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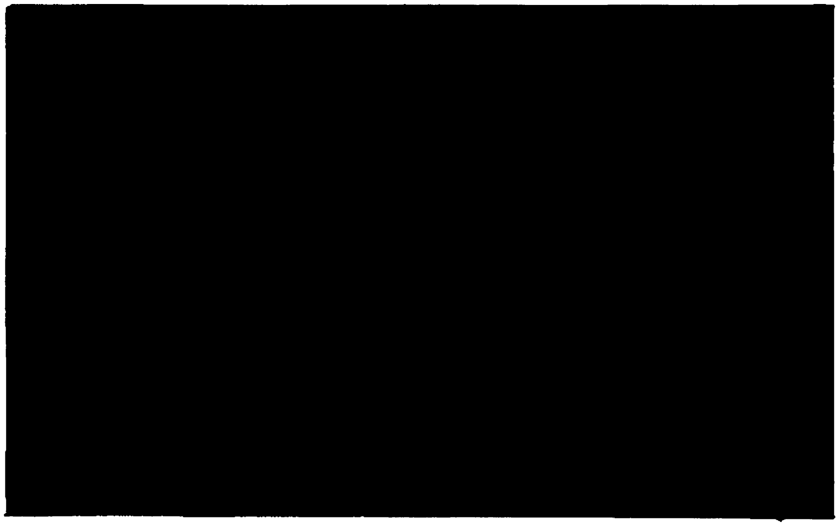

Adverse Selection in Crop Insurance:

Actuarial and Asymmetric Information Incentives

by

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Unpredictable fluctuations in yield are a major problem facing farmers in the U.S. and elsewhere. For many crops, yield fluctuations are a more important problem than price fluctuations. While there has been extensive Government intervention to stabilize prices and mitigate the consequences of price fluctuations, action to deal with yield fluctuations has been less comprehensive and often ad hoc. Federal multiple peril crop insurance has been used on a small scale compared to agricultural policies aimed at price intervention. Government or market provisions for dealing with yield risk are more problematic than other cases which have been handled by insurance mechanisms, both private (e.g., motor vehicle accident insurance) and public (e.g., bank deposit insurance). Given that weather is a major determinant of yield, it is interesting to note that insurance for climatic events is available in some contexts. For example, promoters of public events can obtain insurance against rain and farmers in many areas can obtain insurance against hail damage.

Persistent attempts have been made worldwide to deal with yield risk through various systems of multiple peril crop insurance. In the U.S., multiple peril crop insurance has been in operation since 1939 though on a very limited basis until fairly recently. Other countries in which such schemes have been introduced include Canada, South Africa, and a number of Latin American countries (Hazell, Pomareda, and Valdes) with active debate surfacing recently in such countries as Australia. In nearly all cases, however, multiple peril crop insurance has been disappointing in that premiums have not been consistently sufficient to cover both indemnity payments and administrative costs. In the U.S., indemnity payments have consistently exceeded premium income even in years of good weather conditions (Gardner).

Standard explanations for this failure of multiple peril crop insurance usually involve adverse selection and moral hazard (Ahsan, Ali, and Kurian; Chambers; Goodwin; King and Oamek; Nelson and Loehman; Skees and Reed; Williams, et al.). However, little empirical evidence is available that supports these explanations or assesses the magnitude of these effects. Much of the empirical evidence is based on county data where the important problem of adverse selection due to intra-county variation may be overlooked (e.g., Gardner and Kramer; Goodwin). The objective of this paper is to develop some empirical evidence of the role and importance of adverse selection in U.S. multiple peril crop insurance using farm-level data. Adverse selection losses are decomposed into losses stemming from actuarial and asymmetric information incentives. We first develop a structured theoretical framework to guide the data analysis. The model separates analysis of adverse selection from moral hazard by examining the relationship of insurance decisions to the subjective distribution of yields for individual farmers rather than the relationship to actual yields obtained under insurance.[1] The empirical work is based on a nationwide data set that matches farm-level data from the USDA Farm Costs and Returns Survey (FCRS) with an insurance-specific survey of the same farmers included in the FCRS and policy data obtained from the Federal Crop Insurance Corporation (FCIC).

A Model of Crop Insurance Incentives

The demand for crop insurance may be affected by three closely related incentives. These incentives may be categorized as a risk incentive and an expected revenue incentive. For an actuarially fair insurance policy, the expected revenue incentive is zero. If the policy is not actuarially fair, incorrect expected revenue incentives may lead to adverse selection problems. The expected revenue incentive is further split into an expected revenue incentive based the limited information and subsidies reflected in parameters of FCIC insurance policies (an actuarial incentive) and an additional incentive based on the difference in information held by the farmer from that reflected in FCIC insurance policies (an asymmetric-information incentive).

Denote the farmer's yield by a random variable y and let the farmer's distribution of yield be described by F(y) with mean μ. Also, let the farmer's preference functional over alternative distributions of returns per acre be represented by V. Let the FCIC distribution of yield on which the insurance program is based be represented by G with mean $\bar{\mu}$, where $\bar{\mu}$ is the Approved Program History (APH) yield of the federal crop insurance program, and G embodies the dispersion of yields ascribed by the federal crop insurance program to a farm with APH yield $\bar{\mu}$. For simplicity, assume that yield risk is the only source of uncertainty faced by the farmer.

