

PERFORMANCE OF FARM LEVEL VS AREA LEVEL CROP INSURANCE

by

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(Under the Direction of Gauri S. Datta)

ABSTRACT

This study investigated the performance of Actual Production History (APH), a farm level crop insurance plan, vis-à-vis Group Risk Plan (GRP), an area level crop insurance, as a farm risk management tool. We estimated actuarially fair premiums and trigger probabilities under both plans using a two-step hierarchical Bayes small area estimator. Certainty equivalent revenues based on a risk averse utility function were derived under three insurance choice scenario (APH, GRP, no insurance) with and without actual Federal subsidies. Finally, we derived the performance of each alternative plan with regards to the other following a pair-wise comparison of certainty equivalent revenues.

INDEX WORDS: Crop Insurance, Farm level, Area level, Performance, Small area estimation, Hierarchical Bayes.

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Chapter 1

Introduction

Agricultural production is vulnerable to substantial level of systemic risk caused by adverse weather conditions (droughts, hail, frost, etc) and natural hazards (tornadoes, earthquake, floods). Crop insurance is one of the most important tool in managing such risk.

Initially introduced in 1938, the Federal Crop Insurance Corporation (FCIC) currently provides different types of yield and revenue based insurance plans that can also be classified as farm/individual or area/group level. Also, they subsidizes most (up 62%) of the premiums paid by farmers and provide significant subsidies to private insurance companies as administration cost. The amount of subsidies required to keep the FCIC solvent is ever rising, and currently the program represents one of the most expensive farm program, drawing increased attention from law makers, especially in the wake of Federal deficit reduction. In 2010, the FCIC insured over 256 million acres of farm for a total liability of \$78 billion, costing tax payers \$4.7 billion in subsidies. In 2011, 265.7 million acres were insured for a total liability of \$114.2 billion and costing tax payers \$7.4 billion in subsidies. This represents 46% increase in total liability and 57% increase in total subsidies from the previous year. Past studies have linked the poor actuarial performance and insolvency of the FCIC to mostly adverse selection and moral hazard and unreliable premium estimates.

Introduced in the early nineties, area level policies which cost extremely less to administer

and minimizes problems related to asymmetrical information compared to farm level plans, have long been viewed with the potential to improve risk sharing and lower the amount of subsidies needed to keep the program solvent. Since its introduction in 1993, the level of participation in the program has been slowly increasing up the late 2000's during which it represented about 9% of the FCIC total liability. Since then the level of participation has been falling and in 2011 represented only 6% of the FCIC total liability while most (80%) is associated to farm level plans ¹.

While low participation rate in group plans has generally been linked to the lack of correlation between farm level yield and county average yield, the largely disproportionate preference for farm level plans over area level is hard to go unnoticed and raises several questions. How well do farm level policies protect crop losses relative to area level policies? What factors are most influential in determining farmers' choice of plan? To what extent do basis risk and farmers' risk preferences influence farmer's preferences for area and farm level policies? Do current levels of participation in area and farm level crop insurance plans reflect their individual performances in managing risk?

In an attempt to tackle these questions, this study investigated the performance and choice distribution of a representative area level insurance plan (Group Risk Plan (GRP)) and a corresponding farm level insurance plan (Actual Production History (APH)) for corn farms in eleven Illinois counties which represent agricultural district 40. In the first part of the study, we estimated actuarially fair premiums for for GRP and APH plans with their corresponding trigger probabilities. In the second part, we use the estimates derived to simulate expected certainty equivalent revenue under three insurance scenarios (APH, GRP, no insurance) based on a risk averse utility function. Finally, we compared the performance of each policy option in relation to the others (using the expected certainty equivalent revenues) to determine the best insurance choice option. Premium estimates used in the simulations are estimated from a two-step hierarchical Bayes small area estimator with quasi-simulated

¹The rest is attributed to specialty crops

corn yields based on farm level geospatial data.

Small area estimation is an active area of research which involves obtaining reliable estimates from sub-populations (district, county, state, country, sex, race, sex-race combination, etc) when the survey data involves few observations at least in some subpopulation (commonly referred to as area). The methods developed circumvent this limitation by ‘borrowing strength’ or making use of information from sample variables outside the area of interest. Typically sources from which strength is borrowed include data from neighboring or similar areas in which case we refer to as ‘borrowing strength’ across space, and data from earlier time periods referred to as ‘borrowing strength’ across time. This process increases the ‘effective sample’ size use in the study (Datta and Ghosh, 1991; Rao, 2003) and thus the efficiency of estimated parameters.

Our data generation and estimation approach mimics and accounts for lack of representative sample, spatial and temporal heterogeneity, and uncertainty in premium estimates which are common problems faced by researchers in estimating reliable premiums. As another contribution, the estimator accounts for sampling design which to the best of our knowledge has not been considered so far in rating crop insurance premiums. This allows for the possibility that the data collection process could follow a simple random sampling as well as weighted random sampling to ensure that large farms within a county are more likely to be sampled. This framework is reasonable and consistent with the USDA-NASS area frame design for agricultural surveys which is the methodology used by NASS to develop and sample Primary Sampling Units (PSUs) and segments. In some cases the target segment size is based on the Probability of Selection Proportional to Size (PPS)(USDA-NASS, 2009). Thus putting more weight on large farms within a county. In this case, failure to account for the sampling design could lead to design inconsistent estimates (Datta et al., 1996, 2000; Prasad and Rao, 1999; You and Rao, 2003).

Findings from our study revealed APH plans out performed GRP by 92% when no subsidies are offered. However, under actual levels of subsidies currently offered by the

FCIC, APH out performed GRP between 48% and 71% while GRP also out performed APH between 29% and 51%. The estimated percentages under Federal subsidies are significantly different from the observed preferences between area and farm level plans. Thus suggesting that unobserved factors other than basis risk and farmers' risk preference drive preferences for crop insurance contracts.

The rest of the study is organized as follows. Next we presents a summary of the FCIC. Our model and estimation strategy is specified in chapter two while chapter three duels on the data generation. We present results and discussion in chapter four and sum up our study, main results and suggestions for future research in chapter five.

1.1 Background on U.S. Federal crop insurance

The Federal crop insurance was first authorized in 1930 by Congress to help farmers recover from the Great Depression and Dust Bowl. Eight years later, the FCIC was created to administer the program. Since its inception the program has gone through several transformations and constant expansion and today plays a prominent role in U.S. agricultural policy. The program is currently administered by the U.S. Department of Agriculture's Risk Management Agency (RMA) and provides several types of yield and revenue based insurance for major crops in most counties. Depending on the type and level of coverage chosen by the farmer, he pays up to 62% of the premium or zero in the case of catastrophic coverage while the rest is subsidized by the government. The plans are currently sold and serviced by 15 private insurance companies. The FCIC covers all their administrative and operation costs and also reinsures their losses. The reinsurance agreement allows private insurance companies to shore up low risk and cede high risk to tax payers (Smith, 2011). A yield based policy pays an indemnity when the realized yield falls below the expected yield (yield guarantee) while a revenue based plan triggers an indemnity when the realized revenue fall below the expected level. Each of the plan can further be classified as farm/individual level

or area/group level. Expected yield for farm level plans are based on historical yields from the specific farm while expected yield for area level plans are often based on the expected yield of the area (e.g. county). Area-based policies offer an alternative to farmers to insure their farms at a significantly lower cost (premium) compared to farm level plans. The low premiums result from low cost of administration since damage assessment is not done before indemnity payments. In addition, area based plans considerably reduce adverse selection and moral hazard, both serious problems plaguing farm level plans. This is because farmers are less likely to know the true distribution of the expected county yield thus preventing them from self-selecting into specific plans. In addition, incentives for farmers to engage in negligent behavior after obtaining coverage is significantly reduced since a poor yield on one or few farms may not be sufficient to lower the observed county average yield down to the trigger level. The lack of strong correlation between farm yields and county averages creates basis risk and has been suggested as one of the main reasons why farmers overwhelmingly prefer farm level policies over area level policies. From 2000 to 2006, the program cost to the government fluctuated between \$2 and \$4 billion. In 2007, the cost rose to \$7 billion driven mostly by higher policy premiums from rising food prices and thus higher subsidies paid to farmers and companies. Last year (2012), 282 million acres were insured for a total liability of \$116.8 billion which costed tax payers \$14 billion. The significant rise in cost in the last few years has prompted questions whether the cost to tax payers is worth the risk reduction, and has made the program a potential target for deficit reduction.

Chapter 2

Model specification

For simplicity, we specify a two-step hierarchical Bayes small area estimator based on cross sectional data. This means the nested error contains a spatial random effects but not the temporal. The specification can easily be extended to longitudinal and time series data to fully represent temporal effects following Ghosh et al. (1996); Datta et al. (1999, 2002) and Torabi (2012). The model developed is based on the basic unit level nested error regression (NER) model by Battese et al. (1988) and extensions by Prasad and Rao (1999) and You and Rao (2003) to account for the design.

