Designing and Rating an Area Yield Crop Insurance Contract

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This article documents the design and rate-making procedures used in the development of the Group Risk Plan (GRP)—the new federal crop insurance product that insures based on area yield. The authors of this article worked closely with personnel in the Federal Crop Insurance Corporation and others in developing methodological and practical constraints needed in implementing a workable area yield contract. GRP indemnity payments are made based on percentage shortfalls in actual county yields relative to a forecasted yield. Historical county yield data are used to develop forecasted yields and premium rates.

Key words: agricultural policy, area yield, crop insurance.

This journal has published several articles on area yield insurance. Halcrow published the first such article in 1949. Miranda revisited the issue in 1991. In this article we document the design, rating, and implementation of the U.S. area-based yield insurance called the Group Risk Plan (GRP). Both methodological and practical constraints were imposed to develop a workable area yield contract.

Much of the interest in area yield insurance has been motivated by concerns with problems with the traditional farm-loss crop insurance offered through the Federal Crop Insurance Corporation (FCIC). These problems are well documented (Congressional Commission for the Improvement of the Federal Crop Insurance Program; Goodwin and Smith; Just and Calvin; Quiggin, Karagiannis, and Stanton; Smith and Goodwin; U.S. General Accounting Office 1991, 1992). In some regions, the dual problems of adverse selection and moral hazard have resulted in low participation and high government costs. Halcrow's work recognized these problems and recommended that insuring based on area yields would mitigate adverse selection and moral hazard problems.

Halcrow noted that, in many areas, variations from forecasted farm-level yields are largely a function of systemic risk such as the pervasive drought that occurred in the Midwest in 1983 and 1988. Area yield insurance provides effective risk management only in areas where yield risks are largely systemic. There are areas where yield risks are not systemic. An example is the sub-mountainous deciduous fruit producing region around Hood River, Oregon. In a sub-mountainous region, freeze is the major source of yield risk, and the probability and extent of yield loss are largely a function of localized topographical features such as elevation. Area yield insurance will not provide effective risk management in an area such as this.

Given the problems with farm-level crop insurance—and in an attempt to provide farmers with a viable alternative in areas where farm-level crop insurance exhibited serious shortcomings—the U.S. Department of Agriculture (USDA) initiated a pilot test of area yield insurance for soybeans in selected U.S. counties in 1993. The U.S. area yield insurance, known as the Group Risk Plan (GRP), makes indemnity payments based on shortfalls in county yields (the area equals the county). County yields are estimated by the National Agricultural Statistical Service (NASS) of USDA.

In 1992, Skees provided the background analysis and development for the 1993 pilot test of GRP on soybeans. The president's proposed

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1994 budget strongly endorsed GRP as a replacement for farm-based crop insurance. In response, Congress did not eliminate farm-based crop insurance, but instead mandated that GRP be expanded "to the extent practicable." As a result, GRP was expanded in 1994 to 1,875 county-crop programs for wheat, corn, soybeans, grain sorghum, cotton, barley, forage, and peanuts. GRP was made available in twenty-seven states. When forage is excluded, GRP is available for nearly 70% of all U.S. acres for the seven major crops (Skees 1993).

As an example of how the GRP works, suppose that for a given year a county has a forecasted soybean yield of 40 bushels per acre. This forecast is made about six months before farmers make their insurance purchase decisions and plant their crops. Since farm yields can be greater than county yields, and following principles of hedging that are developed by Miranda, farmers are allowed to scale the amount of protection they purchase by up to 150% of the forecasted yield times the expected price. As Miranda documents, such scaling is important for providing more risk protection, as farm yields are not perfectly correlated with county yields and are based on the relative variation of farm to county yields. The scaling design follows the optimal hedge literature. A scaling of 150% in a county with a forecasted soybean yield of 40 bushels and an established FCIC price of $6.00 allows a farmer to purchase up to $360 of protection per acre. Suppose a farmer in the county purchases $360 of protection per acre and selects a 90% coverage level.[1] This participant will receive an indemnity if the actual county yield is below the critical yield of 36 bushels per acre (40 bushels per acre x 90%). For example, if the actual county soybean yield were 27 bushels per acre, or 25% below the trigger yield of 36 bushels per acre, the GRP participant would receive an indemnity payment of $90 per acre ($360 x 25%). There are obvious advantages to allowing a scale-up.