A farmer participating in the crop insurance program selects one of three yield guarantees, $\beta = .50, .65$, or $.75$, and one of three price guarantees, represented by p_α. The farmer pays a different premium for each choice. If the farmer's yield falls below $\beta\bar{\mu}$, the FCIC pays an indemnity equal to $p_\alpha(\beta\bar{\mu} - y)$ per acre. Denote the insurance premium by $\gamma_{\alpha\beta}$, the guaranteed yield level by $\beta\bar{\mu}$, and the output price by p. Then the revenue under insurance is

$$(1) \qquad \phi(y) = \begin{cases} py - \gamma_{\alpha\beta} \text{ if } y \geq \beta\bar{\mu} \\ py + p_\alpha(\beta\bar{\mu} - y) - \gamma_{\alpha\beta} \text{ if } y < \beta\bar{\mu}. \end{cases}$$

The expected return to crop insurance participation for the insured farmer is

$$(2) \qquad E[\phi(y) - py \mid F].$$

Insurance is chosen if

$$V(\phi(y) \mid F) > V(py \mid F).$$

Assuming the preference functional V yields well-defined certainty equivalents, this condition implies

$$(3) \qquad CE(\phi(y) \mid F) - CE(py \mid F) > 0$$

where CE represents the certainty equivalence operator. The differential $CE(\phi(y) \mid F)$ -

CE(py|F) can be partitioned into three terms,

$$(4)\qquad CE[\phi(y)|F] - CE(py|F) = \Delta_1 + \Delta_2 + \Delta_3,$$

where

$$(5a)\qquad \Delta_1 = R[\phi(y)|F] - R(py|F),$$

$$(5b)\qquad \Delta_2 = E[\phi(y)|G] - E(py|G),$$

$$(5c)\qquad \Delta_3 = \{E[\phi(y)|F] - E[\phi(y)|G]\} - [E(py|F) - E(py|G)],$$

and R is the risk premium, e.g., $R[\phi(y)|F] \equiv CE[\phi(y)|F] - E[\phi(y)|F]$ and $R(py|F) \equiv CE(py|F) - E(py|F)$. The decomposition of (4) into Δ_1, Δ_2, and Δ_3 may briefly be characterized as dividing the overall incentive to participate in crop insurance into risk-aversion, actuarial, and asymmetric-information incentives, respectively. Note from (2) that $\Delta_2 + \Delta_3 = E[\phi(y) - py|F]$ is the expected return to crop insurance.

The Risk-Aversion Incentive

The risk aversion incentive, Δ_1, reflects the incentive for insurance participation to a risk-averse farmer over that of a risk-neutral farmer. The distribution of ϕ - $E[\phi]$ is less risky than the distribution of y - E[y] both in the sense of a mean-preserving spread (Rothschild and Stiglitz 1970, 1971) and in the stronger and more policy relevant sense of a monotone spread (Meyer and Ormiston; Quiggin 1991). [Two variables y_1 and y_2 are related by a monotone spread if (i) $y_1 - y_2$ is an increasing function of some variable w, and (ii) $E(y_1) = E(y_2)$.]

A monotone spread increases risk in the sense of Rothschild and Stiglitz and, hence, leads to a reduction in certainty equivalent for any individual who is risk-averse in the usual expected utility sense with concavity of the utility function. Thus, Δ_1 is be positive except under risk neutrality. The more risky the farm operation, the larger is Δ_1 and the higher the return to insurance, *ceteris paribus*. Also, more risk-averse farmers generally have larger risk premiums.

Note that this result does not hold in general for Rothschild-Stiglitz increases in risk (Ross) but it always holds for monotone spreads (Quiggin 1991).

The Actuarial Incentive

The actuarial incentive term, Δ_2, reflects the incentive for insurance participation to a risk-neutral farmer because of subsidies or premiums that are internally inconsistent with FCIC's own assessment of APH and risk. With actuarially fair premiums, this term would be zero. In private insurance activities, this term must be negative to compensate the insurance underwriter for carrying risk. Beginning with the Federal Crop Insurance Act of 1980, crop insurance premiums for the 50 and 65 percent insurance levels were subsidized at a rate of 30 percent (premiums for the 75 percent level were subsidized by an amount equal to a 30 percent subsidy on the 65 percent insurance level). If premiums before subsidization were actuarially fair, this would make Δ_2 positive so that even risk-neutral farmers would have an incentive to participate.

The Asymmetric-Information Incentive

Asymmetric information is a major problem with administering crop insurance. Farmers may know more about the distribution of yields than the insurer. The third term, Δ_3, in (4) reflects these effects. It represents the error made by the insurer in pricing the crop insurance for the specific circumstances of the farmer. If a farmer has a higher than average probability of loss because of farm- or farmer-specific characteristics of which the insurer is unaware, then the farmer has an expected-return incentive to participate in crop insurance even if risk neutral.

Adverse Selection

Both asymmetric information and differences in actuarial incentives among farmers cause adverse selection in crop insurance participation decisions. Differences in actuarial incentives among farmers causes adverse selection because only those farmers with, say, larger relative incentives tend to participate. This consideration can be important given the structure of the FCIC insurance contract and the differences in yield variation among farmers. For example, 30 percent of premiums has been subsidized for the 50 and 65 percent yield levels but only 16.9 percent of corn and soybean premiums has been subsidized for the 75 percent yield level. Thus, farmers where yields never fall below 65 percent of APH yields cannot buy effective insurance at the same rate of subsidy as where yields are more variable. This causes a difference in actuarial incentives among farmers based on local conditions.

Asymmetric information causes adverse selection because all the characteristics that affect probability and size of indemnity payments cannot be reflected in the premium structure. In this case, farmers whose expected indemnity payments are larger than their premiums are more likely to participate in crop insurance. As a result, the insurer must either set the premium structure to reflect the higher average indemnities due to asymmetric information (thus offering less-fair insurance to farmers with average expected indemnity payments) or incur a loss in insuring farmers who are more risky than average.