The basic unit level NER model takes the form.

$$y_{ij} = x_{ij}^T \beta + u_i + e_{ij}, j = 1, \dots, n_i, i = 1, \dots, m \quad (2.0.1)$$

Where y_{ij} is the yield on farm j in county i , x_{ij} is the vector of auxiliary variables, β is the vector of fixed parameters, u_i is the random effect of area i and e_{ij} the random individual error term. The county effects u_i are assumed independent with zero mean and variance σ_u^2 . Similarly, the errors e_{ij} are independent with mean zero and variance σ_e^2 , u_i 's and the e_{ij} 's are assumed mutually independent. If N_i is large, $N_i^{-1} \sum_{j=1}^{N_i} e_{ij} \approx 0$ and we can approximate

the mean yield for county i by θ_i^1 .

$$\theta_i = \bar{X}_i^T \beta + u_i \quad (2.0.2)$$

Lets suppose that data was collected from n_i corn farms where each sample (n_i) is weighted by the size of the farm with weights w_{ij} . We can combine equation (2.0.1) with the direct county average yields ($\bar{y}_{iw}$) to produce a county-level NER model (equation (2.0.3))².

$$\bar{y}_{iw} = \bar{x}_{iw}^T \beta + u_i + \bar{e}_{iw}, i = 1, \dots, m \quad (2.0.3)$$

2.0.1 Hierarchical Bayes model

To develop an HB estimator based on equation 2.0.1, we consider that (i) $y_{ij}|\beta, u_i, \sigma_e^2 \sim N(x_{ij}^T \beta + u_i, \sigma_e^2), j = 1, \dots, n_i, i = 1, \dots, m$; (ii) $u_i|\sigma_u^2 \sim N(0, \sigma_u^2)$, and we assumed $\pi(\beta, \sigma_u^2, \sigma_e^2) = \frac{1}{\sigma_e^2}$. The joint posterior density function is then given by equation (2.0.4).

$$f(\beta, \sigma_u^2, \sigma_e^2 | y_{ij}, 1 \leq j \leq n_i, 1 \leq i \leq m) \propto \prod_{i=1}^m \left[\prod_{j=1}^{n_i} \left(\frac{1}{\sigma_e^2} \right)^{\frac{1}{2}} e^{-\frac{1}{2\sigma_e^2} (y_{ij} - x_{ij}^T \beta - u_i)^2} \left(\frac{1}{\sigma_u^2} \right)^{\frac{1}{2}} e^{-\frac{1}{2\sigma_u^2} u_i^2} \right] X \frac{1}{\sigma_e^2} \quad (2.0.4)$$

From equation (2.0.4) the following full conditional distributions are derived.

$$u_i | y_{ij}, \beta, \sigma_e^2, \sigma_u^2 \sim N \left((n_i + \frac{\sigma_e^2}{\sigma_u^2})^{-1} \sum_{j=1}^{n_i} (y_{ij} - x_{ij}^T \beta), \left(\frac{n_i}{\sigma_e^2} + \frac{1}{\sigma_u^2} \right)^{-1} \right) \quad (2.0.5)$$

$$\beta | y_{ij}, u_i, \sigma_e^2, \sigma_u^2 \sim N(\Lambda \sigma_e^2 \sum_{i=1}^m \sum_{j=1}^{n_i} (y_{ij} - u_i) x_{ij}, \Lambda = (\sigma_e^{-2} \sum_{i=1}^m \sum_{j=1}^{n_i} x_{ij} x_{ij}^T)^{-1}) \quad (2.0.6)$$

¹where $\bar{X}_i$ and x_{ij} are vectors both with dimensions $k \times 1$ and $\bar{X}_i = \sum_{j=1}^{n_i} \frac{x_{ij}}{N_i}$

²Where $\bar{y}_{iw} = \frac{\sum_{j=1}^{n_i} w_{ij} y_{ij}}{\sum_{j=1}^{n_i} w_{ij}} = \sum_{j=1}^{n_i} w_{ij} y_{ij}; w_{ij} = \frac{w_{ij}}{\sum_{j=1}^{n_i} w_{ij}} = \frac{w_{ij}}{w_i}$ and $\sum_{j=1}^{n_i} w_{ij} = 1$. Similarly $\bar{x}_{iw} = \sum_{j=1}^{n_i} w_{ij} x_{ij}; \bar{e}_{iw} = \sum_{j=1}^{n_i} w_{ij} e_{ij}$ with $E(\bar{e}_{iw}) = 0$ and $\text{Var}(\bar{e}_{iw}) = \sigma_e^2 \sum_{j=1}^{n_i} w_{ij}^2 \equiv \varrho_i^2$

$$\sigma_e^2|y_{ij}, \beta, u_i, \sigma_u^2 \sim IG(\frac{1}{2}\sum_{i=1}^m n_i, \frac{1}{2}\sum_{i=1}^m \sum_{j=1}^{n_i} (y_{ij} - x_{ij}^T \beta - u_i)^2) \quad (2.0.7)$$

$$\sigma_u^2|y_{ij}, \beta, u_i, \sigma_e^2 \sim IG(\frac{m}{2} - 1, \frac{1}{2}\sum_{i=1}^m u_i^2) \quad (2.0.8)$$

However, we are interested in finding the expected county yield (θ_i) based on $\bar{y}_{iw}$. Following the same HB framework using the area level model in equation (2.0.3) gives a similar posterior distribution for $u_i|y_{ij}, \beta, \sigma_e^2, \sigma_u^2 \sim N(q_{iw}(\bar{y}_{iw} - \bar{x}_{iw}^T \beta), q_{iw}\varrho_i^2)$ where $q_{iw} = \frac{\sigma_u^2}{\sigma_u^2 + \varrho_i^2}$. The expected county yield (θ_i) based on $\bar{y}_{iw}$ is derived by substituting the mean and variance of the posterior distribution of u_i in equation (2.0.2) and simplifying. Similarly, the variance is derived as $q_{iw}\varrho_i^2$.

$$E(\theta_i|\bar{y}_{iw}, \beta, \sigma_e^2, \sigma_u^2) = q_{iw}\bar{y}_{iw} + (\bar{X}_i - q_{iw}\bar{x}_{iw})^T \beta \quad (2.0.9)$$

where β, σ_e^2 and σ_u^2 are drawn from the joint posterior distributions derived from the unit level model (equation (2.0.1)).

2.0.2 Estimation

In the first stage of our estimation, equation (2.0.5) to (2.0.8) is used in Gibbs sampling (Gelfand and Smith, 1990) to simulate the joint posterior density. We assume non-informative priors on $\beta, \sigma_e^2, \sigma_u^2$ given as $\beta_l \sim N(0, 10^4), l = 1, \dots, p = 13., \sigma_e^2 \sim IG(10^{-3}, 10^{-3}), i = 1, \dots, m., \sigma_u^2 \sim IG(10^{-3}, 10^{-3})$. With initial values of $\beta, \sigma_e^2, \sigma_u^2$, we draw v_i from 2.0.5. Using the drawn v_i and initial values for σ_e^2, σ_u^2 , we draw and update β with 2.0.6. Similarly, we draw and update σ_e^2 conditional on initial σ_u^2 and updated values of β, u_i . Finally, we also draw and update σ_u^2 given new values of β, u_i and σ_e^2 to complete single phase of simulation. The process is repeated 10000 times to produce 10000 draws for each conditional marginal posterior and the first 5000 draws were burnt. Three separate chains were simultaneously simulated each with 10000 draws and a burn-in of 5000. Diagnostic plots of the three chains are done to ensure convergence in the posterior distributions.

To estimate expected county yields we draw k samples of the parameters with replacement, $s=1, \dots, k$ ($\beta^{(s)}; \sigma_e^{2(s)}; \sigma_u^{2(s)}$) from the simulated joint posterior distribution and use them in equation 2.0.9. Expected county yield is then obtained by averaging over the θ'_i s:

$$\hat{\theta}_i^{HB} = \frac{1}{k} \sum_{s=1}^k [q_{iw}^{(s)} \bar{y}_{iw} + (\bar{X}_i - q_{iw}^{(s)} \bar{x}_{iw})^T \beta^{(s)}] \quad (2.0.10)$$

Likewise, posterior variance of the expected county yield is obtained by drawing k samples from the joint posterior distribution and using them in the variance formula ($q_{iw} \varrho_i^2$) and then taking the average. The same results can be obtained by simply finding the variance of the k simulated county mean draws for each county.

To derive expected indemnity (actuarially fair premium) in each county under the GRP plan, we proceed by simulating k future expected county yield ($\theta_i^{(s)}$) using equation (2.0.2) and k future observed county average yield ($\bar{y}_{iw}^{(s)} = \bar{x}_{iw})^T \beta^{(s)} + u_i \bar{e}_{iw}^{(s)}$, where $\bar{e}_{iw} \sim N(0, \sigma_e^2 \sum_{j=1}^{n_i} w_{ij}^2 \equiv \varrho_i^2)$. The expected indemnity (\$/acre) for a given coverage ($\bar{I}_{iz}^{GRP}$) is obtained by integrating equation 2.0.11 using the k simulations.

$$\begin{aligned} \bar{I}_{iz}^{GRP} &= \int \max\left(\left[\frac{(\hat{\theta}_i^{HB})C_z - \bar{y}_{iw}}{\hat{\theta}_i^{HB}C_z}\right] \hat{\theta}_i^{HB} S, 0\right) x \varphi f(\bar{y}_{iw}) d(\bar{y}_{iw}) \\ &= \frac{1}{k} \sum_{s=1}^k \left[\max\left(\left[\frac{(\theta_i^{(s)})C_z - \bar{y}_{iw}^{(s)}}{\hat{\theta}_i^{(s)}C_z}\right] \theta_i^{(s)} S, 0\right) \right] \varphi, i = 1, \dots, m \quad z = 1, \dots, 6 \end{aligned} \quad (2.0.11)$$

Where φ is the price of a bushel of corn which was taken to be \$7 implying 100% maximum liability. The coverage level, indexed by z (C_z) and scale (S) are chosen by the farmer. For purpose of comparison, we consider four coverage levels ($C_z = \{70\%, 75\%, 80\%, 85\%\}$) common to both GRP and APH plans and also set scale to 1⁴. A scale of 1 has no effect on the expected indemnity. We simulated expected indemnity payments under all four coverage

⁴Awondo et al. (2012) showed that the scale with range 0.9 to 1.5 considered in previous studies has insignificant effect on reducing basis risk

levels in each county.

