Performance of Farm Level Vs Area Level Crop Insurance

S. Awondo[1]; G. Datta[2]

1: The University of Alabama, , United States of America, 2: The University of Georgia, , United States of America

Corresponding author email: ndeawondo@gmail.com

Abstract:

This study investigated the performance of Actual Production History (APH), a farm level crop insurance plan, vis-´a-vis Area Yield Production (AYP), 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, AYP, 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. Results suggest that unobserved factors other than basis risk and farmers' risk preference drive preferences for crop insurance contracts.

Acknowledegment:

JEL Codes: Q14, C11

#1504

PERFORMANCE OF FARM LEVEL VS AREA LEVEL CROP INSURANCE

ABSTRACT

This study investigated the performance of Actual Production History (APH), a farm level crop insurance plan, vis-á-vis Area Yield Production (AYP), 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, AYP, 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, Certainty equivalent, Small area estimation, Hierarchical Bayes.

JEL classification: G22, Q14.

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.

In the U.S., crop insurance is administered by the Risk Management Agency (RMA) of the United States Department of Agriculture (USDA), with the main objective to maximize participation in the Federal crop insurance program and to ensure equity for producers. The RMA heavily subsidizes premiums and fully covers the programs administration, operating, and reinsurance costs. Since inception in 1938, total liabilities and subsidies for the program have increased substantially with the latter amounting to $7 billion in 2014 (Agency, 2015) as the program increasingly becomes a major part of U.S. agricultural policy. Past studies have linked the poor actuarial performance and insolvency of the FCIC to mostly adverse selection and moral hazard and unreliable premium estimates.

The FCIC currently provides different types of crop insurance polices including yield and revenue based insurance plans that can also be classified as farm/individual or area/group level. 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 until 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 area level 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

---

[1] The rest is attributed to specialty crops

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 (Area Yield Production (AYP)) 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 AYP 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, AYP, 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 corn yields based on farm level geospatial data following Awondo et al. (2018).

Findings from our study revealed APH plans out performed AYP by 92% when no subsidies are offered. However, under actual levels of subsidies currently offered by the FCIC, APH out performed AYP between 48% and 71% while AYP 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. The model and estimation strategy is specified in section two while section three duels on the data generation. We present results and discussion in section four and sum up our study, main results and suggestions for future research in chapter five.

2 Model Specification and Estimation

The small area estimator in this study (primarily) aims to better estimate mean county yield in the presence of limited data (Awondo et al., 2018). Mean county yields are used in setting yield guarantees for AYP, which in turn determines indemnity payments and fair premiums. Thus, by efficiently estimating mean county yields, premiums are also efficiently estimated.

Suppose that n_i farms plots are sampled from the population (N_i) in county i with probability of selection proportionate to the farm size. If N_i is large, the idiosyncratic error approaches zero, i.e., $N_i^{-1}\Sigma_{j=1}^{N_i} e_{ij} \approx 0$, and we can approximate the mean yield (θ_i) for county i as

$$\theta_i = \bar{X}_i^T \beta + u_i, \tag{1}$$

where $\bar{X}_i^T$ is a vector of the means of explanatory from the population with $\bar{X}_i = \Sigma_{j=1}^{N_i} \frac{x_{ij}}{N_i}$ and x_{ij} is vector of covariates at unit level, β are the corresponding parameters, and u_i is the county random effect. The expected county mean yield can be derive by taking the expectation of θ_i in equation (1). In the next steps that follows, we develop a two-step Hierarchical Bayes small area estimator of the expectation of θ_i conditional on sample county average yields (using unit level and county level data), that is expected to be more efficient and less biased.

For simplicity, we use cross sectional data at both the farm and county level. The specification can be extended to longitudinal and time series data to represent temporal effects following Ghosh et al. (1996); Datta et al. (1999, 2002) and Torabi (2012).

