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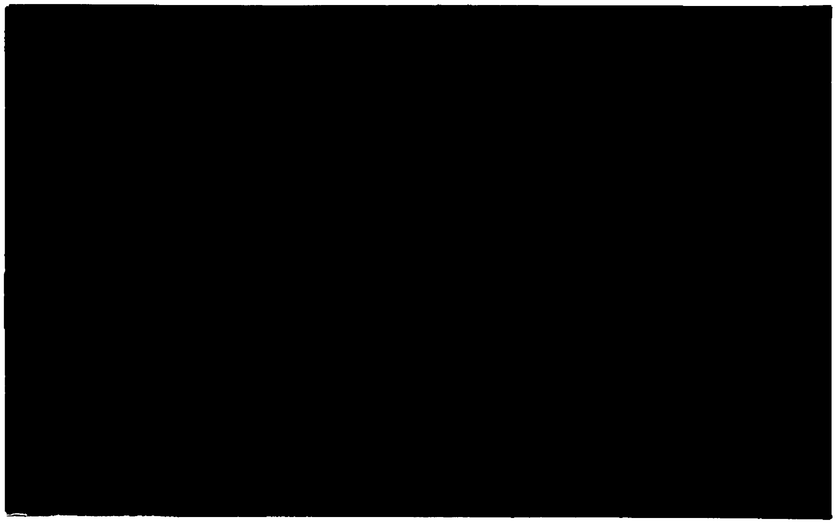

An Empirical Assessment of the Public Cost of Adverse Selection in U.S. Crop Insurance

by

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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 assess the 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 cannot be considered (e.g., Gardner and Kramer). This paper reports on a nation-wide farm-specific 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 were 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 those receiving drought assistance in 1988. Also, beginning with the 1980 Act, much of the delivery of federal crop insurance was shifted to the private sector although the FCIC continues to set all insurance contract parameters. 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 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). This high loss ratio is particularly disturbing given the program goal of gradually privatizing crop insurance and eliminating government subsidization. A loss ratio less than about .95 is generally regarded as necessary for private insurance viability.

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 (after eliminating the high and low yields) obtained on the farm if a verified history is available. Otherwise, the farm's 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 the same dollar amount as 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. Farmers have lower expected returns when insured if the insured percentage of APH yield is smaller, the APH yield is smaller relative to the farmer's true normal yield, or the insured price is lower relative to the normal market price.

Heterogeneity and Adverse Selection

The problem of adverse selection occurs when agents (farmers) differ in ways that affect expected indemnity payments but which are not reflected appropriately in the premium structure. This gives some farmers a better than average chance to profit from purchasing insurance. 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 and risk 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 incur loss because the premium structure based on the average characteristics of all farmers does not represent the self-selected farmers who participate.

To reduce this problem, the insurer must set premiums to better account for the heterogeneity among agents. This paper attempts to assess the extent to which the FCIC currently accounts for heterogeneity among farms and the public cost resulting from failure to account for heterogeneity.

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, substantial probability is far below the $.75\mu$ level so the expected size of the indemnity payment is considerable if insured at the 75 percent level. Figure 1 demonstrates how farmers with the same normal yield level may have quite different expected indemnities.

Until recently, the only farm specific information used by the FCIC to determine the parameters of individual insurance contracts was the APH yield (an assessment of normal yield). The FCIC, in effect, has assumed constant relative risk among farms within rate making areas (Driscoll). Heterogeneity of relative risk among farms was taken into account only by setting premium rates according to loss experience at county or regional levels. Thus, heterogeneity of risk was reflected only to the extent that risk was 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 found that this adjustment is insufficient and favors farmers with lower average yields. More recently, with the 1990 farm bill, the FCIC has begun to adjust premiums to account for farm-specific loss experience but this approach is a slow process. Furthermore, adjustments are only made for insuring farmers because no loss experience accrues for uninsured farmers. Thus, many of the same problems can be expected to continue.

Heterogeneity of Average Yields

Another reason for adverse selection is that farmers' expected yields may not be well reflected in insurable yields. For example, when a sufficient verified production history does not exist, individual 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 APH 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 good land quality even though an insured crop is never grown on good 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 farm-specific distributions of yields.