Trigger probability for each GRP plan is derived as follows:

$$\begin{aligned}
P[\bar{y}_{iw} < \theta_i C_z | data] &= \int^{\theta_i C_z} f(\bar{y}_{iw} | data) d(\bar{y}_{iw}) \\
&= \frac{1}{k} \sum_{s=1}^k I(\bar{y}_{iw}^{(s)} < \theta_i^{(s)} C_z). \tag{2.0.12}
\end{aligned}$$

Similarly, the expected indemnity for each farm under APH is also simulated. In each case, future yields ($y_{ij}^{(s)}$) are simulated by drawing $\beta^{(s)}, u_i^{(s)}, e_{ij}^{(s)}$ samples from the joint posterior and combining with farm level climate covariates in the regression model $y_{ij}^{(s)} = x_{ij}^T \beta^{(s)} + u_i^{(s)} + e_{ij}^{(s)}$. Draws of expected corn yield on each farm is derived as:

$$\theta_{ij}^{(s)} = x_{ij}^T \beta^{(s)} + u_i^{(s)} \tag{2.0.13}$$

The expected indemnity (actuarially fair premium) on each farm for a given coverage level under APH is obtained by taking the average of the simulated indemnities.

$$\begin{aligned}
\bar{I}_{ijz}^{APH} &= \int \max([\theta_{ij} C_z - y_{ij}], 0) \varphi f(y_{ij}) d(y_{ij}) \\
&= \frac{1}{k} \sum_{s=1}^k [\max([\theta_{ij}^{(s)} C_z - y_{ij}^{(s)}], 0) \varphi], i = 1, \dots, m, j = 1, \dots, n_i, z = 1, \dots, 6 \tag{2.0.14}
\end{aligned}$$

Where $C_q = (70\%, 75\%, 80\%, 85\%)$.

Similarly, we estimate the trigger probability of each plan by farm as:

$$P[y_{ij} < \theta_{ij} C_z | data] = \int^{\theta_{ij} C_z} f(y_{ij}) d(y_{ij})$$

$$= \frac{1}{k} \sum_{s=1}^k I(y_{ij}^{(s)} < \theta_{ij}^{(s)} C_z). \quad (2.0.15)$$

The difference in trigger probability between APH and GRP ($P[y_{ij} < \theta_{ij} C_z | data] - P[\bar{y}_{iw} < \theta_i C_z | data]$) is a reliable measure of basis risk.

Considering that only the GRP and APH plans are provided, a farmer j in county i is faced with three alternatives (no insurance, APH or GRP) to choose from. If the farmer is risk neutral, he will be equally likely to choose either of the three options. If he is a risk lover, he is likely to choose the most risky option which may have the highest revenue. If he is risk averse, he will be willing to accept a lower but certain expected revenue (certainty equivalence) for a small fee (premium) in the place of higher but uncertain expected revenue. We assume risk aversion with a utility function given as:

$$U(R_{ijc}^z) = \frac{R_{ijc}^{z(1-\lambda)}}{(1-\lambda)} \quad (2.0.16)$$

Where R_{ijc}^z is the revenue of farm j in county i conditional on his choice of insurance plan $c = \{o = noinsurance, a = APH, g = GRP\}$, λ is a measure of risk aversion or concavity of the utility function. The more concave the function the more risk averse the individual. If the choice is no insurance, APH or GRP the revenue/acre is estimated as $R_{ijo} = \phi y_{ij}$, $R_{ija}^z = \phi y_{ij} - \phi \bar{I}_{ijz}^{APH} + I_{ijz}^{APH}$, $R_{ijg}^z = \phi y_{ij} - \phi \bar{I}_{iz}^{GRP} + I_{iz}^{GRP}$ respectively. The certainty equivalence (CE_{ijc}^z) for each policy scenario is derived as:

$$\begin{aligned} CE_{ijc}^z &= [(1-\lambda) \int U(R_{ijc}^z) f(y_{ij}) d(y_{ij})]^{\frac{1}{(1-\lambda)}} \\ &= [(1-\lambda) (\frac{1}{k} \sum_{s=1}^k U(R_{ijc}^{z(s)}))]^{\frac{1}{(1-\lambda)}} \end{aligned} \quad (2.0.17)$$

Where y_{ij} is the realized farm yield, ϕ is the level of subsidies and $R_{ijo}^{(s)} = \phi y_{ij}^{(s)}$, $R_{ija}^{z(s)} = \phi y_{ij}^{(s)} - \phi \bar{I}_{ijz}^{APH} + I_{ijz}^{APH(s)}$, $R_{ijg}^{z(s)} = \phi y_{ij}^{(s)} - \phi \bar{I}_{iz}^{GRP} + I_{iz}^{GRP(s)}$ are the simulated net revenue/acre

sample ($k=5000$) under no insurance, APH and GRP choice scenarios. The standard error of each sample is taken as the sample standard deviation.

For each farm we separately evaluated the performance of all APH-GRP coverage combinations (16) alongside the opt out option. In each case we simultaneously simulated the performances based on (1) actuarially fair premiums without subsidies, and (2) actuarially fair premiums with actual levels of subsidies. The subsidies levels for 70%, 75%, 80% and 85% coverage are 59%, 55%, 48% and 38% for APH and 59%, 59%, 55% and 55% for GRP.

To determine the best insurance scenario given the three choice options, we first conducted a two sample t-test amongst all alternative pair using individual samples of certainty equivalent revenue/net revenue. If two samples are statistically different at $\alpha=0.05$, the alternative with a higher expected certainty equivalent revenue is considered the best policy option. This strategy allows us to determine policy scenarios that perform best as well as those with equal level of performance while accounting for uncertainty in the expected certainty equivalent estimates. A farmer will therefore be indifferent in choosing between two crop insurance plans or between no insurance and an insurance plan that yields the same expected certainty equivalent revenue.

Chapter 3

Data

Farm level data that allows for estimation of unit level models and conduct indepth analysis of this nature are rare to find. We circumvent this limitation by using quasi-simulated farm level yield data from eleven counties in Illinois which make up Agricultural District 40. This data has the advantage that it is generated from true geospatial covariates attributed to specific corn farm plots from a known population. Moreover, the data generation and thus analysis accounts for sampling design which is important to obtain design consistent yield and premium estimates (Rao and You, 1999).

First, we use 2011 cropland data maps from NASS-USDA obtained from NASA LANDSAT to extract corn farm polygons within the counties. Note that the satellite uses a 250 meter resolution 16-day composite Normalized Difference Vegetation Index (NDVI) to classify crops with a statistical classification accuracy of up to 97% for heavily monocultivated areas like Illinois (NASS-USDA,2010). Figure 1 illustrates classified corn farm polygons in a few neighboring counties within the District. Using the coordinates of each plot, we obtained plot specific climate data from the PRISM website.

Data on each corn farm polygon include elevation, area of polygon (farm), minimum and maximum monthly temperature and cumulative monthly precipitation from 1950 to 2011. To proceed we dropped all plots less than 40470 m^2 (10 acres). After creating weights for

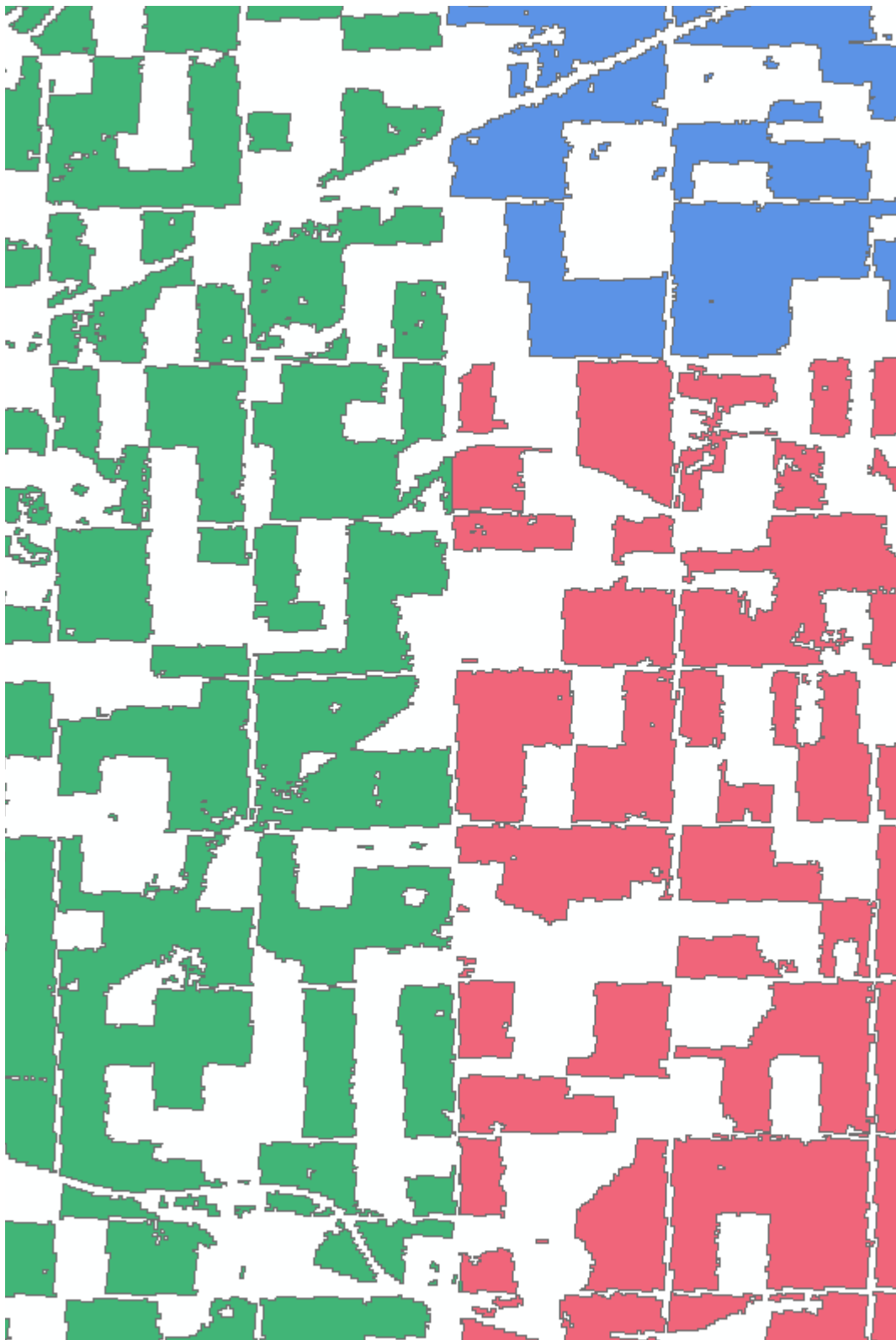


Figure 3.1: Corn plot polygons

each plot by dividing each plot's area by the total area within the county it is located, we then carried out a weighted random sample of n_i corn farm plots by county. Where n_i was drawn from a uniform distribution with range 1 to 5. We simulated yields for corn plots using the regression model below.

