been difficult to assess with readily available data because it depends on estimating the distribution of yields on individual farms.

Necessary Data for Assessing Adverse Selection

These potential explanations for adverse selection dictate the need for several types of data. First, either individualized yield histories or subjective yield distributions of individual farmers are crucial for adequate assessment of farm-level heterogeneity. Because yield histories are not uniformly kept across all farms, the necessity of comparable data dictates collection and use of subjective distributions of farmers. Second, farmers perceptions of the probabilities of obtaining less than 50, 65, and 75 percent of their FCIC insurance yield is crucial to determination of whether farmers are more likely to receive indemnities. The necessity of these two types of data dictate the need for direct interviews of individual farmers. Third, data on actual yields of the insurable crops are important in assessing whether less productive farms participate and whether farm productivity is adequately reflected in parameters of the insurance contract. Perhaps the best nation-wide data reflecting this information is provided by the Farm Cost and Returns Survey (FCRS) administered annually by the National Agricultural Statistical Service (NASS) on behalf of the Economic Research Service (see Economic Research Service, 1989, for a complete description). Fourth, farm-level premium data and the choice of insurance level (both price and yield) are needed to assess whether adverse selection is reflected in the actual insurance decisions that have been made. This information must be crop specific because farmers can choose to insure one crop and not another. For this purpose, the data on actual FCIC policies are useful.

To compile these necessary data to assess adverse selection at the national level, data from the 1988 FCRS for farmers growing corn, sorghum, soybeans, and wheat were supplemented by a Computer Assisted Telephone Interview (CATI) of the same farmers, also administered by NASS, and insurance records of the FCIC were identified for each such farmer included in the FCRS. The CATI survey was designed to assess stochastic distributions of yields and the probability of an insurance indemnity under each type of insurance contract for each crop. For each crop, questions were asked regarding expected average yield on the farm and the chances of an average farm yield of at least 50, 65, and 75 percent of the APH and ASCS yields.[1] The crop-specific questions were repeated for the irrigated and non-irrigated cases. Finally, these data were enhanced by using actual crop insurance policy information for individual farms from the files of the Federal Crop Insurance Corporation (FCIC). Data from all three sources (CATI, FCRS, and FCIC) were merged by farm for the analyses reported in this study. Additional data included FCIC insurance rate data by county.

Survey Response

Relatively complete CATI observations were obtained for 72.6 percent of the usable observations in the 1988 FCRS involving at least one of the subject crops. Some inconsistencies in the data, however, further reduced the number of observations. Of the usable CATI observations, 2.6 percent were excluded because the FCRS indicated participation in federal crop insurance and the CATI did not, and 4.4 percent were excluded because the CATI indicated participation in federal crop insurance and the FCRS did not. An additional 0.6 percent were excluded because the FCIC data indicated a positive premium and the FCRS indicated no federal crop insurance. No such inconsistencies were found with the CATI data. The most serious problem was the elimination of 9.6 percent of the observations for which the FCRS and CATI data indicated the purchase of crop insurance but NASS was unable to identify a corresponding FCIC insurance record. Finally, 0.5 percent of the observations were excluded because the FCIC data indicated a premium for a specific crop for which the FCRS data indicated no acreage. In addition, some observations were excluded from individual calculations below because of a missing response to a specific question or inconsistent responses to a group of questions, e.g., a higher probability of yield falling below 50 percent of normal than for falling below 75 percent of normal. While one must be concerned with possible bias introduced by omitting observations for which come data are missing or inconsistent, means were not available to conduct a follow-up survey. Fortunately, the nature of the omissions suggest no obvious biases in the results presented here.

Distributional Assumptions and Variance Assessment

For the purposes of this paper, the subjective yield distributions of farmers are characterized by means and variances (later transformed into coefficients of variation). To develop a subjective variance from the data, farmer's estimates of probabilities of achieving 50, 65, and 75 percent of the APH yield were used in a three point probit-type regression assuming normality. Specifically, where y is yield, $\bar{\mu}$ is the APH yield, and $\Pr(y < \beta\bar{\mu}) = \psi^{\beta}$ and ψ^{β} represents the farmer's probability of achieving a yield less than $\beta\bar{\mu}$, $\beta = .5, .65, .75$, note that $(\beta\bar{\mu} - \mu)/\sigma = \Phi^{-1}(\psi^{\beta})$ where Φ is the cumulative distribution function of the standard normal distribution. Thus, σ can be estimated by a farmer-specific regression using the equation $\beta\bar{\mu} = \mu + \sigma\Phi^{-1}(\psi^{\beta})$.