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, collection and use of farmers' subjective yield distributions is necessary. Second, farmers perceptions of the probability of an indemnity payment at each of the insurable yield levels is crucial. 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 Costs and Returns

Survey (FCRS) administered annually by the National Agricultural Statistical Service (NASS) on behalf of the Economic Research Service (see U.S. Department of Agriculture 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. 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, a small number of observations were excluded from some individual crop 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, a follow-up survey was not possible for budget reasons. Fortunately, the nature of the omissions suggest no obvious distributional 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). Estimates of each farmer's subjective variance were developed from farmer's estimates of probabilities of achieving 50, 65, and 75 percent of the APH yield assuming normality.

While normality of yields has been questioned in other contexts, it appears to provide 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 assumption of normality, which is required for assessing farmers' 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. Heterogeneity 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 3 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 an adverse selection whereby insuring farmers are those with greater probabilities of receiving indemnity payments. Given the clarity of these results, the rest of this section focuses on whether higher probabilities of indemnities among insurers are explained by heterogeneity of mean yields or heterogeneity of coefficients of variation among farmers.

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 corn, sorghum and wheat, the estimates suggest that insured farmers have higher yields relative to uninsured farmers although the results are insignificant.

These results imply that heterogeneity in expected yields not reflected by FCIC insurance yields explains part of the higher probabilities of collecting indemnities among insured farmers only for soybeans. The results for the other crops imply that characteristics other than expected yields explain any adverse selection because insured farmers actually have higher expected yields relative to insurance yields than do uninsured farmers.

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 charged by the FCIC. This comparison examines whether the FCIC has partially 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. Insured yields used by the FCIC contribute significantly to adverse selection after adjusting for premiums only for soybeans. The results for corn, sorghum, and wheat are all insignificant and the results for corn and sorghum indicate that none of the higher indemnity probabilities of insured farmers is due to errors in insured yields. The lack of significant explanation of adverse selection by errors in insured yields is not surprising because insurance yields tend to be well adapted to individual farms through APH calculations.

Several explanations can be advanced for the poorer performance of insured yields for soybeans. One may be 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. In particular, corn-soybean farmers may have a tendency to allocate poorer land to soybeans more often. 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. The poorer performance for soybeans may be due to the fact that ASCS yields are not kept for soybeans. Alternatively, corn ASCS yields are multiplied by an adjustment factor to calculate soybean APH yields for farmers without adequate production histories. These problems should decline as years of participation are accumulated.

In conclusion, errors in insurance yields appear to have been a source of some adverse selection in federal crop insurance participation but not for all crops. The absence of significant errors in insurance yields for some crops is 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 may be due to farmers with lower average yields not having sufficient yield histories to generate APH yields and/or to farmers not using the same quality land when insuring their crop as when they do not.

Heterogeneity of Average Yields Across Crops. An important point suggested by the fourth column of Table 2 is that 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 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 explanation 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 only 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 explanations 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 less than 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, each farmer's subjective variance of yields was transformed into a coefficient of variation by taking the square root and dividing by the farmer's expected yield.

The top half of Table 3 compares relative risk (coefficients of variation) between insured and uninsured cases by crop. In the case of corn, insured farmers have a coefficient of variation of yield that is 18 percent larger than uninsured farmers. The corresponding percentage is 13 for soybeans, 46 for sorghum, and 19 for wheat. All of these results suggest the possibility of 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).

The last half of Table 3 considers whether the differences in relative risk between insured and uninsured farmers are compensated by higher premiums for farmers with higher risk. To do so, the coefficients of variation are, in effect, divided by the premium. According to FCIC methods, the per acre premium is defined by

$$\gamma_{\alpha\beta} = p_\alpha \beta \bar{\mu} \zeta$$

where p_α is the insured price, β is the proportion of the insurance yield insured, $\bar{\mu}$ is the insurance yield, and ζ is a basic premium rate specific to local loss history by APH range (the FCIC has 9 rates by APH range in each county for this purpose). In this equation, $\bar{\mu}\zeta$ represents farm-specific parameters of the insurance contract while $p_\alpha\beta$ represents farmer choice variables which have the same limited possibilities for all farmers. Thus, to normalize the comparison for all farmers, coefficients of variation are only divided by $\bar{\mu}\zeta$ in the bottom half of Table 3. The results show that insuring farmers have larger relative risk that is not corrected by larger premiums. Furthermore, the statistical significance of the differences is about the same as the uncorrected cases in the top half of Table 3 for every crop except wheat.