$$y_{ij} = 320 - .346P_{ij5} + 10.463P_{ij6} + 6.849P_{ij7} - 0.523P_{ij8} - 0.087P_{ij5}^2 - 0.903P_{ij6}^2 - 0.304P_{ij7}^2 + 0.035P_{ij8}^2 + 1.232T_{ij5} + 1.854T_{ij6} - 2.013T_{ij7} - 3.036T_{ij8} + u_i + e_{ij} \quad (3.0.1)$$

Where y_{ij} is in bu/acre, P_{ij5} to P_{ij8} are cumulative monthly precipitation (inches) for farm j in county i from May to August and P_{ij5}^2 to P_{ij8}^2 are their corresponding squares, T_{ij5} to T_{ij8} are average monthly temperatures (F) from May to August; u_i is county random effect assumed to be normally distributed with mean 0 and variance 15 while e_{ij} is the error assumed to be normally distributed with mean 0 and variance 25. Our range of variance components is consistent with the range estimated by Ramirez et al. (2010) using farm level yields from endowment farms of the University of Illinois Urbana-Champaign. Also, our coefficient estimates are based on estimating the same model using detrended county level data. County level yields were obtained from NASS ⁴. A similar regression model was used by Thompson (1988), Schlenker and Roberts (2006) and Tannura et al. (2008) and has been found to explain over 75% of the variability in corn yield.

3.1 Data summary

Table 3.1 shows summary of the sample used for our analysis. Columns 2 and 3 represent the total number of farms per county (N_i) and the number of individual corn farms sampled in each county (n_i). Stark has the least farm population while Tazewell has the most. The

⁴We thank Dr. Schlenker Wolfram for providing us with county level climate data

Table 3.1: Sample summary

County	N_i	n_i	mean(Y)	min(Y)	max(Y)	mean(A)	min(A)	max(A)
De witt	706	5	188.13	146.42	229.72	506700	107100	1785600
Logan	1023	4	200.39	166.08	216.05	483075	122400	705600
Macon	917	5	177.51	157.42	202.74	877500	76500	3249900
Marshall	708	4	173.89	164.65	192.02	769275	179100	2257200
Mason	871	4	178.30	155.82	198.21	202500	46800	332100
Mclean	1937	4	182.11	134.43	226.01	305775	97200	774900
Menard	581	4	190.25	154.03	232.60	355725	63900	1036800
Peoria	1098	3	164.87	130.41	202.55	474300	284400	689400
Stark	507	4	169.02	133.62	230.23	937800	197100	2403000
Tazewell	1245	1	162.12	162.12	162.12	121500	121500	121500
Woodford	999	4	175.47	143.93	220.81	323775	49500	962100

sample size per county ranges from 1 to 5. Columns 3 through 8 present county average yield (Y) in bu/acre and county average farm size(A) in acres. Sample farm level yields range from a minimum of 130 bu/ha in Peoria to a maximum of 232 bu/ha in Menard. Logan county has the highest county average yield while Tazewell has the lowest. Direct county averages from this sample are likely to be unreliable given that very few farms are sampled in each county relative to the total population, thus justifying the use of small area estimation to provide more reliable county estimates. Individual farm sizes in the sample are as low as 46800 acres in Mason and as high as 284400 acres in Peoria. Average farm size is highest in Stark while Tazewell has the smallest farm size on average ⁴. The range of the simulated yields and the differences in average yield across counties are comparable to the observed average yields published by NASS in the respective Illinois counties.

⁴The total number of corn plots within counties is different from the total number of corn farms from the same counties as given by 2007/2002 agricultural census. This is partly due to that a farm could be made up of 2 or more corn plots

Chapter 4

Results and discussion

Table 4.1 presents summary of hierarchical Bayes estimates of expected county yield from the model. The 95% confidence interval shows that expected county yield are efficiently estimated with Mclean having the highest (188) expected yield while Macon has the least (179).

Table 4.2 presents GRP small area estimates (by county) of actuarially fair premiums for each coverage level without considering subsidies. Their corresponding trigger probabilities are shown in table 4.3. Tables 4.4 and 4.5 present similar results for APH for each farm in the sample.

Results show high variation in premium estimates at county level (GRP) as well as farm level (APH). The variation is higher for GRP plans compared to APH plans for similar coverage levels and tends to decrease with increase in coverage. For example, on average a GRP plan with 75% coverage commands a 0.60\$/acre in Marshall while the same plan costs 3930% more (24.18\$/acre) in Menard. However, a GRP plan with 85% coverage level costs 930% more in Menard compared to Marshall. Similarly, in Mason it costs farm two 3.24\$/acre for an APH plan with 75% coverage while farm four in the same county pays over 76.8% more (5.73\$/acre). On the other hand, farm four pays 28.3% more than farm two under an APH plan with 85% coverage.

Table 4.1: County expected yield (bu/acre)

County	$\theta^{HB}(s.e)$	2.5%	50%	97.5%
DeWitt	183.33 (7.49)	168.34	183.43	183.38
Logan	183.16 (7.31)	168.73	183.06	203.55
Macon	178.89 (10.08)	158.33	178.99	169.07
Marshall	186.21 (11.68)	163.60	186.22	193.04
Mason	184.32 (7.89)	168.16	184.57	187.96
Mclean	188.01 (8.89)	170.62	188.10	194.06
Menard	181.26 (8.33)	164.74	181.37	193.60
Peoria	185.24 (11.10)	163.44	185.30	201.56
Stark	180.26 (14.65)	151.11	180.32	163.73
Tazewell	188.54 (9.00)	170.91	188.53	196.06
Woodford	187.69 (13.78)	160.29	187.61	216.27

Table 4.2: GRP actuarially fair premium-unsubsidized

County	70%	75%	80%	85%
DeWitt	2.68 (19.81)	5.64(29.67)	10.89 (42.73)	19.45(58.90)
Logan	1.75 (16.12)	3.85(24.37)	7.56 (35.55)	13.76(49.63)
Macon	3.37 (21.30)	7.03(32.31)	13.25 (46.43)	23.41(63.50)
Marshall	0.13 (2.74)	0.60(7.06)	1.90 (13.89)	5.59(24.88)
Mason	3.82 (25.30)	7.38(36.02)	13.82 (49.91)	24.94(67.14)
Mclean	6.36 (29.63)	13.23(44.59)	24.90 (63.20)	43.40(84.52)
Menard	14.59 (54.01)	24.18(70.44)	38.22 (89.40)	57.59(110.26)
Peoria	1.52 (13.54)	3.71(22.18)	8.16 (34.27)	16.29(50.13)
Stark	4.84 (28.10)	8.91(39.76)	15.41 (54.11)	25.64(71.09)
Tazewell	3.49 (23.97)	6.92(34.70)	12.92 (48.54)	23.08(65.68)
Woodford	0.08 (2.25)	0.34(5.25)	1.30 (11.07)	3.59(20.31)

Results also show that actuarially fair premiums under APH can be higher or lower than the premiums under GRP for similar plans. For example, GRP premiums in Dewitt are lower than APH premiums for farm one and three, but higher than APH premiums for farm four and five in the same county for similar coverage levels. On average the GRP premiums in Mclean, Menard and Stark are substantially higher than the APH premiums for each farm in the county. Similarly, the GRP premiums for Logan, Marshall, Peoria and Woodford are all lower than the corresponding APH premiums for the individual farms in the county. However, the difference in premium between GRP and APH tend to decrease with increase

Table 4.3: Trigger probability for GRP indemnity-unsubsidized

County	70%	75%	80%	85%
DeWitt	0.0326	0.0630	0.1044	0.1676
Logan	0.0226	0.0436	0.0726	0.1230
Macon	0.0418	0.0770	0.1266	0.1972
Marshall	0.0040	0.0112	0.0344	0.0848
Mason	0.0402	0.0758	0.1330	0.2134
McLean	0.0766	0.1380	0.2232	0.3404
Menard	0.1214	0.1848	0.2630	0.3516
Peoria	0.0216	0.0484	0.0952	0.1638
Stark	0.0490	0.0824	0.1278	0.1982
Tazewell	0.0366	0.0674	0.1188	0.1922
Woodford	0.0018	0.0078	0.0222	0.0508

in coverage for similar level of premium. These results indicate that individual farms can either be over charged or under charged when the purchase the group plan, thus supporting the evidence of basis risk in area level plans.

Results in tableS 4.3 and 4.5 show variation in trigger probabilities across and within counties under both plans, which also tend to decrease with increase in coverage. However, it appear there is no one-to-one relationship between differences in trigger probabilities and differences in premiums estimates. For example, the trigger probability of a GRP with 75% coverage in Marshall is 0.0112 while in Menard the probability is 1550% more (0.1848). However, the GRP premium estimate in Menard is 3930% more than that in Marshall under the same coverage. At an 85% coverage, the trigger probability in Menard is 314.6% more than that in Marshall whereas the premium estimate is 930% more in Menard for the same coverage. Similarly, under an APH with 75% (85%) coverage in Mason, farm four is 65% (23%) more likely to trigger an indemnity than farm two. However, the premium estimates for farm four is 76.8% (28.3%) more than that in farm two. The lack of direct correspondence in differences in trigger probabilities and differences in premium estimates is less obvious with APH plans compared to GRP plans.

Overall, APH indemnities are more likely to be triggered than GRP indemnities for

similar coverage levels, and partly explains why APH premiums are generally higher than corresponding GRP premiums. The likelihood of indemnities to be triggered increases at a decreasing rate with increase in coverage level under both APH and GRP. In Macon, increasing the GRP coverage level from 70% to 75% increases the probability of trigger (premium) by 84% (108%) from 0.0418 (3.37\$/acre) to 0.0770 (7.03\$/acre). Whereas a similar increase in coverage from 80% to 85% increases the probability of trigger (premium) by 56% (77%). Under farm five's APH plan in Macon, increasing the coverage level from 70% to 75% increases the probability of trigger (premium) by 71% (79%) from 0.0352 (3.42\$/acre) to 0.0604 (6.13\$/acre). And increasing coverage from 80% to 85% increases the probability of trigger (premium) by 63% (71%).