The United States is not the first country to offer insurance based on area yields. Sweden began developing an area yield insurance program in 1952 and implemented a program in 1961. Officials from the Canadian province of Quebec studied the Swedish program during the mid 1970s and introduced the Quebec area yield insurance program in 1977. The idea was resurrected in the United States in the 1989 principal report of the Congressional Commission for the Improvement of the Federal Crop Insurance Program. The Food, Agriculture, Conservation, and Trade Act of 1990 included language authorizing a pilot test of what was then being called the "area yield program."

In 1990, Barnaby and Skees presented arguments for area yield insurance and described how such a program might operate. In 1991, Miranda formalized Halcrow's earlier insights, described the conditions under which area yield insurance would reduce a farmer's yield risk, and extended the literature on optimal hedge ratios to show the amount of protection farmers should purchase. Miranda developed a theoretical framework for evaluating the systemic risk protection provided by area yield insurance and applied that framework to a sample of 102 western Kentucky soybean producers.

Using an optimal hedge format, Miranda evaluated the effectiveness of an area yield insurance program with a sample of 102 soybean farms from a twenty-two county area in western Kentucky that is typical of the southern Corn Belt. These farms generally had available at least fifteen years of detrended yield data. Miranda concluded that "...for most producers, area-yield insurance would provide better overall yield risk protection than individual-yield insurance" (p. 242). Miranda allowed both the scaling and the deductible to vary beyond any politically acceptable limits.

In 1993, Hourigan used historical farm-level data from nearly 3,000 soybean farms in several states to show that, during the 1980s, over 60% of those farms would have had a lower coefficient of variation in gross revenue by using GRP at the 90% coverage level rather than the farm-based crop insurance offered by the Federal Crop Insurance Program at the 75% coverage level. Smith, Chouinard, and Baquet evaluated the variance reduction provided by an area yield insurance program for a sample of 123 separately insured dryland wheat units in Chouteau

[1] We use the terms "protection" and "coverage" as they are used by the USDA's Federal Crop Insurance Corporation (FCIC). Readers who are familiar with insurance literature may initially find this confusing. The FCIC uses the term "coverage" to mean one minus the percentage deductible. The FCIC uses the term "protection" synonymously with the insurer's liability, or what the insurance literature often refers to as coverage.

County, Montana, in 1994. They also found that area yield insurance provided risk protection for many of the farms in their sample.[2]

Designing an Area Yield Insurance Policy

Since indemnities are triggered only when area yields are low, an area yield policy is not like traditional multiple-peril or named-peril (e.g., hail) crop insurance. Rather, it is an option on an index. Just as with a put option on a futures contract, an area yield policy has an associated basis risk. Farmers may experience farm-level yield losses when area yield shortfalls are not sufficient to trigger an indemnity payment under an area yield policy. Lowering the chances of such an event (i.e., lowering the basis risk) is an important objective when designing an area yield policy. The magnitude of the basis risk is affected primarily by two elements of the contract design: (*a*) the area to be used for the yield index, and (*b*) the procedures for forecasting the central tendency in yields for the area. Two additional areas of contract design have important implications for managing basis risk: (*a*) the indemnity payout rules, and (*b*) the domain of insurance deductible and protection choices. All of these contract design considerations are politically constrained.

Each of these contract design elements received attention during development of the GRP pilot. The reasoning for the decisions that were made is presented below. It was decided that (*a*) counties were the only practical area for the yield index, (*b*) robust double exponential smoothing would be used initially to establish the central tendency in yields, (*c*) indemnity payments would be made based on the percentage shortfall in area yields rather than the bushel shortfall as typically presented in the agricultural economics literature (Halcrow; Miranda; Smith, Chouinard, and Baquet), and (*d*) farmers would be allowed to scale up protection levels and purchase GRP at between 90% and 150% of the per acre forecasted value of the crop in that county.

[2] Miranda used actual farm yield data from the Kentucky Farm Business Analysis program. Both Hourigan, and Smith, Chouinard, and Baquet used ten years of actual farm yield data from federal farm-level crop insurance records. Smith, Chouinard, and Baquet conducted their analysis using insurance units, a lower level of aggregation than the farm. Units are described by ownership and location of parcels on farms. Had data been available, a more complete analysis would have considered the risk reduction provided by an area yield insurance policy in combination with a named-peril hail insurance policy. The area yield policy would protect against losses from systemic risks, such as drought, while the named-peril policy would protect against the largely nonsystemic risk of hail loss.