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. Provisions of the 1990 farm bill whereby premiums are adjusted by individual-farm loss experience cannot be expected to address this problem adequately because adjustments will occur only for participating farmers. That is, farmers priced out of the insurance market by inappropriately high premiums relative to risk will not have their premiums lowered to entice participation (except in a relative sense by a protracted process where other farmers first participate and then have their premiums gradually increased due to poor loss experience).

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 the fixed insurable yield percentages of 50, 65, and 75 are too rigid to provide insurance equitably to all farmers. Results for wheat and sorghum are inconsistent with this explanation but the number of observations is smaller.

An Assessment of FCIC Losses Due to Adverse Selection

The results of this paper thus far show that farmers participating in crop insurance have greater probabilities of collecting indemnity payments than those who do not participate and that most of this difference is explained by differences in risk among farms. These facts alone, however, do not imply that federal crop insurance programs have been unprofitable because of adverse selection. For example, if insurance parameters correctly reflect risks associated with participating farmers, FCIC crop insurance could still be viable even though fair insurance is not available to uninsured farmers. The remaining purpose of this paper is to assess whether heterogeneity among farms not reflected in individual insurance contracts is a major source explaining FCIC losses. To do this, the yield distributions for individual farmers can be used to calculate expected indemnity payments for insuring farmers. From Johnson and Kotz (pp. 81-83), if y $\sim$ N(μ, σ^2) then

$$\bar{y}_\beta \equiv E(y|y \leq \beta\bar{\mu}) = \mu - \frac{Z}{\Phi}\sigma$$

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

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

From this calculation, the expected indemnity payment is $(\beta\bar{\mu} - \bar{y}_\beta)p_\alpha\Phi$ 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 expected indemnity payment was calculated for each insured farmer in the sample. Then the expected loss (expected indemnity payment minus actual premium) was extrapolated to the national level by using the weighting factors for the FCRS survey. The results are presented in line 6 of Table 4. The first 5 lines of Table 4 give actual data for the FCIC experience in the 1988 as a comparison. The results in line 6 show that expected FCIC losses are substantially greater than subsidies for corn and wheat, somewhat greater for sorghum, and less than subsidies for soybeans. If the current rate of government subsidization were sufficient to make the FCIC sound in expectations (expected revenues equal to expected costs), then subsidies should be equal to expected losses when summed across all insured crops.

Expected indemnities are given in line 7 of Table 4. Clearly, 1988 was a bad year because actual indemnities in line 4 exceed expected indemnities substantially. Also, expected indemnities exceed receipts in line 1 (premiums plus subsidies) on average and strongly for corn and wheat (this comparison is equivalent to the comparison of expected losses to subsidies). Line 8 gives the ratio of expected indemnities to premiums. These ratios range from 1.23 for soybeans to 1.87 for corn. This ratio needs to be less than about .95 for private market viability. Clearly, none of the four crops have indemnity-premium ratios that are close to private viability. Line 9 further gives the ratio of indemnities to FCIC receipts (receipts includes government subsidies). This ratio is about 1 for sorghum indicating a program that is just viable after subsidization. For soybeans, this ratio is less than 1 indicating that less subsidization is needed to make the program work. However, the indemnity-receipts ratio is substantially higher than 1 for both corn and wheat. These results imply that profitable experience with crops like soybeans (after subsidization) is required in order for the FCIC to provide insurance for corn and wheat without heavy overall losses on average.

The decomposition of FCIC losses is given in lines 10 through 13 of Table 4. Line 10 gives the loss due to subsidies (the same as line 3). Subsidies are roughly one-quarter of FCIC receipts in each case. The loss due to adverse selection is expected indemnities minus receipts. This is the FCIC's expected gain or loss because insurance parameters for each farmer are not actuarially fair after considering government subsidization. The result for soybeans shows a gain from adverse selection indicating that the FCIC has an expected profit of about $5.3 million. This expected profit is less than government subsidies implying that soybean insurance, on average, is more than actuarially fair for farmers given the premiums they pay but less than actuarially fair to farmers and government combined given the premiums plus subsidies they pay jointly. In the case of corn and wheat, the losses due to adverse selection are substantial—$37 million for corn and $18 million for wheat. These losses amount to 40% of FCIC receipts for corn and 24% of FCIC receipts for wheat. Although these losses appear small compared to the losses due to a bad crop year in line 10, 1988 was the worst year in recent history. If this analysis could be repeated for other crop years, one would expect the losses due to a bad year to be much less. The losses due to adverse selection, on the other hand, are the structural losses built into the program by rate structures that do not match individual farm circumstances and, thus, can be expected to persist over time.