For a given coverage, the difference in probability of trigger between APH plan for farms within a given county and GRP plans for the same county is a measure of lack of correlation between farm yields and county averages (basis risk).

Tables 4.6 and 4.7 present certainty equivalent revenues for GRP and APH plans with unsubsidized actuarially fair premiums. Tables 4.8 and 4.9 present similar results under GRP and APH plans after subsidizing actuarially fair premiums with actual levels of subsidies.

Under no subsidies, the expected certainty equivalent estimates are equal under APH and GRP plans for a given level of coverage, implying APH and GRP have equal performance for managing farm risk. All else equal, we should therefore expect about equal proportion of farmers choosing APH and GRP. However, certainty equivalent revenue under APH are more efficient (smaller standard errors). If we account for the uncertainty around the estimates in farmers' decision making process, certainty equivalent revenue estimates with larger standard errors will be perceived as more risky even though they are all centered on the same mean. Two sample t-test for all pair-wise APH and GRP plans with similar coverage shows that estimates from both sample are statistically different at $\alpha = 0.05$, indicating that all APH plans perform better than their GRP counterparts, and will be preferred 100% of the time.

Results from tables 4.8, 4.9 and 4.10 show that introducing subsidies substantially improves the performance of GRP with regards to APH and completely renders a no insurance choice the worst option. As expected, due to higher subsidies level for GRP than APH at higher coverage levels, the performance of GRP increases with coverage vis-à-vis APH plans. For example, comparing the performance of a GRP-APH plan combination of (70%,75%), (75%,75%), (80%,75%) and (85%,75%) showed that under no subsidies, on average 100% of APH plans will perform best compared to GRP and no insurance. However after introducing subsidies levels of (59%,55%), (59%,55%), (55%,55%) and (55%,55%) for the corresponding GRP-APH plans, the average percentage of time GRP (APH) performs best increases (decreases) correspondingly as 12% (55%), 40% (29%), 69% (19%) and 83% (9%). Overall, the percentage of times both APH and GRP perform equally decreases with increase in GRP coverage in the GRP-APH combination (33%, 31%, 12% and 7%).

Averaging over all 16 GRP-APH plan combinations presented in table 4.10 reveals that, overall, 34% of APH and 47% of GRP plans performed best while 20% of both plans are indifferent. These imply under actual current level of Federal subsidies, at least 34% and at most 54% of participating farmers should purchase APH plans over GRP. On the other hand, at least 47% and at most 67% of the farmers should choose GRP plans over APH. Assuming a positive linear relationship between proportion of plan choice and their contributions to the FCIC total liability, we therefore expect similar percentage participation of farm level (e.g APH) and area level (e.g. GRP) policies to the FCIC total liability. The results revealed area level crop insurance is a reliable alternative to farm level, and envisaged participation rate in area level plans at least 683% higher than the actual rate (6%). Thus supporting previous findings that farmers' preferences for area or farm level crop insurance is also based on asymmetrical information.

Table 4.4: APH actuarially fair premium-unsubsidized

County	Farm	70%	75%	80%	85%
DeWitt	1	3.88 (24.33)	7.19(34.31)	12.59 (46.92)	21.34(62.17)
DeWitt	2	2.93 (23.18)	5.70(32.25)	10.64 (44.40)	19.09(59.75)
DeWitt	3	4.17 (25.53)	7.50(34.94)	13.09 (46.90)	21.83(61.44)
DeWitt	4	2.11 (17.85)	4.39(27.01)	8.63 (39.19)	16.35(54.89)
DeWitt	5	1.19 (11.93)	3.23(20.48)	7.58 (33.15)	15.05(49.72)
Logan	1	2.33 (19.13)	4.87(28.33)	9.57 (40.76)	17.79(56.62)
Logan	2	4.51 (26.28)	8.13(36.15)	13.92 (48.59)	22.81(63.42)
Logan	3	2.76 (20.57)	5.72(29.91)	10.79 (42.52)	19.11(58.18)
Logan	4	4.70 (27.38)	8.26(36.81)	14.29 (48.86)	23.67(63.60)
Macon	1	2.91 (21.09)	5.83(30.52)	10.75 (42.77)	18.99(57.91)
Macon	2	3.35 (23.11)	6.39(32.36)	11.63 (44.39)	20.26(59.41)
Macon	3	3.16 (22.37)	5.97(31.55)	10.93 (43.42)	19.24(58.31)
Macon	4	2.92 (21.79)	5.61(30.92)	10.38 (42.91)	18.49(58.06)
Macon	5	3.42 (22.80)	6.13(31.98)	10.75 (43.56)	18.42(57.85)
Marshall	1	1.51 (14.25)	3.60(22.89)	7.81 (34.98)	15.68(51.03)
Marshall	2	2.37 (19.18)	5.04(28.41)	9.94 (40.86)	18.23(56.70)
Marshall	3	2.45 (19.21)	4.77(28.07)	9.08 (39.64)	16.61(54.45)
Marshall	4	2.36 (19.77)	4.76(28.50)	9.38 (40.35)	17.77(55.87)
Mason	1	2.17 (17.28)	4.83(26.55)	9.68 (39.18)	17.76(55.09)
Mason	2	1.33 (12.49)	3.24(21.09)	7.36 (33.22)	15.23(49.50)
Mason	3	1.85 (16.72)	3.92(25.09)	7.87 (36.55)	15.19(51.42)
Mason	4	2.85 (20.57)	5.73(29.57)	10.98 (41.62)	19.54(56.79)
McLean	1	2.64 (22.28)	5.22(30.67)	10.08 (42.26)	18.32(57.25)
McLean	2	2.25 (19.30)	4.52(28.05)	8.70 (39.68)	16.37(54.71)
McLean	3	2.35 (18.64)	4.97(27.57)	9.72 (39.69)	18.00(55.19)
McLean	4	2.43 (20.67)	4.81(29.14)	9.23 (40.61)	17.08(55.43)
Menard	1	1.37 (15.13)	3.22(22.76)	6.98 (34.20)	14.11(49.62)
Menard	2	2.57 (19.58)	5.07(28.82)	9.47 (40.87)	17.09(55.92)
Menard	3	3.13 (21.86)	6.00(31.19)	11.00 (43.31)	19.48(58.36)
Menard	4	3.02 (22.31)	5.87(31.27)	11.06 (43.28)	19.50(58.40)
Peoria	1	2.33 (20.06)	4.59(28.38)	9.03 (39.97)	16.88(55.17)
Peoria	2	3.82 (23.45)	7.21(32.83)	12.84 (44.93)	21.58(59.64)
Peoria	3	3.72 (25.27)	6.82(34.43)	12.19 (46.27)	21.03(61.04)
Stark	1	3.30 (23.95)	6.14(33.14)	11.30 (45.09)	19.76(60.11)
Stark	2	1.95 (16.67)	4.14(25.43)	8.39 (37.24)	16.38(52.64)
Stark	3	1.61 (14.98)	3.63(23.40)	7.67 (34.98)	15.54(50.56)
Stark	4	1.81 (18.56)	3.75(26.50)	7.67 (37.62)	14.83(52.63)
Tazewell	1	1.68 (16.72)	3.62(24.94)	7.49 (36.43)	14.62(51.74)
Woodford	1	3.02 (21.80)	5.82(30.67)	10.86 (42.47)	19.18(57.45)
Woodford	2	3.21 (22.31)	5.95(31.46)	10.83 (43.35)	19.29(58.35)
Woodford	3	5.37 (28.94)	9.22(38.61)	15.05 (50.49)	23.83(64.43)
Woodford	4	3.64 (24.50)	6.86(34.33)	12.19 (46.90)	20.99(62.25)

Table 4.5: Trigger probability for APH indemnity-unsubsidized

County	Farm	70%	75%	80%	85%
DeWitt	1	0.0442	0.0736	0.1168	0.1820
DeWitt	2	0.0310	0.0592	0.0988	0.1714
DeWitt	3	0.0466	0.0798	0.1270	0.1956
DeWitt	4	0.0236	0.0446	0.0820	0.1474
DeWitt	5	0.0178	0.0446	0.0818	0.1378
Logan	1	0.0268	0.0518	0.0910	0.1608
Logan	2	0.0514	0.0862	0.1278	0.1978
Logan	3	0.0326	0.0628	0.1014	0.1652
Logan	4	0.0528	0.0874	0.1414	0.2048
Macon	1	0.0366	0.0608	0.1028	0.1706
Macon	2	0.0382	0.0676	0.1152	0.1788
Macon	3	0.0362	0.0618	0.1090	0.1734
Macon	4	0.0312	0.0574	0.0992	0.1652
Macon	5	0.0352	0.0604	0.0988	0.1608
Marshall	1	0.0206	0.0412	0.0830	0.1522
Marshall	2	0.0300	0.0544	0.0990	0.1626
Marshall	3	0.0274	0.0494	0.0908	0.1534
Marshall	4	0.0258	0.0514	0.0948	0.1652
Mason	1	0.0286	0.0554	0.0962	0.1600
Mason	2	0.0190	0.0402	0.0830	0.1480
Mason	3	0.0216	0.0436	0.0776	0.1478
Mason	4	0.0360	0.0666	0.1132	0.1826
McLean	1	0.0292	0.0586	0.1020	0.1682
McLean	2	0.0254	0.0460	0.0844	0.1490
McLean	3	0.0302	0.0572	0.1004	0.1630
McLean	4	0.0270	0.0510	0.0918	0.1576
Menard	1	0.0160	0.0380	0.0716	0.1364
Menard	2	0.0284	0.0528	0.0876	0.1544
Menard	3	0.0338	0.0654	0.1082	0.1762
Menard	4	0.0340	0.0660	0.1094	0.1740
Peoria	1	0.0246	0.0510	0.0870	0.1522
Peoria	2	0.0476	0.0814	0.1272	0.1944
Peoria	3	0.0398	0.0700	0.1208	0.1888
Stark	1	0.0352	0.0640	0.1084	0.1746
Stark	2	0.0238	0.0462	0.0894	0.1558
Stark	3	0.0228	0.0402	0.0846	0.1512
Stark	4	0.0196	0.0396	0.0762	0.1374
Tazewell	1	0.0180	0.0382	0.0740	0.1346
Woodford	1	0.0370	0.0638	0.1098	0.1750
Woodford	2	0.0342	0.0600	0.1032	0.1750
Woodford	3	0.0618	0.0966	0.1396	0.2064
Woodford	4	0.0402	0.0678	0.1130	0.1832