Selection of the Area

Area yield insurance contracts must be based on an index of area yields. To reduce basis risk, the area or zone boundaries for an area yield contract should be selected so as to group together the largest possible number of farms with similar soils and climate. In Quebec, the boundaries frequently are redrawn as new data are made available and as farmers learn that their yields more closely match those of a contiguous zone rather than their current zone. The data requirements for a system such as the one used in Quebec can be formidable. In Ontario, a less resource-intensive index is used. For some crops (e.g., forage), the Ontario crop insurance program uses plant growth simulators to forecast yields. It is likely that the Quebec system has less basis risk than the Ontario system or the GRP.

In the United States, NASS county yields are the only available historical area yield data. An area index based on county yields is not ideal since county boundaries do not necessarily group together farmers with similar patterns of year-to-year percentage deviations from forecasted yields. However, since plant growth simulators cannot capture certain causes of crop yield losses, county yield shortfalls should be a superior measure of systemic risk.

Two criteria were used to select county-crop programs. First, NASS county yield data generally are available from 1956 to the present. All counties selected had to have at least thirty-one continuous years of NASS county yield data available. Second, all counties selected had to have at least 15,000 acres of the commodity (10,000 acres for peanuts) planted in the most recent year for which NASS data were available. In short, only major production areas were selected. Since NASS invests more resources into making yield estimates for major production regions, the yield estimates from these areas should be more accurate than those for fringe areas. Attention was also given to assure that GRP counties selected would form a generally contiguous block (i.e., isolated counties were eliminated).

County yield data can be calculated on either a planted acre or a harvested acre basis. Most GRP contracts are based on planted acre yields, since these yields will represent the true risk associated with abandoned acres. For most crops and in most areas, GRP contracts are based on aggregate acreage and production without regard for production practices. However, in some cases, to improve the yield index (i.e., reduce basis risk), practice-specific GRP contracts are offered. For example, if sufficient (as described above) practice-specific NASS data are available, GRP contracts are offered for both irrigated and nonirrigated production.

Forecasting the Central Tendency in County Yields

Any given yield outcome can be divided into two components: the central tendency, and the deviation from the central tendency. One could argue that the central tendency is a function of management and resource endowment (e.g., cultural practices and the quality of land farmed), while the deviation from the central tendency is a function of nature (e.g., drought, excess moisture, hail, excessive temperature, frost). The purpose of crop insurance is to provide protection against the financial consequences of yield shortfalls due to natural hazards.

The method used to estimate central tendency should be robust, performing well under a wide range of circumstances and reducing the influence of obvious outliers. The method must generate two-year-ahead forecasts since there is a two-year lag in the availability of NASS acreage and production data. Estimators with known statistical properties are preferred to estimators whose properties are unknown, but consideration should be given to estimators that have withstood the test of time and have been widely used in analogous situations. These include methods commonly discussed in the *Journal of Forecasting*. While it may be desirable to use methods that would capture a wide array of market forces, the most critical requirement is that the method be capable of capturing the effects of technology trends. Finally, the method preferably should not be so complex that it cannot be intuitively understood by crop insurance agents and potential GRP purchasers.

The choice of methods for estimating central tendency is constrained by the availability of resources (primarily technical expertise) within the federal agency that administers the program. Structural models of the central tendency in yield for each GRP contract are not practical and the number of data series that would need to be maintained for such models is cost prohibitive.

One class of candidates for estimating the central tendency in yields, locally weighted scatter plot smoothing (LOWESS), was ruled out. LOWESS (Cleveland 1979, 1993; Härdle) was eliminated from consideration because of its lack of widespread application. The first GRP contracts estimated central tendency using a robust double exponential smoothing procedure which provided a locally linear estimate of trend (see Skees, Black, and Barnett). In 1995, central tendency was estimated for wheat GRP using ARIMA models developed by Ker and Goodwin. Concerns were raised about the stability of the AIRMA models due to the short length of yield data available. Further, suggestions in the literature and by practitioners indicate that specification and estimation are a case-by-case task. In 1996, the method for estimating central tendency changed to provide more stability in estimates. Specifically, the use of spline regression was employed to fit up to two linear splines to the data. Robust regression procedures for elimination of outliers were also incorporated. Nonlinear optimization techniques were used to determine the year at which a change in slope was warranted.