There are a number of reasons why adverse selection poses a substantial problem to providing multiple peril crop insurance. First, the design of the federal crop insurance program accounts for differences in mean output levels among farms, but not for all individual differences in variability of output. The only farm specific parameter used in determining the parameters of the insurance policy is the APH yield which is a 10-year average yield for the farm. Premium rates have accounted for variability only at the county or regional level by adjusting premiums according to average loss rate experience. As Driscoll notes, the FCIC has historically developed specific rates within counties on the basis of mean yields using the assumption that relative risk is constant across farms. Heterogeneity of farmland quality and farmer management skills can make this a poor reflection of farm-specific risk. More recently, since the 1990 farm bill, the FCIC has begun to adjust premiums to reflect loss rates on specific farms but this approach takes time to adjust and may inappropriately reflect farm-specific risk during the adjustment period.

Second, farms without sufficient program histories are allowed to substitute Agricultural Stabilization and Conservation Service (ASCS) yields and where those are unavailable the FCIC has, in practice, assigned county average yields to specific farms for insurance purposes. Thus, the FCIC insurance yield parameter used to adapt the insurance policy parameters to the specific farm may be poor.

These considerations suggest inability to reflect adequately farm and farmer specific circumstances in the insurance policy parameters offered at the individual-farm level. Nevertheless, empirical analysis is needed to verify the magnitude of importance of adverse selection. To date, no empirical studies are available that assess the magnitude of adverse selection and its effects at the national level using farm-specific data.

Data Requirements

Several types of data are required to facilitate empirical analysis in the framework of equation (4). First, information on farm-specific distributions of yield are required. Because yield histories are not uniformly kept across all farms, the necessity of comparable data dictates collection and use of subjective assessments by farmers which are available only by direct sampling of farmers. Second, the 50-, 65-, and 75-percent-of-normal-yield points are crucial to the insurance decision and could differ substantially among farmers even if moments such as the mean or variance of yields do not. Thus, collection of subjective assessments of farmers needs to concentrate on accurately reflecting these tail areas of the farm-specific distributions. Third, farm-level premium data and the choice of insurance level (both price and yield) are needed to appropriately evaluate the extent of adverse selection that exists in U.S. crop insurance. For this reason, data on actual FCIC policies was collected from FCIC files. Fourth, the consideration of crop insurance needs to be crop specific. The insured price level and risk differs among crops. Farmers can choose to insure one crop and not another.

The Data

This section briefly discusses the survey instruments used to develop the data set. Little detail is given regarding the FCRS since it is described elsewhere and since only part of that data is used here. The major purpose of relying on the FCRS was to adequately reflect conditions for the specific crops. Somewhat more detail is given regarding the Computer Assisted Telephone Interview (CATI) survey used to augment the FCRS data.

The FCRS is an annual survey undertaken by the National Agricultural Statistical Service (NASS) for the Economic Research Service (ERS) to assess costs of production and returns in agriculture (see Financial Characteristics of U.S. Farmers for a detailed description). It is a stratified sample of farms nationwide with around 3000 farmers included each year. This study relies on the 1988 FCRS survey.

The CATI survey is a telephone survey designed as a follow up on the FCRS to obtain additional information for the analysis of insurance participation. It focuses specifically on major crops such as corn and soybeans. For each crop, questions were asked regarding expected average yield on the farm, the chances of an average farm yield of at least 50, 65, and 75 percent of the expected average yield, and the APH Yield. A response rate of 72.6 percent was attained in the CATI survey of FCRS farms for the specific crops in question. Some inconsistencies in the data from the two sources resulted in further reducing the number of observations by 2.6 percent because the FCRS indicated participation in federal crop insurance and the CATI did not, and by 4.4 percent because the CATI indicated participation in federal crop insurance and the FCRS did not.

The data files of FCIC on actual federal crop insurance policies purchased by farmers were used to obtain data on insurance premiums and insured levels. In merging this data with the FCRS/CATI data, an additional 0.6 percent of the observations 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. An additional 9.6 percent of the observations had to be discarded because FCRS and CATI data indicated the purchase of crop insurance but NASS was unable to identify a corresponding FCIC insurance record. Unfortunately, these exclusions all came out of the insured component of the sample which is already thin because of low participation in the crop insurance program. Finally, an additional 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. While all of these exclusions raise serious concerns about potential bias in the results, no means of checking this bias are available and there is no *a priori* reason to suspect systematic bias.

Empirical Adaptation of the Decomposition

We now assess the magnitude of importance of adverse selection in the U.S. federal crop insurance program using the decomposition in (4). Appropriate measurement of the risk-aversion incentive to participate in crop insurance depends critically on the form of the yield distribution because the effects of insurance are concentrated in the bottom tail of the distribution. Because the effective distribution of yields is modified asymmetrically, we considered the possible applicability of a wide variety of assumptions about the form of the distribution of y.

As a first step in analyzing the data, the form of the distribution was assessed. This was done by fitting actual yields minus expected yields to a number of distributions. The results are summarized in Table 1. 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 A and B, and extreme value distributions of types A and B. In spite of some of the literature which rejects normality in agricultural yields and returns, the results support normality. The Kolmogorov-Smirnov test does not reject normality at the 10 percent level for corn. While it rejects normality at the 5 percent level for soybeans, none of the other ten distributions fit the data better. Thus, the normal distribution is used as the basis for the following analysis.

Given normality, the next step was to estimate the parameters of each farmer's crop-specific yield distribution based on responses to the survey. This was done by using the farmer's response on mean average yield as the mean of the yield distribution, μ. Next, the farmer's estimates of the probability of achieving less than 50, 65, and 75 percent of the APH yield were used in a three point probit regression to estimate the variance of the yield distribution, σ^2, given the mean. Specifically, where $\Pr(y < \beta\bar{\mu}) = \psi^\beta$ and ψ^β represents the farmer's probability of achieving a yield less than $\beta\bar{\mu}$, note that

$$\frac{\beta\bar{\mu} - \mu}{\sigma} = \Phi^{-1}(\psi^\beta)$$

where Φ is the cumulative distribution function of the standard normal distribution. Hence, σ can be estimated by a farmer-specific regression following $\beta\bar{\mu} = \mu + \sigma\Phi^{-1}(\psi^\beta)$.