A basic conditional farm-level yield model takes the form:

$$y_{ij} = x_{ij}^T \beta + u_i + e_{ij}, j = 1, ..., n_i, i = 1, ..., m, \tag{2}$$

where y_{ij} is the yield on farm j in county i, x_{ij} is a vector of explanatory variables, β is a vector of fixed parameters, u_i is the county random effect, and e_{ij} the error term. The county effects u_i are assumed to be independent with zero mean and variance σ_u^2. Similarly, the errors e_{ij} are assumed independent with mean zero and variance σ_e^2. The county random effect and the error are assumed to be mutually independent as well.

By weighting the farm-level data with weights $\breve{w_{ij}}$ and summing the observations within each county, we can combine equation (2) with the direct county average yield ($\bar{y}_{iw}$) to produce a county-level model (equation (3)) given as

$$\bar{y}_{iw} = \bar{x}_{iw}^T \beta + u_i + \bar{e}_{iw}, i = 1, ..., m, \tag{3}$$

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

2.1 Hierarchical Bayes model

To develop an HB estimator based on equation (2), we consider that (i) $y_{ij}|\beta, u_i, \sigma_e^2 \sim N(x_{ij}^T \beta + u_i, \sigma_e^2), j = 1, ..., n_i,\ i = 1, ..., m$; (ii) $u_i|\sigma_u^2 \sim$ N(0,σ_u^2), and (iii) $\beta \sim$ N(0,H) where H is the variance covariance matrix of β. The precision parameter of each of the variance components is assumed to follow an inverse gamma distribution with different parameters; $\sigma_e^2 \sim IG(\lambda_1, \tau_1)$ and $\sigma_u^2 \sim IG(\lambda_2, \tau_2)$. The joint posterior distribution function is then given by equation (4):

$$f(\beta, \sigma_u^2, \sigma_e^2 | y_{ij}, 1 \le j \le n, 1 \le i \le m) = \prod_{i=1}^{m} [\prod_{j=1}^{n_i} (\frac{1}{\sigma_e^2})^{\frac{1}{2}} e^{-\frac{1}{2\sigma_e^2}(y_{ij} - x_{ij}^T \beta - u_i)^2} (\frac{1}{\sigma_u^2})^{\frac{1}{2}} e^{-\frac{1}{2\sigma_u^2} u_i^2}] \tag{4}$$
$$* [\prod_{l=1}^{p} (\frac{1}{h_l^2})^{\frac{1}{2}} e^{-\frac{1}{2h_l^2}\beta_l^2}] (\frac{1}{\sigma_e^2})^{\lambda_1+1} e^{-\frac{\tau_1}{\sigma_e^2}} (\frac{1}{\sigma_u^2})^{\lambda_2+1} e^{-\frac{\tau_2}{\sigma_u^2}}.$$

Substituting the mean ($\bar{y}_{iw} - \bar{x}_{iw}^T \beta$) of the conditional marginal posterior of u_i in $E(\theta_i)$

using equation (1) gives a new (shrinkage) estimator of the county mean yield (θ_i):

$$E(\theta_i|\bar{y}_{iw}, \beta, \sigma_e^2, \sigma_u^2) = q_{iw}\bar{y}_{iw} + (\bar{X}_i - q_{iw}\bar{x}_{iw})^T\beta, \tag{5}$$

where $q_{iw} = \frac{\sigma_u^2}{\sigma_u^2+\varrho_i^2}$, β, σ_e^2 and σ_u^2 are drawn from the joint posterior distributions derived from the unit level model (equation (2)), and the variance of θ_i is given as $q_{iw}\varrho_i^2$. Note that equation (9), derived by systematically combining equation (2) and equation (3), explicitly captures the relative variation in farm-level and county-level yields which drives basis risk, and reveals that, when the variation in farm-level data exceeds that in county level data, less weight is placed on the direct county yield estimate compared to the overall population value, and vice versa. The estimator thus systematically shrinks the direct county yield estimate away or closer to the population value, depending on whether there is higher or lower variation in the farm-level data relative to the county-level.