Using a piece-wise (spline) procedure for fitting up to two robust linear trends provides an extrapolative forecasting method that meets the requirements presented earlier. It is a pragmatic, intuitive approach that is widely used, and it is straightforward for the administrative agency to use in forecasting future yields without a need to redo the analysis every year.

Indemnity Payout Rules

For any given crop year, the area yield, y, is a random variable. The insurer's forecast of the area yield is given by *yfcast*. The insured selects a *scale* of between 0.9 and 1.5, and a yield coverage level (*cov*) of between 0.7 and 0.9 (the deductible equals 1 − *cov*). The critical yield, y_c, is calculated as

$$(1)\quad y_c = yfcast \times cov.$$

The insured receives an indemnity, *indem*, whenever $y < y_c$. The indemnity is calculated as

$$(2)\quad indem = \max\left[\left(\frac{y_c - y}{y_c}\right)(yfcast)(scale),\ 0\right]$$

where *yfcast* times *scale* is the insurer's liability (the insured's protection) or the maximum possible indemnity payment. For ease of presentation, indemnities are measured in units (say, bushels) per acre instead of dollars. To convert to dollars, simply multiply by total acres insured and price per bushel.

Miranda, and Smith, Chouinard, and Baquet examine the performance of several different stylized area yield insurance contracts. All of these designs differ from the current GRP contracts in important respects. Instead of using NASS county yields, Miranda, and Smith, Chouinard, and Baquet calculated y and *yfcast* based on a weighted average of a sample of individual farm yields—thus creating their own areas with a sample of farms.

Both Miranda, and Smith, Chouinard, and Baquet utilize different indemnity payout rules than those used in GRP. Specifically, they calculate *indem* as

$$(3) \quad indem = \max[(y_c - y)scale, 0].$$

Miranda, and Smith, Chouinard, and Baquet measure the yield shortfall as the simple difference between y_c and y (the shortfall is denominated in units such as bushels per acre). GRP pays indemnities based on yield shortfalls measured as a percentage relative to y_c, as shown in equation (2). Measuring yield shortfall as a percentage creates a disappearing deductible. When major yield shortfalls occur, indemnity payments will be significantly higher under GRP rules than they are under the Miranda, and Smith, Chouinard, and Baquet rules. In the extreme, if $y = 0$, the percentage shortfall will be 100% and the indemnity will be 100% of protection regardless of the level of *cov*. This feature makes a GRP policy with a low level of *cov* more attractive for those who are concerned only with catastrophic yield losses.[3] The disappearing deductible rules also increases the importance of loading rates for catastrophic yields that have not been experienced in a short series of data.

Establishing the Domain of Insurance Deductible and Protection Choices

The GRP is a very specific form of an area yield insurance product in which political constraints circumscribe the domain of the insured's choice variables. Currently, the insured may choose a value for *cov* from a limited set of discrete possibilities. Specifically, *cov* can be set at 70%, 75%, 80%, 85%, or 90%.[4] The Federal Crop Insurance Reform and Department of Agriculture Reorganization Act of 1994 (P.L. 103-354) authorized values of *cov* up to 95%. As of yet, a 95% *cov* has not been implemented. The insurer selects a value for *scale* anywhere between 90% and 150%.[5]

Most farm-level yields are more variable than county-level yields. Thus, to achieve a target indemnity payment that will meet cash flow shortfalls in low-yield years, insured farmers can choose levels of *scale* up to 150%. The choice of an optimal level of *scale* is analogous to an optimal hedge ratio in the futures literature.

Rate Making for the Selected Design of Area Yield Insurance in the United States

As much as possible, an effort was made to adopt GRP rate-making procedures that were consistent with standard FCIC procedures. The pure premium rate for any given level of *cov* is simply the average yield shortfall in percentage terms over the historical time series of available data. A pure premium rate is calculated at *cov* = 100% since the precision of the estimates is higher at zero deductible than for any positive levels of deductibles. Ultimately, a parametric structure of rate relativities is imposed to generate premium rate relativities. Pure premium rates also are calculated for the various levels of *cov* used in the GRP (70%, 75%, 80%, 85%, and 90%).