The next step calculated the truncated means and variances of yield that apply to each farmer in the case of insurance. From Johnson and Kotz (pp. 81-83), if $y \sim N(\mu, \sigma^2)$ then

(6) $$E_\beta^+ \equiv E(y|y \geq \beta\bar{\mu}) = \mu + \frac{Z}{1 - \Phi}\sigma$$

(7) $$V_\beta^+ \equiv V(y|y \geq \beta\bar{\mu}) = \left[1 + \frac{zZ}{1 - \Phi} - \left(\frac{Z}{1 - \Phi}\right)^2\right]\sigma^2$$

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

(9) $$V_\beta^- \equiv V(y|y \leq \beta\bar{\mu}) = \left[1 - \frac{zZ}{\Phi} - \left(\frac{Z}{\Phi}\right)^2\right]\sigma^2$$

where

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

(all moments are considered with respect to the farmer's distribution, F). Using these terms, the uninsured return, py, can be compared to the insured return function given by (1). Using properties of conditional probabilities,

(11) $$E(\phi|F) = (pE_\beta^+ - \gamma_{\alpha\beta})(1 - \Phi) + [(p - p_\alpha)E_\beta^- + p_\alpha\beta\bar{\mu} - \gamma_{\alpha\beta}]\Phi$$

(12) $$E[(\phi + \gamma_{\alpha\beta})^2|F] = p^2[V_\beta^+ + (E_\beta^+)^2](1 - \Phi)$$
$$+ \{(p - p_\alpha)^2[V_\beta^- + (E_\beta^-)^2] + p_\alpha^2\beta^2\bar{\mu}^2 + 2p_\alpha\beta\bar{\mu}(p - p_\alpha)E_\beta^-\}\Phi.$$

The effect of insurance on mean returns per acre is the expected return to crop insurance in (2),

(13) $$\Delta\mu = E(\phi|F) - p\mu = \Delta_2 + \Delta_3,$$

and the effect of insurance on the variance of returns per acre is

(14) $$\Delta\sigma^2 = E[(\phi + \gamma_{\alpha\beta})^2|F] - [E(\phi) + \gamma_{\alpha\beta}|F]^2 - p^2\sigma^2 \propto \Delta_1.$$

The latter relationship in (14) follows from the approximation $\Delta_1 \approx -(\rho/2)\,\Delta\sigma^2$ which implies that the variance effect is proportional and opposite in sign to the risk-aversion incentive where the proportion depends on the absolute risk aversion coefficient, ρ.

Based on this framework, the actuarially fair premium, i.e., an alternative premium $\gamma_{\alpha\beta}^{\circ}$

that satisfies $E(\phi|F) = p\mu$, follows (11),

$$E(\phi|F) = p\mu - \gamma^*_{\alpha\beta} + [\beta\bar{\mu} - E_{\bar{\beta}}]\Phi p_\alpha$$

$$= p\mu - \gamma^*_{\alpha\beta} + [\beta\bar{\mu} - \mu + Z\sigma/\Phi]\Phi p_\alpha$$

$$= p\mu - \gamma^*_{\alpha\beta} + [\beta\bar{\mu} - \mu]\Phi p_\alpha + Z\sigma p_\alpha.$$

Setting the latter expression equal to $p\mu$ and solving to $\gamma^*_{\alpha\beta}$ obtains the actuarial fair premium

(15) $$\gamma^*_{\alpha\beta} = [(\beta\bar{\mu} - \mu)\Phi + Z\sigma]p_\alpha.$$

The relationship of actuarially fair premiums (expected indemnities) to actual premiums is instructive for examining adverse selection because it reveals incentives to participate in crop insurance that are not motivated by efforts to transfer risk but rather by efforts to increase profits given subsidized premiums and asymmetric information.

To decompose the expected return into its separate components, Δ_2 and Δ_3, expected returns to insurance as perceived by FCIC must be estimated. This is achieved by first repeating the steps in (6)-(12) replacing μ by $\bar{\mu}$ and σ by $\bar{\sigma}$ where $\bar{\sigma}$ is the standard deviation of yields implied by FCIC insurance rates. That is, the G distribution used by the FCIC is characterized as normal with mean equal to the APH yield and variance extrapolated from the regional premium rate. The calculations corresponding to (13) based on the G distribution thus generate estimates of Δ_2 by analogy with (5b) and Δ_3 can be found as the difference from (13).

To find $\bar{\sigma}$, two approaches can be used. First, note that the FCIC assumes, in effect, constant relative risk across farms (Driscoll). This implies that $\bar{\sigma} = \eta\bar{\mu}$ among all farms in the same rate-making area. Note also that the FCIC per acre insurance premium is calculated as $\gamma^*_{\alpha\beta} = p_\alpha\beta\bar{\mu}r_{\beta\bar{\mu}}$ where $r_{\beta\bar{\mu}}$ is the base rate for the county (which varies by the insured level and APH yield). Substituting these two relationships into (15), replacing μ with $\bar{\mu}$ and σ with $\bar{\sigma}$, and assuming an actuarially fair methodology is used to vary rates among regions obtains

$$\gamma^{\circ}_{\alpha\beta} = p_\alpha \beta \bar{\mu} r_{\beta\bar{\mu}} = p_\alpha \bar{\mu}[(\beta - 1)\Phi + \eta Z].$$

This implies that the latter term in brackets divided by β is the base rate,

(16) $\quad r_{\beta\bar{\mu}} = [(\beta - 1)\Phi + \eta Z]/\beta.$

Both Φ and Z are functions only of z in (10) which becomes $z = (\beta - 1)/\eta$ when $\bar{\mu}$ and $\bar{\sigma}$ are substituted for μ and σ. Equation (16) provides an implicit equation that can be solved for η for each rate so that $\bar{\sigma}$ can be calculated as $\bar{\sigma} = \eta\bar{\mu}$ for each farmer using the FCIC insurance yield. Implicitly, the rate is chosen to be actuarially fair for each farmer given the FCIC assessment of mean and variance. The solution for $\bar{\sigma}$ must satisfy $\Delta_2 = 0$ in equation (5b). Thus, the estimate of $\Delta\mu$ from (13) can be taken as an estimate of Δ_3.