While normality of yields has been questioned in other contexts, it seemed to be a reasonable approximation here. For each crop, the applicability of eleven alternative families of stochastic distributions was assessed. These included the normal, logistic, Weibull, gamma, lognormal, exponential, inverse Gaussian, Pearson types 5 and 6, and extreme value distributions of types A and B. The Kolmogorov-Smirnov test did not reject normality for corn and sorghum. While normality was rejected at the 5 percent level for soybeans, none of the other distributions fit the data better. Normality was rejected for wheat, but only the logistic distribution fit better and only mildly so. As indicated in Table 1, skewness is quite close to zero and kurtosis is quite close to 3 as it should be for normality in every case. Thus, the approach to assessment of subjective variance of yields appears to be a plausible approximation.

The Empirical Results

The empirical results of this paper investigate the extent to which the yield distributions of farmers participating in crop insurance differ from those who do not. If farmers with higher expected losses, greater risk, and higher probabilities of indemnities participate but these differences are not explained by higher premiums, then adverse selection occurs.

Heterogeneity of Probabilities of Indemnities. The presence of adverse selection in the data is first examined by investigating the differences in probabilities of receiving indemnity payments between insurers and non-insurers. This is done in the first three columns of Table 2.[2] The results of this comparison reveal remarkable consistency. For every crop and at every insurance level, insured farmers have higher average probabilities of the insured event than do non-insuring farmers. Overall, insured farmers have about 2 to 9 percent greater chances of receiving indemnity payments than would non-insuring farmers. For corn, soybeans, and wheat, the differences are statistically significant at the 5 percent level except for wheat at the 65 percent insurance level which is significant at the 10 percent level. For sorghum, where the number of insured observations is small, the differences are not significant. These results demonstrate considerable heterogeneity in the farm population. If the FCIC cannot develop a premium structure tailored to this heterogeneity, then adverse selection can affect viability of crop insurance. Given the clarity of this evidence, the remainder of this focuses on heterogeneity by mean and coefficient of variation and analyzes the extent to which these differences are exploited by insurance decisions.

Heterogeneity of Average Yields. First consider the contribution of heterogeneity of expected yields to adverse selection following the intuition of Figure 2. The fourth column of Table 2 gives the average difference between farmers' expected yield and the FCIC insurance yields by crop and by insurance decision. The insurance yield is the APH yield in cases where an APH yield is available; otherwise it is the yield assigned by the FCIC for insurance purposes. Farmers with lower expected yields relative to the insurance yield have a higher probability of collecting an indemnity, *ceteris paribus*. These results show, for example, that insured soybean farmers have a lower expected yield relative to the insurance yield than do uninsured soybean farmers. Furthermore, the difference is substantial — almost 5 bushels per acre — and significant beyond the 1 percent level (standard normal test statistics are asymptotically applicable by the central limit theorem). For wheat, insured farmers also have lower yields but only by .11 bushels per acre which is insignificant. For corn and sorghum, the estimates suggest that insured farmers have higher yields relative to uninsured farmers although both results are insignificant.

These results imply that heterogeneity in expected yields not reflected by FCIC insurance yields explains part of the differences in probabilities of collecting indemnities for soybeans and perhaps for wheat. However, the results for corn and sorghum imply that characteristics other than expected yields explain any adverse selection. For wheat, characteristics other than expected yields must explain any strong adverse selection.