Premium Rate Relativities

Rating a county yield insurance product presented some special challenges. It was determined that rating the individual county without

[3] If the insurance purchaser could optimally choose levels of *cov* and/or *scale* under the Miranda, and Smith, Chouinard, and Baquet indemnity payout rules, it would be possible to achieve significantly higher indemnity payments when major yield shortfalls occur. However, the maximum values of *cov* and *scale* are politically constrained. Federal Crop Insurance Corporation decision makers, whose backgrounds are in farm-level crop insurance, are not comfortable with an area yield insurance program that allows for very high levels of *cov* or *scale*. While conceptually one could offer an area yield insurance policy for any combination of nonnegative values of *cov* and *scale*, this could lead to politically unpalatable outcomes. Specifically, if *cov* > 100%, indemnity payments would be made even if the actual yield, *y*, is greater than the forecasted yield, *yfcast*. If *scale* is allowed to be very high, indemnity payments may be very high.

[4] The Federal Crop Insurance Corporation is considering a proposal to allow GRP purchasers to select a value for *cov* at any discrete level between 70% and 95%.

[5] The maximum value of *scale* is set at 150%. The minimum value is set at 0.6 times the maximum value of *scale* which equals 90%. These values are constrained politically, unlike the work of Miranda, and Smith, Chouinard, and Baquet. In that work, they allowed the scaling to reach extremely high values.

using information from nearby counties would be inappropriate. Spatial correlation among county yields is important for rating. Further, since only thirty-five to forty years of data were available, it was critical to load the rates for catastrophic events that may not have been experienced. Providing structure to rate relationship across coverage levels became a key in anchoring rates. This is a common practice in rate making. The empirical rates for the various coverage levels (sum of all percentage shortfalls divided by the number of years) are useful. However, using empirical rates has some limitations. For example, within the time series of NASS yield data available, some counties never may have experienced situations where $y < y_c$ at the lower levels of *cov*. This results in a pure premium rate of 0.0 (and therefore a premium of $0.00) at that level of *cov*. Obviously, this is not realistic since there is always some likelihood that y will be less than y_c, even at low levels of *cov*.

A graphical review of the many county distributions of the residuals about the estimate of central tendency demonstrated that county yields are typically asymmetrically distributed with a negative skew and a thick left tail. Statistical tests of skewness confirmed this observation. Thus using a normal assumption for yield distribution is inappropriate.

As the first step in transformation to a negatively skewed, thick left-tailed distribution, an approximation based on the Botts and Boles procedure was implemented. The Botts and Boles procedure calculates premium rates given information on the coefficient of variation of an assumed normal yield distribution. No county coefficient of variation was allowed to be less than 15%.[6] The implied coefficient of variation, based on the empirical premium rate at *cov* = 100%, was put into the Botts-Boles algorithm to develop parametric premium rates for each level of *cov* used in the GRP. The resulting parametric premium rates were then loaded by dividing through by the *cov* times 0.01. The effect of this procedure is to add a greater load (in percentage terms) to the lower *cov* levels. There are at least two reasons for loading premium rates in this manner. First, lower levels of *cov* will have lower premium rates. Yet, at lower levels of *cov*, there are fewer empirical observations where $y < y_c$. Hence, there is less empirical information on which to base an empirical premium rate at lower levels of *cov*. Second, low empirical premium rates (at any level of *cov*) may simply reflect the fact that a true catastrophic yield has not occurred during the historical time frame being considered. This, however, may lead to the wrong conclusion about the possibility of such an event occurring. The loaded parametric premium rates are consistent with a negatively skewed distribution with a thick left tail (such as a beta). Further, rate relativities generated using this procedure also match the average empirically based rate relativities.

For a given GRP contract, the "parametric" premium rate is compared to the empirical premium rate at each level of *cov*. If the empirical rates demonstrate a greater frequency of serious yield shortfalls than the parametric procedure, the empirical rates are used.

Reserve Loading

It is standard insurance practice to add a reserve load to premium rates in order to build reserves. In principle, the concept assumes that a reserve load will increase the chances that reserve funds can be accumulated before a major payout occurs. Following standard practice for the traditional federal farm-level crop insurance product, reserve loading is implemented by dividing the selected premium rates (either the empirical values or the parametrically adjusted rates) by 0.9. These procedures were imposed by the FCIC.