2.2 Estimation

In the first stage of estimation, Gibbs sampling (Gelfand and Smith, 1990) is used to simulate the marginal posterior distributions of β, u_i, σ_e^2 and σ_u^2 using non-informative priors.

To estimate expected county yields we draw k samples of the parameters with replacement, s=1,...,k ($\beta^{(s)}; \sigma_e^{2(s)}; \sigma_u^{2(s)}$) from the simulated joint posterior distribution and use them in equation (5). Expected county yield is then obtained by averaging over the $\theta_i^{\prime}$s:

$$\hat{\theta}_i^{HB} = \frac{1}{k}\Sigma_{s=1}^{k}[q_{iw}^{(s)}\bar{y}_{iw} + (\bar{X}_i - q_{iw}^{(s)}\bar{x}_{iw})^T\beta^{(s)}] \tag{6}$$

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

$$\bar{I}_{iz}^{AYP} = \int max([\frac{(\hat{\theta}_i^{HB})C_z - \bar{y}_{iw}}{\hat{\theta}_i^{HB}C_z}]\hat{\theta}_i^{HB}S, 0)x\wp f(\bar{y}_{iw})d(\bar{y}_{iw})$$

$$= \frac{1}{k}\Sigma_{s=1}^k[max([\frac{(\theta_i^{(s)})C_z - \bar{y}_{iw}^{(s)}}{\hat{\theta}_i^{(s)}C_z}]\theta_i^{(s)}S, 0)]\wp, i = 1, .., m \; z = 1, .., 6 \tag{7}$$

Where $\wp$ 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 AYP and APH plans and also set scale to 1 [4]. A scale of 1 has no effect on the expected indemnity. We simulated expected indemnity payments under all four coverage levels in each county.

Trigger probability for each AYP plan is derived as follows:

$$P[\bar{y}_{iw} < \theta_i C_z | data] = \int^{\theta_i C_z} f(\bar{y}_{iw}|data)d(\bar{y}_{iw})$$

$$= \frac{1}{k}\Sigma_{s=1}^k I(\bar{y}_{iw}^{(s)} < \theta_i^{(s)}C_z). \tag{8}$$

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:

$$\theta_{ij}^{(s)} = x_{ij}^T\beta^{(s)} + u_i^{(s)} \tag{9}$$

---

[4] Awondo 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

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.

$$\bar{I}_{ijz}^{APH} = \int max([\theta_{ij}C_z - y_{ij}], 0)\wp f(y_{ij})d(y_{ij})$$

$$= \frac{1}{k}\Sigma_{s=1}^{k}[max([\theta_{ij}^{(s)}C_z - y_{ij}^{(s)}], 0)x\wp], i = 1, .., m, j = 1, .., n_i, z = 1, .., 6 \qquad (10)$$

Where C_Z=(70%, 75%, 80%, 85%).

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

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

$$= \frac{1}{k}\Sigma_{s=1}^{k}I(y_{ij}^{(s)} < \theta_{ij}^{(s)}C_z). \qquad (11)$$

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

Considering that only the AYP and APH plans are provided, a farmer j in county i is faced with three alternatives (no insurance, APH or AYP) 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:

$$U(R_{ijc}^{z}) = \frac{R_{ijc}^{z(1-\lambda)}}{(1-\lambda)} \qquad (12)$$

Where R_{ijc}^{z} is the revenue of farm j in county i conditional on his choice of insurance plan $c = \{o = noinsurance,\ a = APH,\ g = AYP\}$, 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 AYP the revenue/acre is estimated as $R_{ijo} = \wp y_{ij}$, $R^{z}_{ija} = \wp y_{ij} - \o \bar{I}^{APH}_{ijz} + I^{APH}_{ijz}$, $R^{z}_{ijg} = \wp y_{ij} - \o \bar{I}^{AYP}_{iz} + I^{AYP}_{iz}$ respectively. The certainty equivalence (CE^{z}_{ijc}) for each policy scenario is derived as:

$$
\begin{aligned}
CE^{z}_{ijc} &= [(1-\lambda)\int U(R^{z}_{ijc}) f(y_{ij}) d(y_{ij})]^{\frac{1}{(1-\lambda)}} \\
&= [(1-\lambda)(\frac{1}{k}\Sigma^{k}_{s=1} U(R^{z(s)}_{ijc}))]^{\frac{1}{(1-\lambda)}} \qquad (13)
\end{aligned}
$$

Where y_{ij} is the realized farm yield, $\o$ is the level of subsidies and $R^{(s)}_{ijo} = \wp y^{(s)}_{ij}$, $R^{z(s)}_{ija} = \wp y^{(s)}_{ij} - \o \bar{I}^{APH}_{ijz} + I^{APH(s)}_{ijz}$, $R^{z(s)}_{ijg} = \wp y^{(s)}_{ij} - \o \bar{I}^{AYP}_{iz} + I^{AYP(s)}_{iz}$ are the simulated net revenue/acre sample (k=5000) under no insurance, APH and AYP 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-AYP 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 AYP.

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 α=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.

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).

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 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.

$$y_{ij} = 320 - .346P_{ij5} + 10.463P_{ij6} + 6.849P_{ij7} - 0.523P_{ij8} - 0.087P_{ij5}^2 - 0.903P_{ij6}^2 - 0.304P_{ij7}^2$$

$$+0.035P_{ij8}^2 + 1.232T_{ij5} + 1.854T_{ij6} - 2.013T_{ij7} - 3.036T_{ij8} + u_i + e_{ij} \tag{14}$$

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_{ij5}^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 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 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.

---

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

[4] The 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

4 Results and discussion

Table 2 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 3 presents AYP small area estimates (by county) of actuarially fair premiums for each coverage level without considering subsidies. Tables 4 present similar results for APH for each farm in the sample.

Results show high variation in premium estimates at county level (AYP) as well as farm level (APH). The variation is higher for AYP plans compared to APH plans for similar coverage levels and tends to decrease with increase in coverage. For example, on average a AYP 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 AYP 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.

Results also show that actuarially fair premiums under APH can be higher or lower than the premiums under AYP for similar plans. For example, AYP 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 AYP premiums in Mclean, Menard and Stark are substantially higher than the APH premiums for each farm in the county. Similarly, the AYP 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 AYP and APH tend to decrease with increase 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 area level plan, thus supporting the evidence of basis risk in the plans.

Results also 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 AYP with 75% coverage in Marshall is 0.0112 while in Menard the probability is 1550% more (0.1848). However, the AYP 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 AYP plans.

Overall, APH indemnities are more likely to be triggered than AYP indemnities for similar coverage levels, and partly explains why APH premiums are generally higher than corresponding AYP premiums. The likelihood of indemnities to be triggered increases at a decreasing rate with increase in coverage level under both APH and AYP. In Macon, increasing the AYP 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 AYP plans for the same county is a measure of lack of correlation between farm yields and county averages (basis risk).

Tables 5 and 6 present certainty equivalent revenues for AYP and APH plans with unsubsidized actuarially fair premiums. Tables 7 and 8 present similar results after subsidizing actuarially fair premiums with actual levels of subsidies.

Under no subsidies, the expected certainty equivalent estimates are equal under APH and AYP plans for a given level of coverage, implying APH and AYP have equal performance for managing farm risk. All else equal, we should therefore expect about equal proportion of farmers choosing APH and AYP. 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 AYP 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 AYP counterparts, and will be preferred 100% of the time.