Alternatively, one can consider that the FCIC adjusts rates in response to loss experience. In this case, the rates should tend toward an appropriate reflection of farm-specific standard deviations of yield to the extent that they can be explained by variation in rates between counties and by variation in FCIC insurance yields within counties. For this case, a reasonable approach is to regress the standard deviations of yield on FCIC insurance yields and insurance premiums taking the predicted values from the regression as estimates of $\bar{\sigma}$. Then Δ_2 can be found by analogy with equation (13) and Δ_3 can be found by computing $\Delta_3 = \Delta\mu - \Delta_2$. This approach is considered below.

Results

Table 2 reports the estimated effects of insurance on mean returns per acre and the variance of returns per acre for corn for each of the nine alternative crop insurance choices available to the farmer following equations (13) and (14). The farmer has the choice of insuring yields at one of three levels — 50, 65, or 75 percent of the APH yield — and at one of three price levels — \$1.25, \$1.50, or \$2.00 per bushel in the sample year. The farmer pays a different premium for each choice.

Several interesting results are evident in Table 2. First, as one would expect, the risk-aversion incentives to participate (which are proportional and opposite in sign to the variance effects estimated in Table 2) appear to be considerably greater at higher levels of insurance (higher insured yields and higher insured prices). For the high insurance contract, the reduction in variance is equivalent to a reduction in the standard deviation of returns by $60.20 which is substantial compared to an average price of $2.40 per bushel and an average expected yield of 125.7 bushels per acre among farmers insuring at the high price and high yield level.

Second and more interestingly, Table 2 suggests that the risk-aversion incentive for farmers that participate in crop insurance is higher than for those who do not. While this conclusion would formally require information on risk aversion by farmer, the reduction in risk is clearly larger for those who insure than for those who do not with respect to every individual contract where more than two observations are available on the insured case. Considering only the two contracts with a reasonable number of observations, the reduction in risk also appears to be higher for the higher insurance level as one might expect. Farmers insured at the 75 percent level receive a reduction in risk 65 percent greater than would non-insured farmers. The fact that farmers with greater risk effects of insurance tend to be the ones participating, however, does not by itself imply adverse selection. A public insurance program with actuarially fair premiums would tend to draw participation from farmers facing the greatest risks (and having the greatest risk aversion) but adverse selection only occurs if farmers do not pay premiums commensurate with the higher expected indemnities received.

This question of adverse selection can be examined using the estimated effects of insurance on mean returns in Table 2. Here the results show that those who insure enjoy a positive effect on expected returns (except for the two cases with no more than two observations). This implies that subsidized premiums plus asymmetric information are sufficient to make insurance participation profitable apart from any risk-aversion incentive. By comparison, the expected revenue effect of insurance on returns is negative for non-insuring farmers and strongly so at the 75 percent level. Because the rate of subsidization of premiums is lower for the 75 percent level of insurance, this result is plausible. A wide spread in expected revenue effects between insurers and non-insurers, and a large positive effect for insurers, is evidence of the presence of adverse selection. Specifically, weighting all of the insured observations together, the results imply that insuring farmers receive an average benefit of $1.92 per acre from participating in crop insurance for corn purely because of subsidized premiums and opportunities to take advantage of asymmetric information by adverse selection (excluding any benefit related to reducing risk). By comparison, non-insuring farmers who face the same rate of premium subsidy have a negative incentive to participate, e.g., -$.65 per acre for the middle yield and high price contract. Apparently, the difference of $2.57 per acre is due to adverse selection.

Table 3 presents results for the case of soybeans that are similar in character to those for corn. For every contract, the risk effect of insurance offers a positive incentive to participate (the variance effect is negative), the risk-reduction effect is larger for higher levels of insurance, and the effect is larger for insuring farmers than non-insuring farmers (ignoring comparisons with cases where only one insured observation is available). Also, for soybeans, larger differences in incentives between insured and non-insured farmers tend to occur at the higher levels of insurance (compare the two cases with substantial numbers of observations).

The expected revenue effects in Table 3 again suggest that some farmers are receiving benefits through subsidies and adverse selection apart from benefits of transferring risk. The expected revenue effect is positive although small for every insurance contract among insuring farmers (except the one case with only one insured observation). In other words, average premiums are somewhat better than actuarially fair for those farmers who insure. On the other hand, the expected revenue effect is negative in every case for non-insuring farmers with a disincentive of $1.34 per acre at the 65 percent level and $4.15 per acre at the 75 percent level. This implies a problem of adverse selection because non-insuring farmers who receive the same premium subsidy do not have the same expected benefits of participation. Particularly at the 75 percent level, non-insuring farmers would have to pay considerably higher than actuarially fair premiums in spite of premium subsidization.

Tables 4 and 5 further decompose the mean net income effect into an actuarial effect (Δ_2) and an asymmetric information effect (Δ_3) for corn and soybeans, respectively. The results show that the actuarial effect of crop insurance is generally positive for both insurers and non-insurers. This is as expected due to subsidization of crop insurance premiums by the FCIC. Furthermore, the actuarial effect is larger for contracts at the 65 percent level than for contracts at the 50 percent level at each respective price level. Although 30 percent of premiums are subsidized at both the 50 and 65 percent levels, premiums are larger at the 65 percent level which explains the larger actuarial incentive.