Conclusions

This paper presents a comprehensive statistical examination of the presence of adverse selection in observed U.S. crop insurance participation decisions. The results show that adverse selection exists and contributes substantially to losses incurred by the FCIC in providing federal crop insurance. For soybeans, some 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 an insured crop. 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 data for this study were generated, variations in risk were considered by the FCIC 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 to address this problem is to use the verified production history to assess the variance of yields at the individual farm level. New practices instituted with the 1990 farm bill will tend to mitigate these problems but only partially and slowly over time.

In addition, the results suggest adverse selection among crops because FCIC methods of computing insurance yields tend to lag behind true expectations and because 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 yield percentages are needed to provide the same amount of financial stability. One possibility would be to set percentage levels of variability by state based on the ratio of cost-of-production estimates to normal revenue (APH yield times the insured price).

In summary, while substantial adverse selection has been shown to exist in U.S. federal crop insurance, possibilities exist for providing multiple peril crop insurance more equitably. Removing these inequities, however, may further exacerbate the bottom line losses of the FCIC because the same level of insurance (which has not been privately viable) would be provided to a broader group of producers thereby. Apparently, some of the new experimental approaches whereby indemnities are triggered by area yields may be necessary to provide private viability.

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 to assess a farmer's subjective 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 from computations for individual crops 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 by 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	Probability of Indemnity 65% Level	Probability of Indemnity 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 = 63	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
Corn	.104 (.064)	.130 (.067)	2.74	.162 (.110)	.118 (.069)	.152 (.053)
	n = 440	n = 61		n = 3	n = 37	n = 18
Soybeans	.333 (.184)	.384 (.155)	2.32	.402 (0)	.360 (.155)	.406 (.115)
	n = 307	n = 64		n = 1	n = 41	n = 21
Sorghum	.159 (.094)	.221 (.098)	1.61	- -	.196 (.081)	.369 (0)
	n = 85	n = 7		n = 0	n = 6	n = 1
Wheat	.267 (.150)	.282 (.194)	.49	.189 (.049)	.276 (.229)	.313 (.094)
	n = 294	n = 48		n = 2	n = 34	n = 12

[a] Estimates in the upper half of the table are for coefficients of variation of yield. Estimates in the lower half are for coefficients of variation corrected for premium rate. 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, 1988

Revenues/Costs	Corn	Soybeans	Grain Sorghum	Wheat
1. FCIC Receipts	$94,187,254	$80,908,921	$7,610,058	$75,409,567
2. Premiums	70,288,277	61,596,830	5,572,838	56,772,384
3. Subsidies	23,898,977	19,312,091	2,037,220	18,637,183
4. FCIC Payouts	301,667,927	157,999,379	10,615,856	298,583,904
5. FCIC Actual Losses	207,480,673	96,402,549	5,043,018	223,174,337
6. Expected Losses	61,274,037	14,034,772	2,061,436	36,727,091
7. Expected Indemnities	131,562,314	75,631,602	7,634,274	93,499,475
Expected Loss Ratio				
8. Expected Indemnities/Premiums	1.87	1.23	1.37	1.65
9. Expected Indemnities/Receipts	1.40	0.93	1.00	1.24
Decomposition of FCIC Losses				
10. Loss Due to Subsidy	23,898,977	19,312,091	2,037,220	18,637,183
11. Loss Due to Adverse Selection	37,375,060	-5,277,319	24,216	18,089,908
12. Loss Due to Bad Year	146,206,636	82,367,777	2,981,582	186,447,246
13. Total FCIC Losses	207,480,673	96,402,549	5,043,018	223,174,337

Source: Calculations with the FCRS, CATI, and FCIC data. Lines 1 through 5 correspond to actual FCIC data at the national level. Line 6 is estimated by extrapolating estimates in this paper to the national level by means of FCRS weighting factors. Line 7 is line 6 plus line 2. Line 8 is line 7 divided by line 2. Line 9 is line 7 divided by line 1 Line 10 is the same as line 3 for convenience. Line 11 is line 7 minus line 1. Line 12 is line 5 minus lines 10 and 11. Line 13 is the sum of lines 10 through 12 (and is the same as line 5).