Table 4.6: Certainty equivalent revenue (\$/acre) for unsubsidized GRP

County	Farm	70%		75%		80%		85%		<i>NOIN</i>
DeWitt	1	1204.6	(234.9)	1204.6	(236.0)	1204.6	(238.2)	1204.6	(241.9)	1204.6 (234.0)
DeWitt	2	1293.8	(233.4)	1293.8	(234.5)	1293.8	(236.5)	1293.8	(240.2)	1293.8 (232.2)
DeWitt	3	1124.1	(236.7)	1124.1	(237.8)	1124.1	(240.1)	1124.1	(244.0)	1124.1 (235.2)
DeWitt	4	1396.2	(230.6)	1396.2	(231.8)	1396.2	(233.8)	1396.2	(237.1)	1396.2 (229.5)
DeWitt	5	1412.3	(225.5)	1412.3	(226.5)	1412.3	(228.3)	1412.3	(231.3)	1412.3 (224.9)
Logan	1	1334.2	(224.8)	1334.2	(225.3)	1334.2	(226.7)	1334.2	(229.1)	1334.2 (224.3)
Logan	2	1133.0	(247.1)	1133.0	(247.7)	1133.0	(248.8)	1133.0	(251.1)	1133.0 (246.5)
Logan	3	1274.2	(239.6)	1274.2	(240.3)	1274.2	(242.0)	1274.2	(244.6)	1274.2 (239.2)
Logan	4	1114.7	(256.9)	1114.7	(257.4)	1114.7	(258.8)	1114.7	(261.1)	1114.7 (256.4)
Macon	1	1236.7	(233.6)	1236.7	(234.9)	1236.7	(237.5)	1236.7	(241.4)	1236.7 (232.0)
Macon	2	1211.2	(243.7)	1211.2	(244.9)	1211.2	(246.9)	1211.2	(250.3)	1211.2 (242.7)
Macon	3	1231.5	(238.7)	1231.5	(240.1)	1231.5	(242.9)	1231.5	(247.0)	1231.5 (237.8)
Macon	4	1278.9	(244.4)	1278.9	(245.6)	1278.9	(247.8)	1278.9	(251.5)	1278.9 (243.5)
Macon	5	1217.6	(250.7)	1217.6	(251.8)	1217.6	(253.8)	1217.6	(257.7)	1217.6 (249.9)
Marshall	1	1395.4	(226.9)	1395.4	(227.1)	1395.4	(227.5)	1395.4	(228.6)	1395.4 (226.8)
Marshall	2	1302.4	(228.2)	1302.4	(228.2)	1302.4	(228.4)	1302.4	(229.2)	1302.4 (228.2)
Marshall	3	1302.3	(241.9)	1302.3	(242.1)	1302.3	(242.5)	1302.3	(243.3)	1302.3 (241.9)
Marshall	4	1323.3	(232.0)	1323.3	(232.0)	1323.3	(232.2)	1323.3	(232.9)	1323.3 (232.0)
Mason	1	1306.7	(221.4)	1306.7	(222.6)	1306.7	(224.8)	1306.7	(228.5)	1306.7 (220.7)
Mason	2	1418.4	(234.3)	1418.4	(235.8)	1418.4	(238.5)	1418.4	(243.1)	1418.4 (232.8)
Mason	3	1350.0	(225.4)	1350.0	(226.8)	1350.0	(229.4)	1350.0	(233.9)	1350.0 (223.5)
Mason	4	1212.7	(244.2)	1212.7	(245.5)	1212.7	(248.0)	1212.7	(251.6)	1212.7 (243.4)
Mclean	1	1263.6	(229.2)	1263.6	(231.6)	1263.6	(235.8)	1263.6	(242.1)	1263.6 (227.2)
Mclean	2	1331.7	(220.9)	1331.7	(223.8)	1331.7	(228.7)	1331.7	(235.9)	1331.7 (218.8)
Mclean	3	1279.2	(235.5)	1279.2	(237.6)	1279.2	(241.6)	1279.2	(248.0)	1279.2 (234.0)
Mclean	4	1297.5	(229.4)	1297.5	(231.8)	1297.5	(236.3)	1297.5	(242.7)	1297.5 (227.6)
Menard	1	1458.8	(251.6)	1458.8	(255.3)	1458.8	(260.6)	1458.8	(268.0)	1458.8 (246.5)
Menard	2	1304.1	(240.6)	1304.1	(244.8)	1304.1	(250.7)	1304.1	(259.1)	1304.1 (233.9)
Menard	3	1214.0	(230.2)	1214.0	(234.9)	1214.0	(241.8)	1214.0	(250.8)	1214.0 (223.0)
Menard	4	1227.4	(239.8)	1227.4	(243.9)	1227.4	(250.0)	1227.4	(258.0)	1227.4 (232.9)
Peoria	1	1359.4	(254.9)	1359.4	(255.2)	1359.4	(256.2)	1359.4	(258.3)	1359.4 (254.8)
Peoria	2	1114.6	(237.7)	1114.6	(238.4)	1114.6	(239.8)	1114.6	(242.5)	1114.6 (237.5)
Peoria	3	1188.4	(240.0)	1188.4	(240.6)	1188.4	(241.8)	1188.4	(244.5)	1188.4 (239.9)
Stark	1	1226.5	(229.7)	1226.5	(231.2)	1226.5	(233.8)	1226.5	(238.1)	1226.5 (228.5)
Stark	2	1342.0	(234.6)	1342.0	(236.2)	1342.0	(239.1)	1342.0	(243.5)	1342.0 (232.9)
Stark	3	1369.7	(238.1)	1369.7	(239.9)	1369.7	(242.9)	1369.7	(247.6)	1369.7 (236.7)
Stark	4	1415.0	(235.5)	1415.0	(236.9)	1415.0	(239.5)	1415.0	(244.0)	1415.0 (234.2)
Tazewell	1	1427.9	(231.6)	1427.9	(233.1)	1427.9	(235.7)	1427.9	(239.9)	1427.9 (230.5)
Woodford	1	1234.8	(263.6)	1234.8	(263.7)	1234.8	(264.0)	1234.8	(264.6)	1234.8 (263.6)
Woodford	2	1254.7	(245.8)	1254.7	(245.9)	1254.7	(246.1)	1254.7	(246.9)	1254.7 (245.8)
Woodford	3	1054.2	(247.9)	1054.2	(247.9)	1054.2	(248.0)	1054.2	(248.6)	1054.2 (247.8)
Woodford	4	1224.0	(228.1)	1224.0	(228.2)	1224.0	(228.5)	1224.0	(229.2)	1224.0 (228.1)