Using Contiguous Counties to Smooth Rates

Premium rates for the federal farm-level insurance product are smoothed cross-sectionally by utilizing information from contiguous rating areas. For this reason, and following the lines of credibility theory, the final premium rate for each county GRP contract is calculated as a weighted average of the premium rate for that county and the premium rate for each contiguous GRP county. The weights are calculated as follows:

$$(4) \qquad w_{target} = 0.9\left(\frac{acres\ planted_{target}}{100{,}000}\right)^{0.5}$$

subject to $0.4 \leq w_{target} \leq 0.9$, where w_{target} is the weight assigned to the target county and *acres*

[6] While imposing a lower bound of 15% on the CV for yields was somewhat arbitrary, this value gives very low premium rates. Even rates at the 90% *cov* are around 2.5%. In a series of thirty-five years, it only requires two years with yield shortfalls of 40% below the critical yield in order to obtain a rate of about 2.5% (80% divided by 35 = 2.29). This procedure protects against unexperienced yield losses. It is not likely that farmers in counties with little or no experience of yield losses will find GRP attractive.

$planted_{target}$ is the average acres planted in the target county over the most recent ten-year period; and

$$(5)\quad w_{contig(i)} = (1 - w_{target})\left(\frac{acres\ planted_{contig(i)}}{\sum_i acres\ planted_{contig(i)}}\right)$$

where $w_{contig(i)}$ is the weight assigned to the ith contiguous GRP county, and $acres\ planted_{contig(i)}$ is the average acres planted over the most recent ten-year period for each contiguous GRP county. All weights sum to one. The final premium rate for each county GRP contract is calculated as

$$(6)\quad final\ premium\ rate_{target} = (w_{target})(rate_{target}) + \Sigma_i[(w_{contig(i)})(rate_{contig(i)})].$$

Information from all available contiguous GRP counties is used to smooth rates.

Experience with GRP

While only two years of GRP experience is available since the major expansion, that experience does provide some information. In the two crop years since the major expansion, GRP premiums have exceeded $8 million in each year. The loss ratio was 1% in 1994 and 16% in 1995. While the APH loss ratio was 63% and 100% of premium for 1994 and 1995, it is too early to make meaningful comparisons of loss ratios for the GRP versus the APH. In particularly bad crop years, one can expect GRP loss ratios to exceed APH loss ratios. The major participation has been in GRP corn policies comprising nearly $6 million of the $8.7 million in total premium in 1995. While $6 million is a relatively small share of the $372 million for APH corn in 1995, there are markets where GRP comprised a significant share of the total premium for corn insurance. In nearly one hundred counties, GRP comprised more than 5% of the corn insurance in 1995. As figure 1 reveals,