The last column of Table 2 gives a further comparison of farmer expectations with insurance yields correcting for the insurance premium. This is done by multiplying the difference in the APH and expected yields by the price guarantee and the insured level, and then subtracting the insurance premium that was or would have been charged by the FCIC. This comparison examines whether the FCIC has mitigated the potential for adverse selection due to differences between APH and expected yields by charging different premiums. The results, however, are consistent with those in the fourth column and the statistical significances are virtually identical. Thus, FCIC methods of premium adjustment apparently have not corrected for heterogeneity of yields verifying a significant problem of adverse selection at least for soybeans. However, the results for wheat are again insignificant and the results for corn and sorghum are again inconsistent with adverse selection due to errors in insurance yields.

Adverse selection due to errors in insurance yields is possible given FCIC practices. One problem is that some farmers rotate land so that the average quality of land used in any particular year may be different from the land quality reflected in the APH yield. Another problem is that, for farmers who choose to insure but have not accumulated a farm-specific approved production history, other information such as area yields or ASCS yields have been used to set insurance yields. Thus, some farmers may have insurance yields not well matched to their individual farms at least in the initial years of participation. These problems necessarily decline as years of participation are accumulated. Another problem is that insurance yields may not be well matched to individual farms when farmers are changing technologies. A new variety may cause the true expected yield to exceed the APH yield while a switch to low-till technology may cause expected yield to be lower than the APH yield. The latter effect may explain some of the apparent adverse selection for soybeans.

In conclusion, errors in insurance yields appear to have been a source of adverse selection in federal crop insurance participation for some crops but not others. The latter conclusion may not be surprising given that most of the FCIC efforts to tailor the insurance program to local conditions are based on average yields. For example, if all farms had constant technologies, sufficient approved production histories from which to calculate APH yields, and land quality was homogeneous within farms, then FCIC yields used for insurance purposes should order farms correctly according to their heterogeneity of average yields. The observed differences here for soybeans and wheat may be due to farmers with lower average yields not having sufficient yield histories to generate APH yields, to farmers not using the same quality land when insuring their crop as when they do not, and/or to APH yields lagging behind true yields because they are 10-year moving averages.

Heterogeneity of Average Yields Across Crops. An important point suggested by the fourth column of Table 2 is that the insurance yields are uniformly lower than farmers' expected yields. For corn, the FCIC yields used for insurance purposes are 17.9-19.7 bushels below farmers' expectations. That FCIC yields are consistently below farmers' expectations can be explained by the fact that FCIC yields are based on rather long yield histories (ten years) and yields are generally increasing over time. Thus, FCIC yields may lag behind actual yields. For this reason, some have suggested the need for a trend adjustment in the APH yields (Skees).

National average feed grain yields over the last decade have increased by an average of about 5 percent per year so a ten year historical average can be about 25 percent lower than current yield expectations. This is roughly consistent with both the corn and sorghum yield differences in Table 2. By contrast, national average wheat yields over the last decade have increased by about 1 percent per year so a ten year average would be roughly 5 percent below current yield expectations. Similarly, national average soybean yields have increased by about 1.7 percent per year making a 10 year historical average about 8 or 9 percent lower. Again, these figures are roughly consistent with the yield differences in the fourth column of Table 2.

Because insurance yields are lower than expected yields, an insurance indemnity cannot be collected unless the yield is considerably less than 50, 65, or 75 percent of the expected yield depending on insurance level. Furthermore, because of the different rates of technological growth of yields among crops, the failure by federal crop insurance to take account of yield growth causes an inequity among producers of different crops. Using the growth rates cited above, a corn farmer insured at the 50 percent level would have to experience a yield of only 40 percent of current expected yield to collect an indemnity whereas a wheat producer would only need a yield below 47.6 percent of normal to collect an indemnity when insured at the 50 percent level. Thus, adverse selection apparently occurs across crops due to differences in yield growth rates not built into FCIC insurance yields. This bias is evidenced by a higher participation rate for wheat than corn (32 percent for wheat compared to only 20 percent for corn in 1988). A simple and obvious correction of FCIC methods of determining insurance yields could mitigate this inequity among crops.

Heterogeneity of Risk. Next consider the contribution of heterogeneity of risk to the explanation of adverse selection following the intuition of Figure 1. The heterogeneity of relative risk is examined in Table 3. For this purpose, the farmer's subjective variance of yields is estimated from the three point probit-type regressions (explained above) and then transformed to a coefficient of variation by taking a square root and dividing by the farmer's expected yield.