Table 4.7: Certainty equivalent revenue (\$/acre) for unsubsidized APH

County	Farm	70%		75%		80%		85%		NOIN
DeWitt	1	1204.6	(225.9)	1204.6	(220.7)	1204.6	(213.4)	1204.6	(203.6)	1204.6 (234.0)
DeWitt	2	1293.8	(225.7)	1293.8	(221.1)	1293.8	(214.1)	1293.8	(204.4)	1293.8 (232.2)
DeWitt	3	1124.1	(226.8)	1124.1	(221.9)	1124.1	(215.0)	1124.1	(205.9)	1124.1 (235.2)
DeWitt	4	1396.2	(224.6)	1396.2	(220.5)	1396.2	(214.2)	1396.2	(204.7)	1396.2 (229.5)
DeWitt	5	1412.3	(222.3)	1412.3	(218.7)	1412.3	(212.1)	1412.3	(202.7)	1412.3 (224.9)
Logan	1	1334.2	(219.1)	1334.2	(214.7)	1334.2	(208.0)	1334.2	(198.1)	1334.2 (224.3)
Logan	2	1133.0	(237.8)	1133.0	(232.6)	1133.0	(225.6)	1133.0	(216.6)	1133.0 (246.5)
Logan	3	1274.2	(233.2)	1274.2	(228.5)	1274.2	(221.7)	1274.2	(212.6)	1274.2 (239.2)
Logan	4	1114.7	(247.4)	1114.7	(242.5)	1114.7	(235.7)	1114.7	(226.9)	1114.7 (256.4)
Macon	1	1236.7	(226.0)	1236.7	(221.3)	1236.7	(214.6)	1236.7	(205.4)	1236.7 (232.0)
Macon	2	1211.2	(235.8)	1211.2	(231.0)	1211.2	(224.1)	1211.2	(214.7)	1211.2 (242.7)
Macon	3	1231.5	(231.1)	1231.5	(226.6)	1231.5	(219.8)	1231.5	(210.6)	1231.5 (237.8)
Macon	4	1278.9	(237.3)	1278.9	(233.0)	1278.9	(226.6)	1278.9	(217.8)	1278.9 (243.5)
Macon	5	1217.6	(242.8)	1217.6	(238.6)	1217.6	(232.7)	1217.6	(224.8)	1217.6 (249.9)
Marshall	1	1395.4	(223.4)	1395.4	(219.6)	1395.4	(213.2)	1395.4	(203.6)	1395.4 (226.8)
Marshall	2	1302.4	(223.1)	1302.4	(218.7)	1302.4	(211.8)	1302.4	(202.2)	1302.4 (228.2)
Marshall	3	1302.3	(236.7)	1302.3	(232.8)	1302.3	(226.8)	1302.3	(218.3)	1302.3 (241.9)
Marshall	4	1323.3	(226.7)	1323.3	(222.6)	1323.3	(216.0)	1323.3	(206.4)	1323.3 (232.0)
Mason	1	1306.7	(215.8)	1306.7	(211.1)	1306.7	(203.9)	1306.7	(193.8)	1306.7 (220.7)
Mason	2	1418.4	(229.7)	1418.4	(226.3)	1418.4	(220.2)	1418.4	(210.5)	1418.4 (232.8)
Mason	3	1350.0	(219.2)	1350.0	(215.5)	1350.0	(209.5)	1350.0	(200.5)	1350.0 (223.5)
Mason	4	1212.7	(237.6)	1212.7	(233.1)	1212.7	(226.2)	1212.7	(217.0)	1212.7 (243.4)
McLean	1	1263.6	(221.3)	1263.6	(217.0)	1263.6	(210.2)	1263.6	(200.6)	1263.6 (227.2)
McLean	2	1331.7	(213.6)	1331.7	(209.6)	1331.7	(203.3)	1331.7	(194.1)	1331.7 (218.8)
McLean	3	1279.2	(228.9)	1279.2	(224.6)	1279.2	(218.1)	1279.2	(208.9)	1279.2 (234.0)
McLean	4	1297.5	(222.1)	1297.5	(218.0)	1297.5	(211.6)	1297.5	(202.2)	1297.5 (227.6)
Menard	1	1458.8	(243.1)	1458.8	(239.9)	1458.8	(234.3)	1458.8	(225.6)	1458.8 (246.5)
Menard	2	1304.1	(228.3)	1304.1	(224.2)	1304.1	(218.0)	1304.1	(209.3)	1304.1 (233.9)
Menard	3	1214.0	(216.3)	1214.0	(211.7)	1214.0	(204.8)	1214.0	(195.1)	1214.0 (223.0)
Menard	4	1227.4	(226.5)	1227.4	(221.9)	1227.4	(214.8)	1227.4	(205.5)	1227.4 (232.9)
Peoria	1	1359.4	(249.4)	1359.4	(245.7)	1359.4	(239.5)	1359.4	(230.8)	1359.4 (254.8)
Peoria	2	1114.6	(230.0)	1114.6	(225.1)	1114.6	(218.3)	1114.6	(209.7)	1114.6 (237.5)
Peoria	3	1188.4	(232.2)	1188.4	(227.3)	1188.4	(220.3)	1188.4	(210.8)	1188.4 (239.9)
Stark	1	1226.5	(221.5)	1226.5	(216.9)	1226.5	(209.9)	1226.5	(200.4)	1226.5 (228.5)
Stark	2	1342.0	(228.6)	1342.0	(224.9)	1342.0	(218.7)	1342.0	(209.2)	1342.0 (232.9)
Stark	3	1369.7	(233.2)	1369.7	(229.7)	1369.7	(224.0)	1369.7	(215.0)	1369.7 (236.7)
Stark	4	1415.0	(230.0)	1415.0	(226.5)	1415.0	(220.5)	1415.0	(211.8)	1415.0 (234.2)
Tazewell	1	1427.9	(226.5)	1427.9	(223.0)	1427.9	(217.1)	1427.9	(208.2)	1427.9 (230.5)
Woodford	1	1234.8	(257.6)	1234.8	(253.3)	1234.8	(247.2)	1234.8	(239.1)	1234.8 (263.6)
Woodford	2	1254.7	(238.8)	1254.7	(234.4)	1254.7	(227.8)	1254.7	(218.9)	1254.7 (245.8)
Woodford	3	1054.2	(237.9)	1054.2	(232.6)	1054.2	(225.8)	1054.2	(217.4)	1054.2 (247.8)
Woodford	4	1224.0	(220.4)	1224.0	(215.3)	1224.0	(208.0)	1224.0	(197.9)	1224.0 (228.1)

Table 4.8: Certainty equivalent revenue (\$/acre) for subsidized GRP

County	Farm	70%		75%		80%		85%		NOIN	
DeWitt	1	1206.2(	234.9)	1207.9(	236.0)	1210.6(	238.2)	1215.3(	241.9)	1204.6(	234.0)
DeWitt	2	1295.4(	233.4)	1297.1(	234.5)	1299.8(	236.5)	1304.5(	240.2)	1293.8(	232.2)
DeWitt	3	1125.7(	236.7)	1127.4(	237.8)	1130.1(	240.1)	1134.8(	244.0)	1124.1(	235.2)
DeWitt	4	1397.8(	230.6)	1399.5(	231.8)	1402.2(	233.8)	1406.9(	237.1)	1396.2(	229.5)
DeWitt	5	1413.9(	225.5)	1415.7(	226.5)	1418.3(	228.3)	1423.0(	231.3)	1412.3(	224.9)
Logan	1	1335.2(	224.8)	1336.5(	225.3)	1338.4(	226.7)	1341.8(	229.1)	1334.2(	224.3)
Logan	2	1134.0(	247.1)	1135.3(	247.7)	1137.2(	248.8)	1140.6(	251.1)	1133.0(	246.5)
Logan	3	1275.3(	239.6)	1276.5(	240.3)	1278.4(	242.0)	1281.8(	244.6)	1274.2(	239.2)
Logan	4	1115.8(	256.9)	1117.0(	257.4)	1118.9(	258.8)	1122.3(	261.1)	1114.7(	256.4)
Macon	1	1238.7(	233.6)	1240.8(	234.9)	1244.0(	237.5)	1249.5(	241.4)	1236.7(	232.0)
Macon	2	1213.2(	243.7)	1215.4(	244.9)	1218.5(	246.9)	1224.1(	250.3)	1211.2(	242.7)
Macon	3	1233.4(	238.7)	1235.6(	240.1)	1238.7(	242.9)	1244.3(	247.0)	1231.5(	237.8)
Macon	4	1280.9(	244.4)	1283.0(	245.6)	1286.2(	247.8)	1291.8(	251.5)	1278.9(	243.5)
Macon	5	1219.5(	250.7)	1221.7(	251.8)	1224.8(	253.8)	1230.4(	257.7)	1217.6(	249.9)
Marshall	1	1395.5(	226.9)	1395.7(	227.1)	1396.4(	227.5)	1398.5(	228.6)	1395.4(	226.8)
Marshall	2	1302.5(	228.2)	1302.8(	228.2)	1303.5(	228.4)	1305.5(	229.2)	1302.4(	228.2)
Marshall	3	1302.4(	241.9)	1302.7(	242.1)	1303.4(	242.5)	1305.4(	243.3)	1302.3(	241.9)
Marshall	4	1323.4(	232.0)	1323.6(	232.0)	1324.3(	232.2)	1326.4(	232.9)	1323.3(	232.0)
Mason	1	1308.9(	221.4)	1311.0(	222.6)	1314.3(	224.8)	1320.4(	228.5)	1306.7(	220.7)
Mason	2	1420.7(	234.3)	1422.8(	235.8)	1426.0(	238.5)	1432.1(	243.1)	1418.4(	232.8)
Mason	3	1352.3(	225.4)	1354.4(	226.8)	1357.6(	229.4)	1363.7(	233.9)	1350.0(	223.5)
Mason	4	1214.9(	244.2)	1217.0(	245.5)	1220.3(	248.0)	1226.4(	251.6)	1212.7(	243.4)
Mclean	1	1267.3(	229.2)	1271.4(	231.6)	1277.3(	235.8)	1287.5(	242.1)	1263.6(	227.2)
Mclean	2	1335.4(	220.9)	1339.5(	223.8)	1345.4(	228.7)	1355.6(	235.9)	1331.7(	218.8)
Mclean	3	1283.0(	235.5)	1287.1(	237.6)	1292.9(	241.6)	1303.1(	248.0)	1279.2(	234.0)
Mclean	4	1301.2(	229.4)	1305.3(	231.8)	1311.2(	236.3)	1321.4(	242.7)	1297.5(	227.6)
Menard	1	1467.4(	251.6)	1473.1(	255.3)	1479.8(	260.6)	1490.5(	268.0)	1458.8(	246.5)
Menard	2	1312.7(	240.6)	1318.4(	244.8)	1325.2(	250.7)	1335.8(	259.1)	1304.1(	233.9)
Menard	3	1222.6(	230.2)	1228.3(	234.9)	1235.0(	241.8)	1245.7(	250.8)	1214.0(	223.0)
Menard	4	1236.0(	239.8)	1241.7(	243.9)	1248.4(	250.0)	1259.1(	258.0)	1227.4(	232.9)
Peoria	1	1360.3(	254.9)	1361.6(	255.2)	1363.9(	256.2)	1368.4(	258.3)	1359.4(	254.8)
Peoria	2	1115.5(	237.7)	1116.8(	238.4)	1119.1(	239.8)	1123.6(	242.5)	1114.6(	237.5)
Peoria	3	1189.3(	240.0)	1190.6(	240.6)	1192.9(	241.8)	1197.3(	244.5)	1188.4(	239.9)
Stark	1	1229.3(	229.7)	1231.7(	231.2)	1235.0(	233.8)	1240.6(	238.1)	1226.5(	228.5)
Stark	2	1344.9(	234.6)	1347.3(	236.2)	1350.5(	239.1)	1356.1(	243.5)	1342.0(	232.9)
Stark	3	1372.6(	238.1)	1375.0(	239.9)	1378.2(	242.9)	1383.8(	247.6)	1369.7(	236.7)
Stark	4	1417.9(	235.5)	1420.3(	236.9)	1423.5(	239.5)	1429.1(	244.0)	1415.0(	234.2)
Tazewell	1	1429.9(	231.6)	1432.0(	233.1)	1435.0(	235.7)	1440.6(	239.9)	1427.9(	230.5)
Woodford	1	1234.9(	263.6)	1235.0(	263.7)	1235.6(	264.0)	1236.8(	264.6)	1234.8(	263.6)
Woodford	2	1254.7(	245.8)	1254.9(	245.9)	1255.4(	246.1)	1256.6(	246.9)	1254.7(	245.8)
Woodford	3	1054.2(	247.9)	1054.4(	247.9)	1054.9(	248.0)	1056.2(	248.6)	1054.2(	247.8)
Woodford	4	1224.0(	228.1)	1224.2(	228.2)	1224.7(	228.5)	1226.0(	229.2)	1224.0(	228.1)