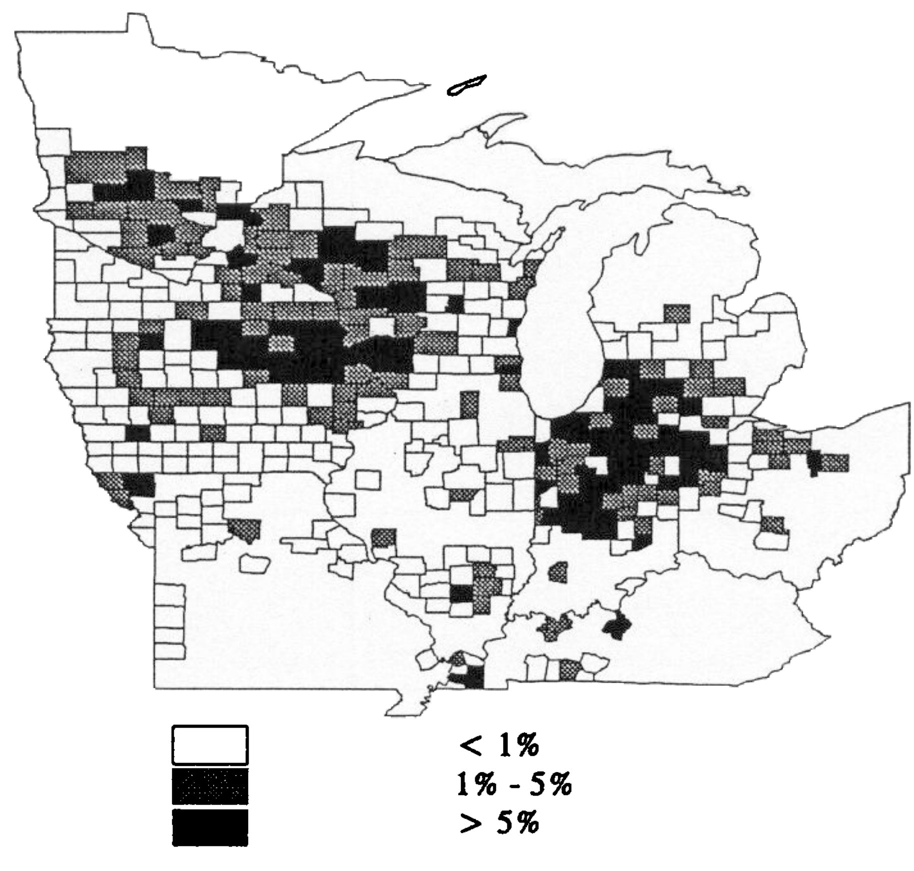

Figure 1. Percentage of GRP corn insurance premium to all federal crop insurance premium for corn in 1995

these counties are grouped together. This suggests that marketing efforts and knowledge by sales agents play a major role in the acceptability of a new product like GRP.

Another measure of acceptability is to examine GRP relative to other crops insured by FCIC. Federal crop insurance was available for sixty crops in 1995. GRP corn ranked number 24 when crops are arrayed by total premium. Thus, while GRP insurance has not been widely accepted, it does represent a niche market for the Federal Crop Insurance program. Opportunities for further growth will depend on the industry response in developing individual crop insurance policies that are coupled with the GRP policy. Such wraparound policies are now being developed. Companies can key these policies to individual underwriting and reduce the incidence of moral hazard and adverse selection. The real advantage of a wraparound policy is that it segments the functions for crop insurance delivery in a fashion that exploits the comparative advantage of government versus private companies. Government protects the systemic risk with the GRP, and private insurance companies protect the individual risk with the wraparound. Companies can use the county yield to gauge which farms have different yields and the extent to which these differences are due to moral hazard and/or adverse selection. Huang empirically examined such a contract design and concluded that it was workable for a large percentage of farmers in the Midwest. Separating systemic and independent risk in this fashion offers significant promise for mixing government and insurance markets.

Further Needs in Designing GRP

Area yield crop insurance is now in place in the United States. The design and rating issues addressed in this study should be subjected to rigorous review. There are opportunities to improve the Group Risk Plan. The contract design can be refined. The use of county boundaries for the area yield needs to be evaluated. County boundaries may be too small for some regions and too large for other regions. If significant systemic risks are present, it may be practical to increase the size of the area (e.g., crop reporting districts). In some regions, the soils and climate may require an area smaller than the county. In other regions, where yield risks are independent (i.e., the systemic risk component is missing), area yield crop insurance should not be attempted.

Previous studies (Miranda; Smith, Chouinard, and Baquet) discuss using higher coverage levels or allowing for higher scaling (increasing the liability). There are significant political and statistical constraints to these strategies. Offering coverage at or above forecasted yields compounds the rate-making and forecasting problems discussed in this study. Offering the opportunity to scale liability beyond the 150% level for county revenue may be workable. Future research using farm-level and county data should investigate the potential benefits of such a change in contract design. Another contract design consideration may involve incorporating "ground-level" truth in estimating the central tendency in yields. If a radical change occurs in the production process (e.g., sudden widespread use of irrigation or the elimination of irrigation), adjustments will be needed.

Rate-making issues that need further development include (*a*) the imposition of rate relativities (currently the procedure uses both a parametric and nonparametric structure), (*b*) the current methods for catastrophic loading (i.e., it may be necessary to use additional information from long series of weather data), and (*c*) the current methods for weighting contiguous counties. Each of these three issues should be examined rigorously. While the current procedures in these three areas have intuitive appeal, they can be improved upon with further research.

Area yield insurance will not work without systemic risk. The greater the systemic risk, the more workable is area yield insurance. Redefining GRP boundaries may improve the current area yield product in some regions. However, this activity may involve significant transaction costs and may be politically unlikely. Of more importance is the opportunity provided to private insurance companies under Crop Insurance Reform. These companies can package farm-level insurance with the GRP. Such policies would mitigate the basis risk and provide a superior model for government involvement in the market for crop insurance. Farmers would receive more protection for systemic risk events while still having farm-level protection for other random yield losses. Insurance companies would be protected from catastrophic losses by the GRP policy and would offer insurance for events that are more independent.