In the case of corn, insuring farmers have a coefficient of variation of yield that is 18 percent larger than non-insuring farmers. The corresponding percentage is 13 for soybeans, 46 for sorghum, and 19 for wheat. All of these results suggest adverse selection due to risk. Furthermore, these differences are significant beyond the 1 percent level for corn, beyond the 2 percent level for soybeans and wheat, and at about the 5 percent level for sorghum (again, standard normal test statistics are applicable asymptotically by the central limit theorem).

These results together with the results in Table 2 suggest that adverse selection in federal crop insurance is largely explained by heterogeneity of risk. The presence of adverse selection with respect to risk is not surprising because FCIC methods of rate making have not considered farm-specific yield variability in the approved production history. Interestingly, with the most recent farm bill, further adjustments have been introduced whereby premiums are adjusted by individual-farm loss experience. Thus, adverse selection due to errors in risk assessment should begin to decline as loss experience is accumulated.

Heterogeneity and Inequity in Provision of Insurance. The remaining three columns of Table 3 relate to the possibility of adverse selection of the insured level, i.e., whether farmers tend to select different insurance levels because of different levels of risk. Here the results are somewhat inconclusive mostly because the number of observations in some cells is small. For corn, the results suggest that farmers with smaller relative risk tend to insure at higher yield levels. The results are similar for soybeans ignoring the 50 percent level where only one observation is available. This would be expected if yield distributions for low-risk farmers are not sufficiently wide to make collection of indemnities at the lower insured levels very likely as in Figure 1 (b). This could suggest that fixed insurable yield percentages of 50, 65, and 75 are too rigid to provide insurance equitably to all farmers.

An Assessment of FCIC Losses Due to Adverse Selection

The empirical results of this paper can be used to assess the magnitude of FCIC losses due to adverse selection. To do this, the yield distributions for individual farmers can be used to calculate expected indemnity payments for both insuring farmers and non-insuring farmers. From Johnson and Kotz (pp. 81-83), if y ~ $N(\mu, \sigma^2)$ then

$$y_\beta^* \equiv E(y \mid y \leq \beta\bar{\mu}) = \mu - \frac{Z}{\Phi}\sigma$$

where y is actual yield, β is the proportion of the insurance yield insured, $\bar{\mu}$ is the insurance yield, and

$$z = \frac{\beta\bar{\mu} - \mu}{\sigma}, \qquad Z = \frac{1}{\sqrt{2\pi}} e^{-z^2/2}, \qquad \Phi = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-x^2/2}\, dx.$$

From this calculation, the expected indemnity payment is $(\beta\bar{\mu} - y_\beta^*)p_\alpha\Phi$ where p_α is the insured price (note that Φ is the probability of $y \leq \beta\bar{\mu}$). Of course, the expected indemnity is the actuarially fair premium.

Using these methods, the actuarially fair premium was calculated for each insured farmer in the sample. Then the actuarially fair premium, the premium actually paid, and the associated subsidy were extrapolated to the national level by using the weighting factors for the FCRS survey and adjusting all data proportionally to agree with premiums actually collected by FCIC. The results are presented in Table 4.

Conclusions

This paper presents a comprehensive statistical examination of the presence of adverse selection in observed U.S. crop insurance participation decisions. The results present strong evidence that adverse selection exists and contributes substantially to losses incurred by the FCIC in providing federal crop insurance. For some crops, adverse selection occurs because FCIC insurance yields are not well tailored to individual farms. This may be due either to some farms not having sufficient verified yield histories or to farmers choosing to insure only when using the poorer land on their farms to produce the crop in question. The latter form of adverse selection is akin to moral hazard and will likely not be mitigated without monitoring within - farm production practices.[3]

For all the crops considered, however, significant adverse selection appears to occur because FCIC methods do not adequately capture variations in risk among farmers. This can be expected because FCIC methods do not tailor assessments of yield variability to individual farms. At the time of the sample, variations in risk were considered only by setting premium rates at county or regional levels according to loss experience. This approach cannot capture the variations in risk among individual farmers. One possibility here is to use the verified production history to assess the variance of yields at the individual farm level.