Comparing the 75 percent level to the 65 percent level, the actuarial incentive is larger for insurers and smaller for non-insurers. Because premiums at the 75 percent level are insured only up to the amount of the subsidy for the 65 percent level, one would expect the overall actuarial incentive at the 75 percent level to be the same as at the 65 percent level. However, the potential for adverse selection appears to be greater at the 75 percent level than at the 65 percent level (as represented by the wider dispersion of actuarial effects). Thus, the results with both higher actuarial incentives for insurers and lower actuarial incentives for non-insurers at the 75 percent level compared to the 65 percent level is plausible.

Comparing the actuarial incentive between insuring and non-insuring groups, the insurers have a higher actuarial incentive to participate than non-insurers for most contracts. This represents an adverse selection incentive reflected in the FCIC premium rate structure. That is, assuming the FCIC insurance yields properly reflect individual farm yields, the differences in the actuarial incentives between the insuring and non-insuring cases reflect a bias in the FCIC premium rates which give some farmers a greater opportunity to take advantage of the program than others. These differences are not large for the most popular insurance contract (high price and 65 percent yield level) for both corn and soybeans. However, for the farmers in the tails of the distribution (those insuring at the 50 and 75 percent level) these opportunities are apparently greater.

One of the most interesting results in Tables 4 and 5 is that the asymmetric information incentive is negative in almost every case. This may be surprising to some who expect that insurers can take advantage of an insurance underwriter that does not possess full information. The explanation for crop insurance appears to be different. The results in Tables 4 and 5 suggest that federal crop insurance would not be beneficial for either the insuring group or the non-insuring group without the subsidy (represented in the actuarial incentive). The reason is that the FCIC insurance yields are apparently well below farmers' expected yields on average. For corn, average expected yield exceeds the average FCIC insurance yield by 19.7 bushels per acre for insurers and 17.8 bushels per acre for non-insurers. For soybeans, average expected yield exceeds the average FCIC insurance yield by 4.2 bushels per acre for insurers and 9.2

bushels for non-insurers. Thus, in all cases, federal crop insurance is a much poorer prospect for farmers than suggested by FCIC insurance yields due to asymmetry of information. As explained in another paper (Just and Calvin), this bias in insurance yields is largely due to the FCIC practice of calculating APH yield roughly as a 10-year moving average (the high and low year are excluded) in which case it lags about 5 years behind actual expected yields.

In the case of every insurance contract for both crops (where a comparison is possible based on more than 2 insured observations), the difference in the asymmetric information incentive between the insured and non-insured cases is consistent with adverse selection whereby insurers are better off than would be non-insurers if they had insured. The additional benefits for insurers range from $1.42 to $3.34 per acre.

Table 6 examines the relationship of the actuarially fair premium to the actual premium. Numbers in the table give the ratio of the actuarially fair premium calculated according to equation (15) to the actual premium that farmers paid or would have paid according to FCIC procedures if insured. The results are presented only for the high price level of insurance. The results for non-insured farmers at alternative price levels are identical while only a few observations on insured farmers are available at other price levels.

The results in Table 6 suggest that farmers who insure tend to be those for whom the actuarially fair premium would be much higher than the actual premium paid by farmers to the FCIC, i.e., the premium after the subsidy is deducted. If premiums are actuarially fair, then the entries in Table 6 should all be 1. According to the design of the program, premiums are subsidized 30 percent at the 50 and 65 percent levels. If actual premiums were actuarially fair before subsidization, then the entries in Table 6 should be 1.43 (that is, 70 percent of 1.43 is 1.00) at the 50 and 65 percent levels. With no adverse selection, the ratios should be 1.43 for both insured and uninsured farmers. The choice to insure would then be based solely on risk-aversion incentives.

The ratios range up to 3.6 among insurers but among non-insurers are not greater than 1.01 and in some cases are considerably less than 1. Interestingly, the ratios for farmers insured at the 65 percent level are close to the theoretical 1.43 level (the ratios at the 50 percent level are not reliable because they are based on few observations). The results for farmers insured at the 75 percent level are consistent with a lower relative rate of subsidization for soybeans but imply a higher rate of subsidization for corn.

Overall, these differences in ratios between insured and non-insured farmers demonstrate the presence and magnitude of adverse selection. The differences are statistically significant in 3 of the 4 cases with a reasonable number of observations for comparison. These results are consistent with the FCIC adjusting premium rates to bring indemnities in line with non-subsidized premiums so that over the long term FCIC losses amount roughly to total subsidies. However, these results also suggest a problem whereby premiums are set according to this goal only for participating farmers while many farmers are priced out of insurance because the parameters of insurance contracts offered to them do not fit their farm-specific yield distributions. That is, the program offers insurance to farmers with sufficiently above-average expected indemnities at subsidized rates that are more than actuarially fair while farmers with lower-than-average expected indemnities cannot insure even at actuarially fair premiums. The reason for this difference is that either FCIC insurance yields do not reflect farm-specific expected yields or the premiums used by the FCIC do not reflect farm-specific risk. This explains why the FCIC can consistently experience a loss without attracting more participation in crop insurance.