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References

Barnaby, G.A., and J.R. Skees. "Public Policy for Catastrophic Yield Risk: An Alternative Crop Insurance Program." *Choices*, Second Quarter 1990, pp. 7–9.

Botts, R.R., and J.N. Boles. "Use of Normal-Curve Theory in Crop Insurance Ratemaking." *J. Farm Econ.* 40(August 1958):733–40.

Cleveland, W.S. "Robust Locally Weighted Regression and Smoothing Scatter Plots." *J. Amer. Statist. Assoc.* 74(December 1979):829–36.

___. *Visualizing Data*. Summit NJ: Hobart Press, 1993.

Congressional Commission for the Improvement of the Federal Crop Insurance Program. *Recommendations and Findings to Improve the Federal Crop Insurance Program.* Washington DC, May 1993.

Goodwin, B.K. "An Empirical Analysis of the Demand for Multiple-Peril Crop Insurance." *Amer. J. Agr. Econ.* 75(May 1993):425–34.

Goodwin, B.K., and V.H. Smith. *The Economics of Crop Insurance and Disaster Aid.* Washington DC: American Enterprise Institute Press, 1995.

Halcrow, H.G. "Actuarial Structures for Crop Insurance." *J. Farm Econ.* 21(May 1949):418–43.

Härdle, W. *Applied Nonparametric Regression.* Cambridge: Cambridge University Press, 1990.

Hourigan, J.D. "A Farm-Level Analysis of Alternative Crop Insurance Designs: Multiple-Peril Versus Area-Yield." Master's thesis, Dept. Agr. Econ., University of Kentucky, 1993.

Huang, L. "Mixing Government and Markets for an Improved Crop Insurance Program." Master's thesis, Dept. Agr. Econ., University of Kentucky, 1995.

Just, R.E., and L. Calvin. "An Empirical Analysis of U.S. Participation in Crop Insurance." *Economics of Agricultural Crop Insurance: Theory and Evidence.* D.L. Hueth and W.H. Furtan, eds., pp. 205–52. Boston: Kluwer Academic Publishers, 1993.

Ker, A., and B. Goodwin. "Rating and Yield Predicting Procedures for the Group Risk Federal Crop Insurance Program." Progress Report delivered to Federal Crop Insurance Corporation, May 1995.

Miranda, M.J. "Area Yield Insurance Reconsidered." *Amer. J. Agr. Econ.* 73(May 1991):233–42.

Quiggin, J., G. Karagiannis, and J. Stanton. "Crop Insurance and Crop Production: An Empirical Study of Moral Hazard and Adverse Selection." *Economics of Agricultural Crop Insurance: Theory and Evidence.* D.L. Hueth and W.H. Furtan, eds., pp. 253–72. Boston: Kluwer Academic Publishers, 1994.

Skees, J.R. "Background Research and Educational Material for a Pilot Test of the Group Risk Plan for Soybeans." Paper presented to the Board of the Federal Crop Insurance Corporation, 17 September 1992.

___. "The Political Economy of a Crop Insurance Experiment." W.I. Myers Lecture Series Paper, Dept. Agr., Resour., and Managerial Econ., Cornell University, 14 October 1993.

Skees, J.R., J.R. Black, and B.J. Barnett. "Designing and Rating an Area Yield Crop Insurance Contract." Paper presented at AAEA annual meeting, Indianapolis IN, 6–9 August 1995.

Smith, V.H., H.H. Chouinard, and A.E. Baquet. "Almost Ideal Area Yield Crop Insurance Contracts." *Agr. and Resour. Econ. Rev.* 23(April 1994):75–83.

Smith, V.H., and B.K. Goodwin. "Crop Insurance, Moral Hazard, and Agricultural Chemical Use." Dept. Agr. Econ. and Econ. Staff Paper No. 94-3, Montana State University, 1994.

U.S. General Accounting Office. *Crop Insurance: Inaccurate FCIC Price Forecasts Increase Program Costs.* Report to the Honorable J. Robert Kerrey, U.S. Senate, PEMD-92-4, Washington DC, 1991.

___. *Crop Insurance: Program Has Not Fostered Significant Risk Sharing by Insurance Companies.* Report to the Chairman, Committee on Agriculture, Nutrition, and Forestry, U.S. Senate, RCED-92-25, Washington DC, 1992.