In addition, the results suggest adverse selection among crops because FCIC methods of computing insurance yields tend to lag behind true expectations and the rate of technological progress has not been the same for all crops. These problems can be corrected by using an extrapolative method of computing insurance yields. However, if this approach is adopted to bring insurance yields more into line with true expected yields, FCIC losses will increase (unless other measures are also taken) because insured yields will increase accordingly.

Finally, the results suggest the need for tailoring the insurable percentages of normal yield to local or individual circumstances. Farmers who have low relative yield risk may not be able to get adequate insurance under the current program regardless of their level of financial risk. For example, Montana dryland wheat farmers may have large probabilities of 35 percent yield losses while irrigated wheat farmers in California have small probabilities of even 25 percent losses. Given the higher costs of irrigation and intensive use of other variable inputs that lead to relatively less yield variability, higher insurable yields are needed to provide the same amount of financial stability. One possibility would be to set percentage levels of variability by state based on cost-of-production estimates.

In summary, while substantial adverse selection has been shown to exist in U.S. federal crop insurance, many possibilities exist for reducing the problem and providing multiple peril crop insurance more equitably. However, further research is needed to determine whether adoption of these possibilities can make multiple peril crop insurance viable either publicly or privately.

Footnotes

[1] The farmer's subjective variance of yield is not a term that can be requested directly from the farmer. It can be estimated by assuming a particular parametric form (normality) and ascertaining the farmer's likely worst annual average yield over a given period of years. For example, the likely worst yield in six years is approximately one standard deviation below the mean under normality. Alternatively, the farmer's responses on the probability of less than 50, 65, and 75 percent of expected yield can be used as 3 observations in a probit regression estimating the variance. Both methods were used here although the results are reported only for the latter approach. The two approaches produced similar results.

[2] Some observations were dropped because they appeared to be unrealistic. If an observation was at least 50 percent greater than the next largest observation, it was dropped. The number of observations dropped for this reason was small: 2 for corn, 6 for soybeans, 1 for grain sorghum, and 2 for wheat. Also, observations that were more than 3 standard deviations from the mean were dropped. Finally, to assure comparability of the results in Tables 2 through 5, observations were dropped if they did not have complete data on yield expectation and variance and on insurance yield and premium. These steps resulted in reducing the sample size by 65 for corn, 78 for soybeans, 8 for grain sorghum, and 70 for wheat.

[3] Here the distinction between adverse selection and moral hazard becomes weak. If a farmer rotates crop production among alternative tracts for agronomic reasons, then insuring only poor land is a problem of adverse selection. If a farmer rearranges the use of his crop land so as to use only poor land when insuring, then the problem can be argued to be one of moral hazard (use of less productive inputs because outcomes are insured). Of course, moral hazard is also a potentially serious problem for viability of multiple peril crop insurance. The problem

of moral hazard is abstracted out of most of the analyses in this paper be focusing on the difference in characteristics of yield distributions between insuring and non-insuring farmers rather than differences in actual yields which occur because of simultaneous adoption of insurance and reduction of input use. The data base analyzed here will be used to examine the presence of moral hazard in a subsequent paper.

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TABLE 1. Applicability of the Normal Distribution to Yield Deviations

Crop	Number of Observations	Mean	Variance	Skewness	Kurtosis	Kolmogorov Smirnov Statistic	Distributions Dominating the Normal[a]
Corn	818	-39.53	1232.66	-.12	3.35	.028	None
Soybeans	588	-9.93	103.96	-.04	3.72	.049*	None
Sorghum	144	-11.40	497.83	-.66	3.65	.073	Extreme Value A
Wheat	684	-2.64	195.24	-.36	3.89	.058*	Logistic

* Significant at the .05 level.

[a] From among the normal, logistic, Weibull, gamma, lognormal, exponential, inverse Gaussian, Pearson types 5 and 6, and extreme value distributions of types A and B.

Source: Calculations with the FCRS, CATI, and FCIC data.