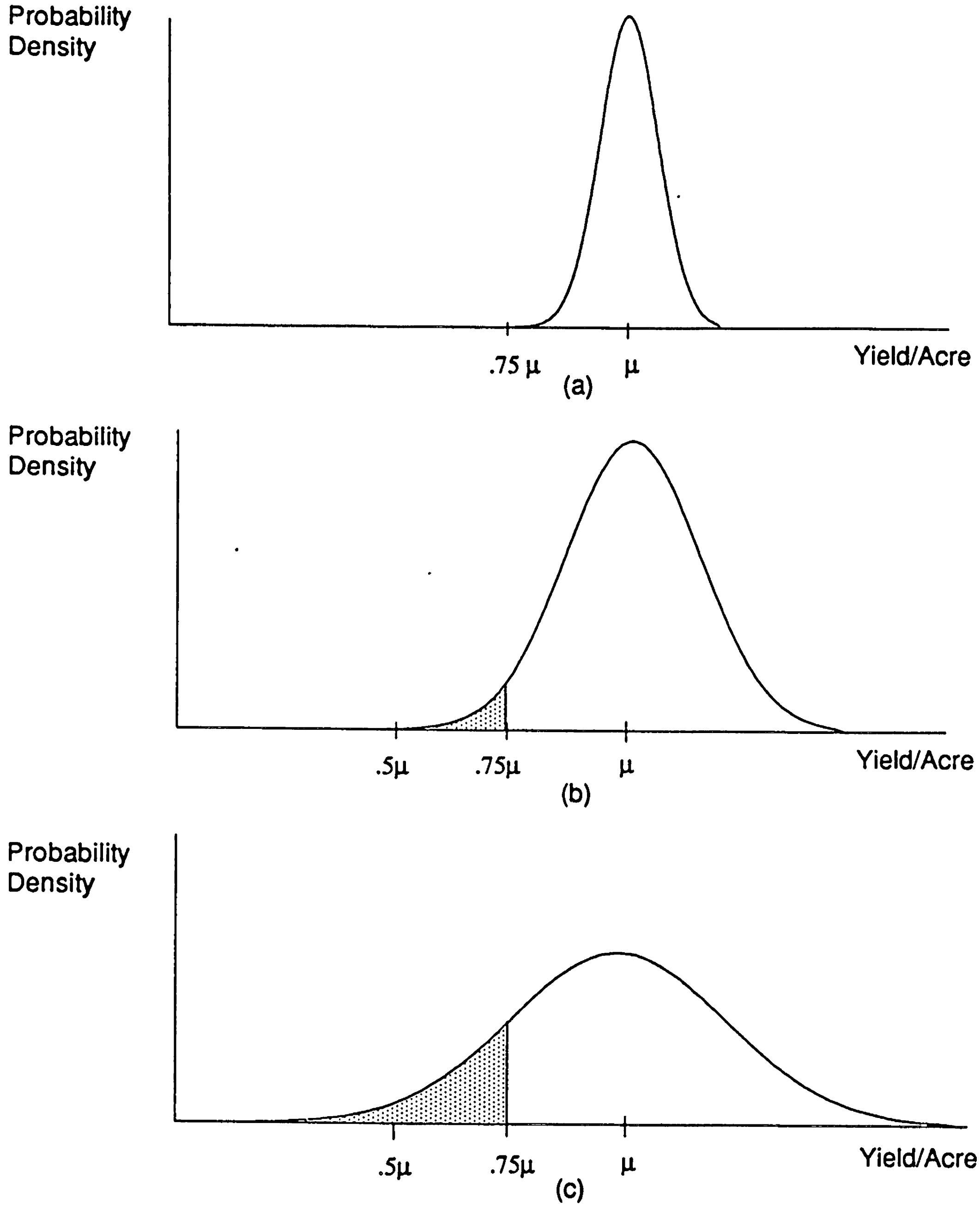

Figure 1. Effect of Risk on Ability to Collect Indemnities

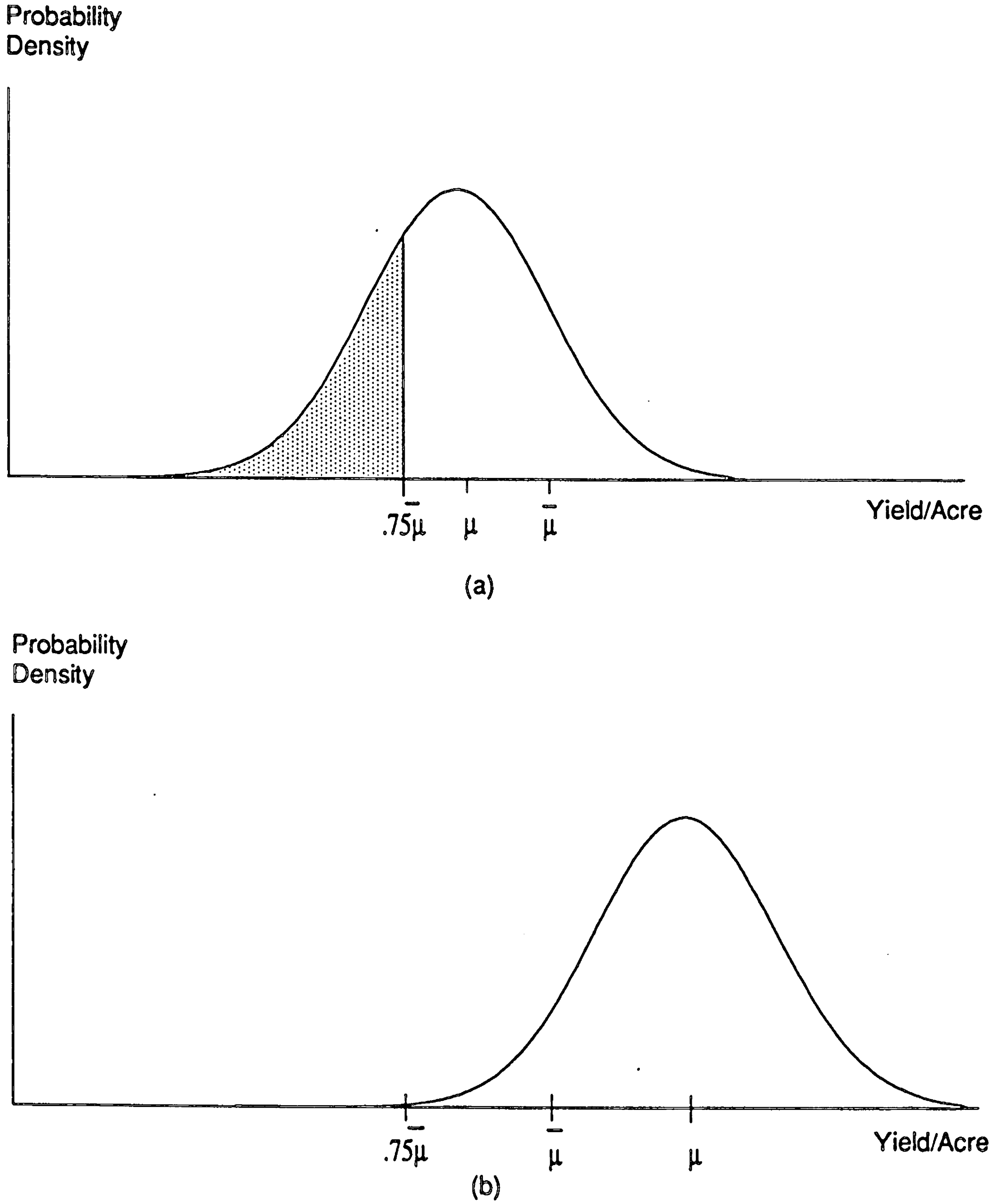

Figure 2. Effect of the Relationship of Expected Yield and Insurance Yield on the Ability to Collect Indemnities