Results from tables 7, 8 and 9 show that introducing subsidies substantially improves the performance of AYP with regards to APH and completely renders a no insurance choice the worst option. As expected, due to higher subsidies level for AYP than APH at higher coverage levels, the performance of AYP increases with coverage vis-á-vis APH plans. For example, comparing the performance of a AYP-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 AYP and no insurance. However after introducing subsidies levels of (59%,55%), (59%,55%), (55%,55%) and (55%,55%) for the corresponding AYP-APH plans, the average percentage of time AYP (APH) performs best increases (decreases) correspondingly as 12% (55%), 40% (29%), 69% (19%) and 83% (9%). Overall, the percentage of times both APH and AYP perform equally decreases with increase in AYP coverage in the AYP-APH combination (33%, 31%, 12% and 7%).

Averaging over all 16 AYP-APH plan combinations presented in table 9 reveals that, overall, 34% of APH and 47% of AYP 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 AYP. On the other hand, at least 47% and at most 67% of the farmers should choose AYP 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. AYP) 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.

5 Conclusion

This study investigated the performance of a representative area level (AYP) 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 AYP 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 AYP 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 AYP plans over APH. Contrary to observed actual contribution of area and farm level insurance to the FCIC total liability, 29%-51% of all AYP plans were found to perform better than APH plans while 48%-71% of all APH plans out performed AYP plans under current subsidies. Thus suggesting the presence of asymmetrical information in the crop insurance industry.

References

Agency, R. M. (2015). Federal crop insurance corporation: Nationwide summary by crop,.

Awondo, S. N., G. S. Datta, O. A. Ramirez, and E. G. Fonsah (2012, August 13-16.). Estimation of crop yield distribution and insurance premium using shrinkage estimator: A hierarchical bayes and small area estimation approach. Paper presented at Agricultural and Applied Economics Association Annual Meeting, Seattle, WA.

Awondo, S. N., O. A. Ramirez, G. S. Datta, G. Colson, and E. G. Fonsah (2018). Estimation of crop yields and insurance premiums using a shrinkage estimator. *North American Actuarial Journal,*. forthcoming.

Datta, G. S., P. Lahiri, and T. Maiti (2002). Empirical bayes estimation of median income of four-person families by state using time series and cross-sectional data. *Journal of Statistical Planning and Inference 102*, 83–97.

Datta, G. S., P. Lahiri, T. Maiti, and K. L. Lu (1999). Hierarchical bayes estimation of unemployment rates for the states of the u.s. *Journal of the American Statistical Association 94*, 1074–1082.

Gelfand, A. E. and A. F. M. Smith (1990). Sampling-based approaches to calculating marginal densities. *Journal of the American Statistical Association 85*, 398–409.

Ghosh, M., N. Nangia, and D. H. Kim (1996). Estimation of median income of four person

Table 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

families:a bayesian time series approach. *Journal of the American Statistical Association 91*, 1423–1431.

Ramirez, O. A., T. U. McDonald, and C. A. Carpio (2010). A flexible parametric family for the modeling and simulation of yield distributions. *Journal of Agricultural and Applied Economics 42*(2), 1–17.

Schlenker, W. and M. Roberts (2006). The impact of global warming on u.s. agriculture: An econometric analysis of optimal growing conditions. *Review of Economics and Statistics 88*(1), 113–125.

Tannura, M. A., S. H. Irwin, and D. L. Good (2008, February). Weather, technology, and corn and soybean yields in the u.s. corn belt. marketing and outlook research report.

Thompson, L. M. (1988). Effects of changes in climate and weather variability on the yields of corn and soybeans. *Journal of Production Agriculture 1*, 20–27.

Torabi, M. (2012). Hierarchical bayes estimation of spatial statistics. *Journal of Statistical Planning and Inference 142*, 358–365.

Table 2: 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 3: AYP 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)

Table 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 5: Certainty equivalent revenue ($/acre) for unsubsidized AYP

County	Farm	70%	75%	80%	85%	*NOIN*
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 6: 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 7: Certainty equivalent revenue ($/acre) for subsidized AYP

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 8: 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 9: Average performance of APH over AYP

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