TABLE 2. Evidence of Adverse Selection: Errors in Mean Yields[a]

Crop	Insurance Participation Decision	Probability of Indemnity 50% Level	65% Level	75% Level	Difference in Mean Yields[b] (bushels)	Difference in Revenue Less Premium (dollars/acre)
Corn	Insured	0.09	0.19	0.27	19.71	15.78
		(0.08)	(0.12)	(0.13)	(15.71)	(14.71)
		n = 61	n = 61	n = 57	n = 61	n = 61
	Not Insured	0.06	0.14	0.23	17.88	13.71
		(0.07)	(0.12)	(0.13)	(19.30)	(18.98)
		n = 440	n = 434	n = 415	n = 440	n = 440
		[3.48]	[2.93]	[2.11]	[.83]	[.99]
Soybeans	Insured	0.08	0.17	0.28	4.23	8.13
		(0.08)	(0.11)	(0.13)	(7.06)	(18.06)
		n = 64	n = 64	n = 57	n = 64	n = 64
	Not Insured	0.05	0.14	0.24	9.22	20.85
		(0.07)	(0.12)	(0.13)	(8.06)	(20.78)
		n = 307	n = 307	n = 295	n = 307	n = 307
		[2.42]	[2.20]	[2.40]	[-5.01]	[-4.99]
Sorghum	Insured	0.14	0.26	0.37	13.51	10.45
		(0.14)	(0.12)	(0.15)	(12.25)	(12.12)
		n = 7	n = 7	n = 7	n = 7	n = 7
	Not Insured	0.09	0.19	0.28	9.40	6.40
		(0.10)	(0.13)	(0.15)	(17.10)	(16.65)
		n = 85	n = 85	n = 77	n = 85	n = 85
		[.93]	[1.58]	[1.58]	[.82]	[.82]
Wheat	Insured	0.09	0.16	0.27	4.49	4.08
		(0.09)	(0.13)	(0.14)	(8.84)	(13.05)
		n = 48	n = 48	n = 46	n = 48	n = 48
	Not Insured	0.05	0.13	0.22	4.60	4.58
		(0.07)	(0.11)	(0.12)	(10.95)	(16.18)
		n = 294	n = 291	n = 280	n = 294	n = 294
		[2.25]	[1.65]	[2.05]	[-.08]	[-.24]

[a] Numbers in parentheses are standard deviations and n is the number of observations. Numbers in brackets are standard normal test statistics for the equality of the insured and uninsured cases.
[b] The difference in means is the farmer's subjective mean yield minus the insurance yield.
Source: Calculations with the FCRS, CATI, and FCIC data.

TABLE 3. Evidence of Adverse Selection: Yield Coefficient of Variation by Insurance Decision[a]

Crop	Uninsured	Insured	Z^b	Insured Level		
				50%	65%	75%
Corn	.342 (.147)	.404 (.161)	2.84	.407 (.162)	.406 (.181)	.393 (.134)
	n = 440	n = 61		n = 3	n = 37	n = 18
Soybeans	.344 (.139)	.387 (.150)	2.11	.297 (0)	.392 (.156)	.370 (.137)
	n = 307	n = 64		n = 1	n = 41	n = 21
Sorghum	.425 (.228)	.621 (.312)	1.63	- -	.552 (.278)	1.034 (0)
	n = 85	n = 7		n = 0	n = 6	n = 1
Wheat	.340 (.147)	.403 (.195)	2.14	.408 (.014)	.395 (.219)	.425 (.136)
	n = 294	n = 48		n = 2	n = 34	n = 12

[a] The numbers in parentheses are standard deviations and n is the number of observations.
[b] Standard normal test statistic for equality of insured and uninsured coefficients of variation.
Source: Calculations with the FCRS, CATI, and FCIC data.

Table 4. Estimated Costs of Adverse Selection for Federal Crop Insurance

Revenues/Costs	Corn	Soybeans	Grain Sorghum	Wheat
FCIC Receipts	$94,187,254	$80,908,921	$7,610,058	$75,409,567
Premiums	70,288,277	61,596,830	5,572,838	56,772,384
Subsidies	23,898,977	19,312,091	2,037,220	18,637,183
FCIC Payouts	301,667,927	157,999,379	10,615,856	298,583,904
FCIC Actual Losses	207,480,673	96,402,549	5,043,018	223,174,337
Expected Losses	169,392,688			
Loss Due to Bad Year	38,087,985			
Fair Premiums	239,680,965			
Loss Due to Adverse Selection				
Loss Due to Bad Year				
Loss Due to Subsidies				

Source: Calculations with the FCRS, CATI, and FCIC data.