Concluding Comments

This study has examined the presence and magnitude of adverse selection in the federal crop insurance program using nation-wide, cross-section data at the farm level. The results show that farmers who insure tend to receive greater benefits in terms of risk reduction than could farmers who do not insure. While this alone does not indicate adverse selection, the results also show that returns to insurance for farmers that insure are substantial and considerably higher than for farmers who do not insure. These results support the widely held view that losses incurred by the FCIC are, at least in part, due to adverse selection problems. In particular, losses are due to the necessity of setting premiums with limited information. As a result, participating farms tend to be those that have higher expected indemnities than indicated by the limited information available to FCIC. Farms with lower expected indemnities than indicated by the limited information are priced out of the program. In these circumstances, raising premiums to reduce losses of the program only prices more farms out and reduces the set of farms that can take advantage of the program. In effect, premiums have been adapted to a small subset of farmers whose insurance parameters offer the greatest advantages of participation. These considerations also suggest that the new approach of adjusting premiums to individual farmer loss histories will do little to correct the problem. Apparently, a majority of farmers are priced too far out of participation to make compiling a lengthy participation record of favorable loss history worth any subsequent insurance benefits.

The decomposition of the expected revenue incentive of crop insurance shows that considerable adverse selection occurs in the actuarial effect (which represents the benefits of insurance participation given that FCIC insurance yields appropriately characterize individual farm yield distributions). This adverse selection is due to bias in the premium structure and rigidity in the insurable yield percentages.

Surprisingly, the estimated asymmetric-information effects on farmer revenues are negative. The FCIC insurance yields are, on average, lower than farmers' expected yields due to lags introduced by calculating APH yields roughly as a 10-year moving average of actual yields. Apparently, subsidies are necessary to induce participation in crop insurance given this bias against farmers in the program due to asymmetric information. Nevertheless, estimates of the asymmetric-information effect reveal additional adverse selection due to errors in FCIC insurance yields.

The analysis in this paper presents a unique attempt to quantify and decompose the sources of adverse selection in explaining FCIC losses. Results suggest the magnitude of the problem of adverse selection preventing private offerings of multiple peril crop insurance. However, additional work needs to be done to assess the social costs of public crop insurance programs. Such analysis needs to consider how the demand for crop insurance is affected by asymmetric information and how the supply of specific crops is affected by availability of insurance subject to adverse selection. In a simple framework where crop supply is unaffected by crop insurance availability, adverse selection in crop insurance is strictly a problem of transfers from government to producers (although on an inequitable basis). Effects of crop insurance on crop supply are difficult to assess just as are risk aversion effects on crop supply. In addition, such work needs to assess the additional role of moral hazard. Moral hazard may cause farmers who insure to achieve lower yields than if they did not insure. These effects are excluded from the empirical analysis of this paper by focusing on the relationship of farmers' subjective yield distributions to the insurance decision rather than the relationship of actual yields to the insurance decision. Finally, it would be useful to extend the empirical analysis of this paper to consider potential differences in the farmers' subjective distributions of yields from the actual distributions. To do this, one needs panel data including individualized farm histories of yields. Such data would permit examination of the applicability of rank dependent utility models where poor outcomes tend to be more heavily weighted by farmers in making decisions.

Footnotes

1 We assume that farmers' assessments of yield distributions do not depend on changes in behavior between insured and uninsured cases associated with moral hazard. If this is not the case, then the estimates here are lower bounds on adverse selection effects.

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Table 1. Applicability of the Normal Distribution for Yields

Crop	Number of Observations	Mean	Variance	Skewness	Kurtosis	Kolmogorov Smirnov Statistic	Dominating Distributions[a]
Corn	818	-39.53	1232.66	-.12	3.35	.028	None
Soybeans	588	-9.93	103.96	-.04	3.72	.049*	None

* Significant at the 5 percent level.

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

Source: Calculated from the FCRS, CATI, and FCIC data.

Table 2. Effects of Insurance on Mean and Variance of Net Income for Corn[a]

Insurance Level	Participation Choice	Insured Price Level					
		$1.25/bu.		$1.50/bu.		$2.00/bu.	
		Mean	Variance	Mean	Variance	Mean	Variance
50 Percent	Not Insured	-.34 (2.05) n = 346	-658.37 (1045.13) n = 346	-.40 (2.46) n = 346	-773.29 (1224.52) n = 346	-.54 (3.28) n = 346	-986.37 (1553.80) n = 346
	Insured	n = 0	n = 0	n = 0	n = 0	3.50 (6.52) n = 3	-1833.40 (2052.64) n = 3
65 Percent	Not Insured	-.41 (3.28) n = 346	-1086.17 (1437.70) n = 346	-.49 (3.94) n = 346	-1271.59 (1679.12) n = 346	-.65 (5.26) n = 346	-1610.61 (2116.15) n = 346
	Insured	n = 0	n = 0	-3.04 (0) n = 1	-136.29 (0) n = 1	.95 (8.87) n = 26	-1981.21 (2601.83) n = 26
75 Percent	Not Insured	-2.31 (4.84) n = 346	-1486.32 (1746.45) n = 346	-2.77 (5.81) n = 346	-1735.28 (2034.81) n = 346	-3.69 (7.74) n = 346	-2184.91 (2551.13) n = 346
	Insured	n = 0	n = 0	-1.51 (1.46) n = 2	-1523.87 (782.06) n = 2	3.93 (7.51) n = 16	-3624.60 (2329.02) n = 16

[a] Numbers in parentheses are standard errors and n is the number of observations. All estimates are on a per acre basis.

Source: Calculated from the FCRS, CATI, and FCIC data.