Table 4.9: Certainty equivalent revenue (\$/acre) for subsidized APH

County	Farm	70%		75%		80%		85%		NOIN	
DeWitt	1	1206.9(	225.9)	1208.5(	220.7)	1210.6(	213.4)	1212.7(	203.6)	1204.6(	234.0)
DeWitt	2	1295.5(	225.7)	1297.0(	221.1)	1298.9(	214.1)	1301.1(	204.4)	1293.8(	232.2)
DeWitt	3	1126.5(	226.8)	1128.2(	221.9)	1130.4(	215.0)	1132.4(	205.9)	1124.1(	235.2)
DeWitt	4	1397.4(	224.6)	1398.6(	220.5)	1400.3(	214.2)	1402.4(	204.7)	1396.2(	229.5)
DeWitt	5	1413.0(	222.3)	1414.1(	218.7)	1416.0(	212.1)	1418.1(	202.7)	1412.3(	224.9)
Logan	1	1335.6(	219.1)	1336.9(	214.7)	1338.8(	208.0)	1341.0(	198.1)	1334.2(	224.3)
Logan	2	1135.7(	237.8)	1137.5(	232.6)	1139.7(	225.6)	1141.7(	216.6)	1133.0(	246.5)
Logan	3	1275.8(	233.2)	1277.4(	228.5)	1279.4(	221.7)	1281.5(	212.6)	1274.2(	239.2)
Logan	4	1117.5(	247.4)	1119.3(	242.5)	1121.6(	235.7)	1123.7(	226.9)	1114.7(	256.4)
Macon	1	1238.4(	226.0)	1239.9(	221.3)	1241.8(	214.6)	1243.9(	205.4)	1236.7(	232.0)
Macon	2	1213.2(	235.8)	1214.8(	231.0)	1216.8(	224.1)	1218.9(	214.7)	1211.2(	242.7)
Macon	3	1233.3(	231.1)	1234.7(	226.6)	1236.7(	219.8)	1238.8(	210.6)	1231.5(	237.8)
Macon	4	1280.6(	237.3)	1282.0(	233.0)	1283.9(	226.6)	1285.9(	217.8)	1278.9(	243.5)
Macon	5	1219.6(	242.8)	1220.9(	238.6)	1222.7(	232.7)	1224.6(	224.8)	1217.6(	249.9)
Marshall	1	1396.3(	223.4)	1397.4(	219.6)	1399.1(	213.2)	1401.4(	203.6)	1395.4(	226.8)
Marshall	2	1303.8(	223.1)	1305.2(	218.7)	1307.2(	211.8)	1309.4(	202.2)	1302.4(	228.2)
Marshall	3	1303.8(	236.7)	1305.0(	232.8)	1306.7(	226.8)	1308.7(	218.3)	1302.3(	241.9)
Marshall	4	1324.7(	226.7)	1325.9(	222.6)	1327.8(	216.0)	1330.0(	206.4)	1323.3(	232.0)
Mason	1	1308.0(	215.8)	1309.3(	211.1)	1311.3(	203.9)	1313.4(	193.8)	1306.7(	220.7)
Mason	2	1419.2(	229.7)	1420.2(	226.3)	1422.0(	220.2)	1424.2(	210.5)	1418.4(	232.8)
Mason	3	1351.1(	219.2)	1352.2(	215.5)	1353.8(	209.5)	1355.8(	200.5)	1350.0(	223.5)
Mason	4	1214.4(	237.6)	1215.8(	233.1)	1218.0(	226.2)	1220.1(	217.0)	1212.7(	243.4)
Mclean	1	1265.2(	221.3)	1266.5(	217.0)	1268.4(	210.2)	1270.6(	200.6)	1263.6(	227.2)
Mclean	2	1333.0(	213.6)	1334.2(	209.6)	1335.9(	203.3)	1337.9(	194.1)	1331.7(	218.8)
Mclean	3	1280.6(	228.9)	1282.0(	224.6)	1283.9(	218.1)	1286.1(	208.9)	1279.2(	234.0)
Mclean	4	1298.9(	222.1)	1300.1(	218.0)	1301.9(	211.6)	1304.0(	202.2)	1297.5(	227.6)
Menard	1	1459.6(	243.1)	1460.6(	239.9)	1462.2(	234.3)	1464.2(	225.6)	1458.8(	246.5)
Menard	2	1305.7(	228.3)	1306.9(	224.2)	1308.7(	218.0)	1310.6(	209.3)	1304.1(	233.9)
Menard	3	1215.9(	216.3)	1217.3(	211.7)	1219.3(	204.8)	1221.4(	195.1)	1214.0(	223.0)
Menard	4	1229.2(	226.5)	1230.6(	221.9)	1232.7(	214.8)	1234.8(	205.5)	1227.4(	232.9)
Peoria	1	1360.8(	249.4)	1361.9(	245.7)	1363.7(	239.5)	1365.8(	230.8)	1359.4(	254.8)
Peoria	2	1116.9(	230.0)	1118.6(	225.1)	1120.8(	218.3)	1122.8(	209.7)	1114.6(	237.5)
Peoria	3	1190.6(	232.2)	1192.1(	227.3)	1194.2(	220.3)	1196.4(	210.8)	1188.4(	239.9)
Stark	1	1228.4(	221.5)	1229.9(	216.9)	1231.9(	209.9)	1234.0(	200.4)	1226.5(	228.5)
Stark	2	1343.2(	228.6)	1344.3(	224.9)	1346.0(	218.7)	1348.2(	209.2)	1342.0(	232.9)
Stark	3	1370.7(	233.2)	1371.7(	229.7)	1373.4(	224.0)	1375.6(	215.0)	1369.7(	236.7)
Stark	4	1416.1(	230.0)	1417.1(	226.5)	1418.7(	220.5)	1420.7(	211.8)	1415.0(	234.2)
Tazewell	1	1428.9(	226.5)	1429.9(	223.0)	1431.5(	217.1)	1433.4(	208.2)	1427.9(	230.5)
Woodford	1	1236.6(	257.6)	1238.0(	253.3)	1240.1(	247.2)	1242.1(	239.1)	1234.8(	263.6)
Woodford	2	1256.5(	238.8)	1257.9(	234.4)	1259.9(	227.8)	1262.0(	218.9)	1254.7(	245.8)
Woodford	3	1057.4(	237.9)	1059.3(	232.6)	1061.4(	225.8)	1063.2(	217.4)	1054.2(	247.8)
Woodford	4	1226.2(	220.4)	1227.8(	215.3)	1229.9(	208.0)	1232.0(	197.9)	1224.0(	228.1)

Table 4.10: Average performance of APH over GRP

Cov_{GRP}	Cov_{APH}	APH_S	GRP_S	$Indif$
0.70	0.70	28.57	38.10	33.33
0.70	0.75	54.76	11.90	33.33
0.70	0.80	73.81	9.52	16.67
0.70	0.85	90.48	2.38	7.14
0.75	0.70	19.05	61.90	19.05
0.75	0.75	28.57	40.48	30.95
0.75	0.80	42.86	23.81	33.33
0.75	0.85	66.67	9.52	23.81
0.80	0.70	9.52	80.95	9.52
0.80	0.75	19.05	69.05	11.90
0.80	0.80	26.19	54.76	19.05
0.80	0.85	40.48	26.19	33.33
0.85	0.70	2.38	90.48	7.14
0.85	0.75	9.52	83.33	7.14
0.85	0.80	14.29	76.19	9.52
0.85	0.85	19.05	66.67	14.29

Chapter 5

Conclusion

This study investigated the performance of a representative area level (GRP) and farm level (APH) crop insurance plans on corn farms in eleven counties in Illinois which make up Agricultural District 40. A two-step hierarchical Bayes small area estimator was used to simulate and compare actuarially fair premiums, trigger probabilities and certainty equivalent revenue under both plans, first ignoring Federal subsidies and then accounting for actual levels of subsidies.

We found that indemnities were more likely to be triggered under APH plans than GRP with similar coverage levels thus demanding corresponding higher premiums. High variation in premium estimates across and within counties was observed. This variance was higher in GRP plans than APH. Similar but lower variation was observed with trigger probability estimates. However, no one-to-one relationship between differences in trigger probabilities and differences in premiums estimates was established. Expected certainty equivalent revenues under no subsidies for both plans with similar coverage levels were equal, but APH estimates were more efficient. Considering actual subsidies levels alongside actuarially fair premiums, we found significant improvements in the performance of GRP plans over APH. Contrary to observed actual contribution of area and farm level insurance to the FCIC total liability, 29%-51% of all GRP plans were found to perform better than APH plans while 48%-71%

Table 5.1: Posterior summary

Parameter	mean	<i>sd</i>	2.5%	50%	97.5%
β_0	-7.744164	314.420013	-612.769213	-8.757253	608.276065
P_5	-75.86983	190.03285	-443.13227	-74.99907	301.24005
P_6	109.49973	73.79472	-36.74530	109.85406	253.32487
P_7	-77.93479	103.52736	-281.03845	-78.49074	125.42189
P_8	136.10278	87.43957	-34.61015	136.05756	304.56067
P_5^2	4.038653	19.073558	-33.622211	3.752764	41.380409
P_6^2	-7.311572	5.910596	-18.970107	-7.318405	4.443292
P_7^2	14.67679	23.25330	-30.61459	14.45923	59.96426
P_8^2	-30.38619	22.71825	-74.25356	-30.62534	14.08172
T_5	-3.972948	48.891269	-98.296157	-3.641314	93.716078
T_6	5.298882	37.121045	-67.109712	6.063242	78.261013
T_7	26.80241	38.31500	-51.20988	27.47836	102.24907
T_8	-29.71528	42.10907	-111.73128	-30.51194	54.78297
σ_u^2	7.610617e+01	2.117918e+02	9.985699e-04	1.352251e+00	6.704169e+02
σ_e^2	820.8927	229.6922	474.0477	789.5517	1357.6264

of all APH plans out performed GRP plans under current subsidies. Thus suggesting the presence of asymmetrical information in the crop insurance industry.

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