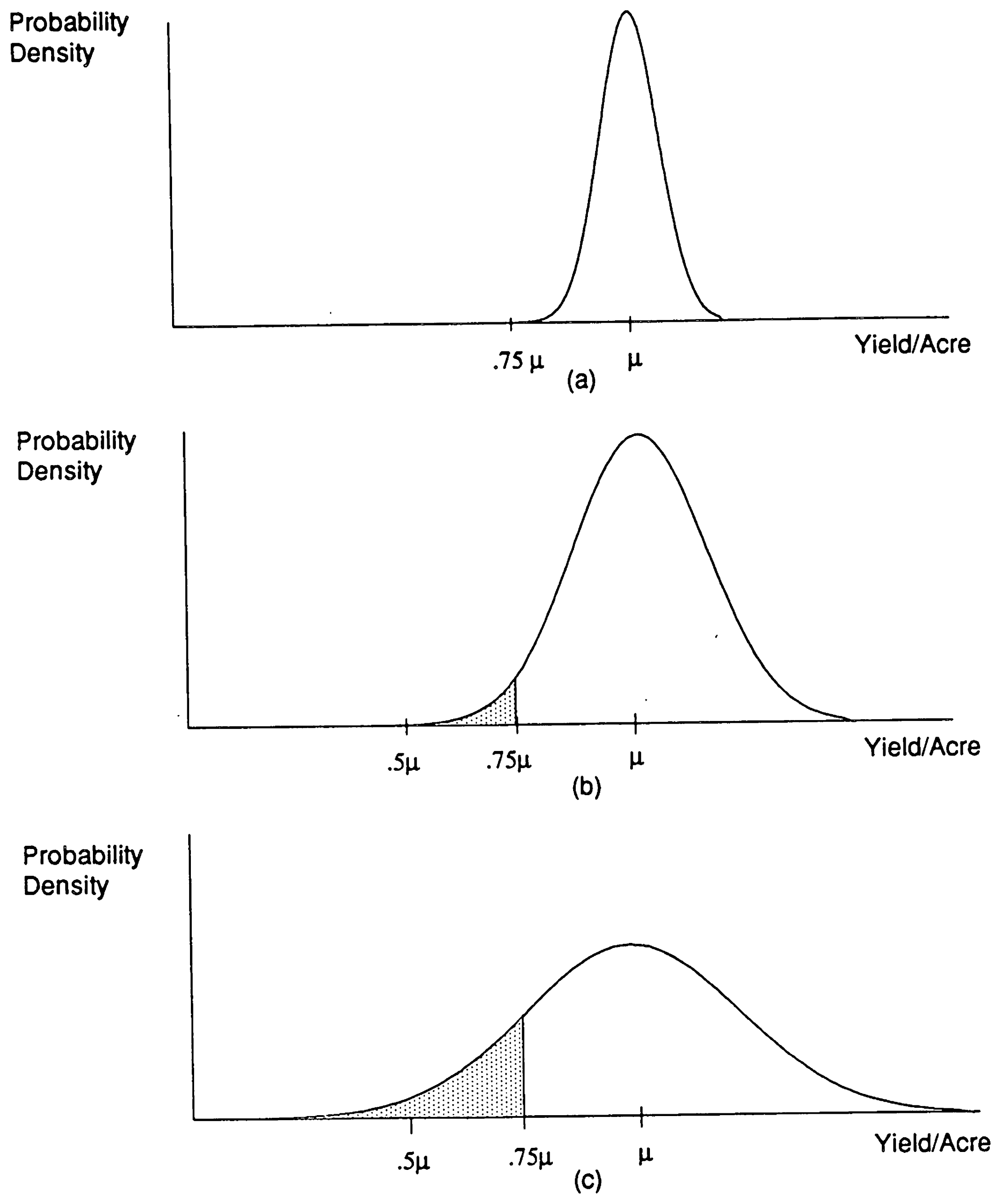

Figure 1. Effect of Risk on Ability to Collect Indemnities

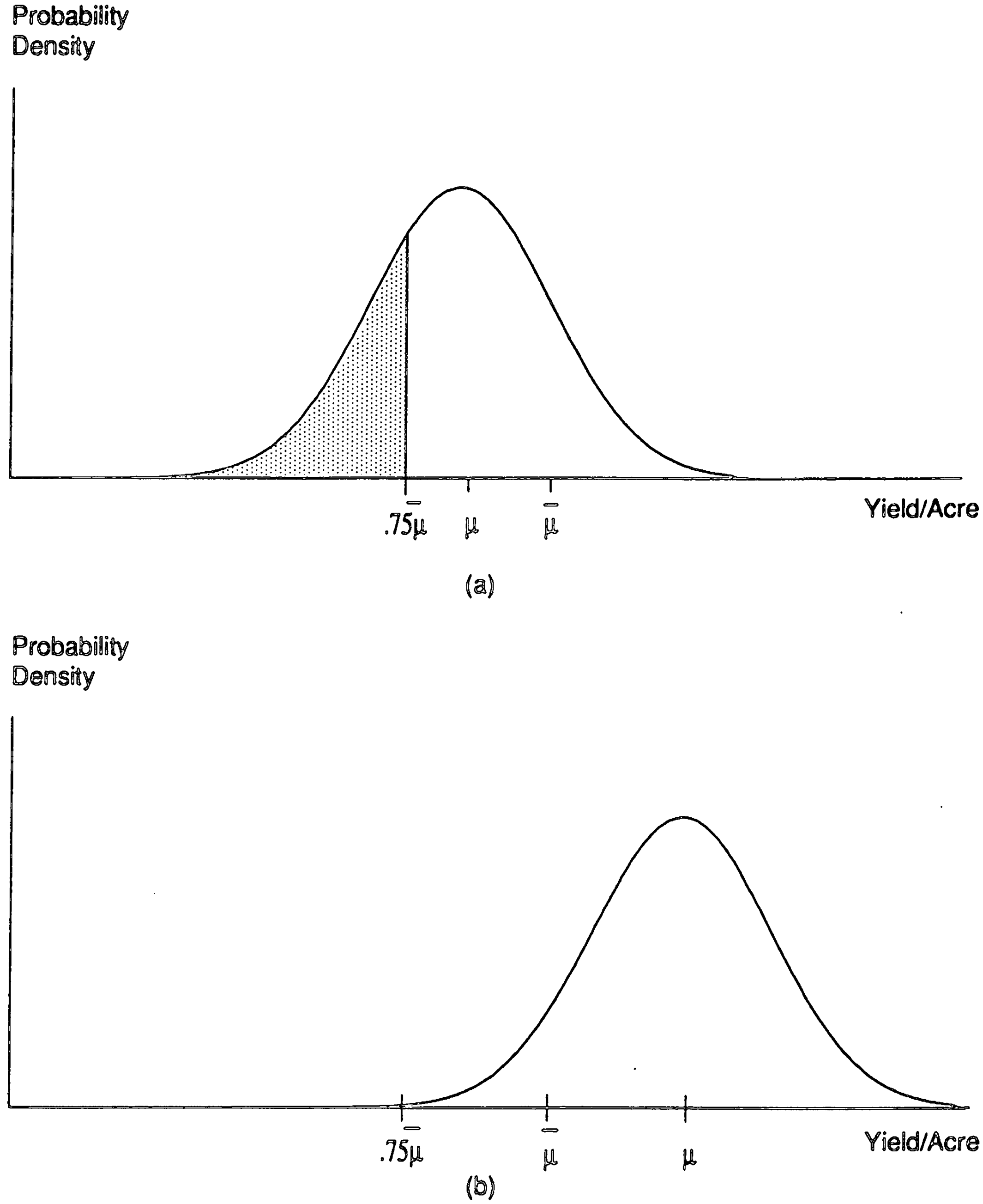

Figure 2. Effect of the Relationship of Expected Yield and Insurance Yield on the Ability to Collect Indemnities