Table 3. Effects of Insurance on Mean and Variance of Net Income for Soybeans[a]

Insurance Level	Participation Choice	Insured Price Level					
		$3.00/bu.		$4.00/bu.		$5.00/bu.	
		Mean	Variance	Mean	Variance	Mean	Variance
50 Percent	Not Insured	-.53 (1.32) n = 285	-312.93 (495.00) n = 285	-.70 (1.77) n = 285	-404.82 (639.64) n = 285	-.88 (2.21) n = 285	-490.51 (772.44) n = 285
	Insured	n = 0	n = 0	n = 0	n = 0	1.01 (0) n = 1	-481.49 (0) n = 1
65 Percent	Not Insured	-.80 (2.34) n = 285	-528.33 (742.02) n = 285	-1.07 (3.12) n = 285	-679.86 (951.19) n = 285	-1.34 (3.90) n = 285	-819.10 (1141.35) n = 285
	Insured	n = 0	n = 0	n = 0	n = 0	.16 (5.26) n = 35	-1144.67 (1289.23) n = 35
75 Percent	Not Insured	-2.49 (8.83) n = 285	-730.60 (943.39) n = 285	-3.32 (5.10) n = 285	-936.02 (1203.59) n = 285	-4.15 (6.38) n = 285	-1122.40 (1436.78) n = 285
	Insured	n = 0	n = 0	-.77 (0) n = 1	-1823.11 (0) n = 1	.01 (6.10) n = 18	-1618.13 (1485.73) n = 18

[a] Numbers in parentheses are standard errors and n is the number of observations. All estimates are on a per acre basis.

Source: Calculated from the FCRS, CATI, and FCIC data.

Table 4. Decomposition of the Mean Net Income Effect of Insurance for Corn[a]

Insurance Level	Participation Choice	Insured Price Level: $1.25/bu. Δ_2	$1.25/bu. Δ_3	$1.50/bu. Δ_2	$1.50/bu. Δ_3	$2.00/bu. Δ_2	$2.00/bu. Δ_3
50 Percent	Not Insured	.46 (.95) n = 346	-.80 (1.98) n = 346	.55 (1.14) n = 346	-.95 (2.37) n = 346	.73 (1.52) n = 346	-1.27 (3.16) n = 346
	Insured	n = 0	n = 0	n = 0	n = 0	1.65 (.99) n = 3	1.94 (5.56) n = 3
65 Percent	Not Insured	1.65 (1.81) n = 346	-2.06 (3.12) n = 346	1.98 (2.17) n = 346	-2.47 (3.75) n = 346	2.64 (2.89) n = 346	-3.30 (4.99) n = 346
	Insured	n = 0	n = 0	.93 (0) n = 1	-3.97 (0) n = 1	2.57 (2.62) n = 26	-1.61 (8.08) n = 26
75 Percent	Not Insured	1.04 (3.45) n = 346	-3.35 (4.19) n = 346	1.25 (4.14) n = 346	-4.02 (5.02) n = 346	1.66 (5.52) n = 346	-5.36 (6.70) n = 346
	Insured	n = 0	n = 0	3.07 (.79) n = 2	-4.58 (2.25) n = 2	5.95 (3.68) n = 16	-2.02 (8.48) n = 16

[a] Numbers in parentheses are standard errors and n is the number of observations. All estimates are on a per acre basis.

Source: Calculated from the FCRS, CATI, and FCIC data.

Table 5. Decomposition of the Mean Net Income Effect of Insurance for Soybeans[a]

Insurance Level	Participation Choice	$3.00/bu.		$4.00/bu.		$5.00/bu.	
		Δ_2	Δ_3	Δ_2	Δ_3	Δ_2	Δ_3
50 Percent	Not Insured	1.05	-1.59	1.41	-2.12	1.76	-2.64
		(.39)	(1.16)	(.51)	(1.55)	(.64)	(1.94)
		n = 285	n = 285	n = 285	n = 285	n = 285	n = 285
	Insured					2.12	-1.11
						(0)	(0)
		n = 0	n = 0	n = 0	n = 0	n = 1	n = 1
65 Percent	Not Insured	2.12	-2.92	2.82	-3.90	3.53	-4.87
		(1.07)	(1.88)	(1.42)	(2.50)	(1.78)	(3.13)
		n = 285	n = 285	n = 285	n = 285	n = 285	n = 285
	Insured					3.61	-3.45
						(1.74)	(4.53)
		n = 0	n = 0	n = 0	n = 0	n = 35	n = 35
75 Percent	Not Insured	1.64	-4.13	2.19	-5.51	2.74	-6.89
		(2.47)	(2.55)	(3.30)	(3.40)	(4.12)	(4.25)
		n = 285	n = 285	n = 285	n = 285	n = 285	n = 285
	Insured			4.51	-5.28	4.83	-4.82
				(0)	(0)	(3.26)	(4.74)
		n = 0	n = 0	n = 1	n = 1	n = 18	n = 18

Insured Price Level spans the $3.00/bu., $4.00/bu., and $5.00/bu. columns.

[a] Numbers in parentheses are standard errors and n is the number of observations. All estimates are on a per acre basis.

Source: Calculated from the FCRS, CATI, and FCIC data.

Table 6. Comparison of Actuarially Fair Premiums to Actual Premiums[a]

Crop	Yield Insurance Level	Not Insured	Insured	Test Statistic for Equality
Corn	50 Percent	.92 (1.43) n = 346	3.60 (4.50) n = 3	1.03
	65 Percent	1.01 (1.32) n = 346	1.48 (2.34) n = 26	1.01
	75 Percent	.74 (.86) n = 346	1.60 (1.24) n = 16	2.74**
Soybeans	50 Percent	.71 (1.12) n = 285	1.76 (0) n = 1	NA
	65 Percent	.79 (1.11) n = 285	1.30 (1.59) n = 35	1.84*
	75 Percent	.59 (.77) n = 285	1.04 (1.04) n = 18	1.80*

[a] Numbers in parentheses are standard errors and n is the number of observations. All estimates are ratios of actuarially fair premiums to actual premiums. Significance at the 5 percent level is indicated by "*" and significance at the 1 percent level is indicated by "**"; "NA" is given for the case where the number of observations is insufficient to perform the test.

Source: Calculated from the FCRS, CATI, and FCIC data.