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CROP YIELD AND REVENUE INSURANCE: CHOOSING BETWEEN POLICIES THAT TRIGGER ON FARM VS. COUNTY INDEXES

By

Ben Chaffin

A Plan B Paper

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Master of Science

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ABSTRACT

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Insurance policies that trigger on county yield and revenue indexes are expected to be more actuarially fair than policies that trigger on individual farm yield and revenue since individual farm hidden actions and hidden information impacting purchase decisions will be built into insurance premium rates.

Findings are expected to help farmers, insurance agents, lenders, and those in academia better understand and evaluate insurance policies that trigger indemnity payments based on county indexes. Case studies are provided to facilitate understanding of tracking between farm and county yields and the importance of the farm-county yield correlation. A protocol is developed to standardize county and farm yields to better illustrate tracking and rules-of- thumb are developed to aid in crop insurance purchase decisions.

Cumulative probability distributions of net yields with and without insurance are used to show the effects of county and farm trigger insurance policies on risk transfer. The farm location and spatial diversification in a county result in variations in the farm-county yield correlations and yield basis risk. These measures are directly related to the risk transfer performance of county trigger policies relative to no insurance and to farm trigger insurance policies.

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LIST OF ABBREVIATIONS

Actual Production History (APH)

Crop Revenue Coverage (CRC)

Cumulative Density Functions (CDFs)

Group Risk Income Policy (GRIP)

Group Risk Income Policy with Harvest Revenue Option (GRIP-HRO)

Group Risk Plan (GRP)

National Agricultural Statistics Services (NASS)

Revenue Assurance (RA)

Revenue Assurance with Harvest Revenue Option (RA-HRO)

Risk Management Agency (RMA)

United States Department of Agriculture (USDA)

INTRODUCTION

There are many tools and entitlement programs available to farmers to help reduce revenue risk associated with price and yield variations. The United States Department of Agriculture (USDA) facilitates crop insurance policies for a wide range of crops. The USDA also provides loan deficiency payments, direct payments, and counter-cyclical payments for USDA program crops. Other risk transfer tools are available for corn, soybean, and wheat producers that include futures contracts, options on futures contracts, and cash-forward contracts. Farmers can also reduce financial risk with crop mix and spatial diversification, as well as grain storage and selling crops throughout the crop year.

The principal yield and revenue crop insurance programs are administered and subsidized by the Risk Management Agency (RMA) of USDA, but they are delivered through the private sector. There are also individual peril insurance policies, such as for hail damage, provided by the private sector without subsidy. Farmers typically consider insurance products for one or more of the following reasons:

1. The farm has a high debt-to-asset ratio that limits its ability to self-insure. Crop insurance limits exposure to revenue shortfalls when yields are substantially below normal. Therefore, crop insurance is a substitute for equity. Nyambane (2005) and Atwood (1996) have explored this issue.

2. Because a farm is growing, the owners need to leverage equity to grow vs. limiting growth because of the need for equity to self-insure. This group needs risk control tools that substitute for equity.

3. The farm has a moderate-to-low debt- to-asset ratio, but the owner wants to limit potential reductions in net worth. The owner prefers a more predictable revenue stream vs. relying solely on self-insurance. This group often includes farmers who are approaching retirement.

A Generic Look at Insurance Policies

An overview of yield and revenue policy designs is described below. Edwards, Barnaby, Drummond, Baquet, and Harvey (2000) gave a good overview of insurance policies. Available policies that trigger on yield shortfalls are referred to as Actual Production History (APH) and Group Risk Plan (GRP). Policies that trigger on revenue shortfalls are referred to as Revenue Assurance (RA), Revenue Assurance with Harvest Revenue Option (RA-HRO), Crop Revenue Coverage (CRC), Group Risk Income Policy (GRIP), and Group Risk Income Policy with Harvest Revenue Option (GRIP-HRO). Policies that trigger on farm or sub-farm parcel (farm units) that yield shortfalls are APH, RA, RA-HRO, & CRC. Policies that trigger on the County indices are GRP, GRIP, & GRIP-HRO.

All crop insurance policies start by establishing an estimate of expected yield or revenue. Next, a portion of the estimate of expected yield or revenue is insured prior to planting. If the realized yield or revenue is below the guaranteed yield or revenue, an insurance payment is made. The insurance policies are described in more detail below.

Yield Polices

Yield policies guarantee a yield that is based either on county expected yields or an average of past yields[1]. If there are fewer than four past yields for a crop, T yields[2] are used. An APH policy that uses a farm unit as the basis for coverage, uses past yields from the section[3] and guaranties that a farmer will get a percentage of theses yields. The more spread out a farm is, the more farm units they will have; also, rental agreements enter into the definition of a farm unit. With farm unit policies the scale factor[4] is equal to one. If a farmer chooses a county trigger policy, a percentage of county expected yield is insured. If the realized county yield index falls below the guarantee, a payment is made. A limitation of county trigger insurance is that farm yields do not track perfectly with county yields, leading to yield basis risk. To help with the tracking problem, farmers are able to scale-up county trigger insurance policies. A farm can choose to buy between 0.9 and 1.5 times the amount of insurance per acre with county policies. When a farmer chooses a scale of 1.5 for county trigger insurance, it is like insuring 1.5 times the planted acres. Scaling also helps to adjust for differences between expected farm and expected county yields, and the fact is that farm yields are nearly always more variable than county yields.

The equation below demonstrates how yield policies work.

[1] The crop insurance industry uses a different definition of the term "expected" in policies than is used in probability and statistics; their definition is typically an estimator of central tendency, where the measure of central tendency is typically not stated.

[2] A yield established by RMA to use if insufficient yield history.

[3] Section, usually a 1 mile by 1 mile area, is shown in county plat books.

[4] With county trigger insurance policies, farmers are allowed to increase or decrease the guaranteed amounts to track better county shortfalls. Scale factors must be between .9 and 1.5 times the policy guarantee.

- Yield Guarantee = Coverage × Expected Yield
- Loss = Max(Yield Guarantee – Realized Yield, 0)
- Indemnity = Loss × Indemnity Price × Scale

Revenue Policies

Revenue policies build on yield policies. To insure an amount of revenue, the yield guarantee is multiplied by a spring price. This generates guaranteed revenue for the county and farm unit trigger policies. The guaranteed revenue is based on the Chicago Board of Trade; "farmers have to take into account local bases." After harvest, the realized yield is multiplied by fall price. If the realized revenue is less than the insured revenue, an insurance payment is made. The insured revenue will vary from actual revenue because of local bases. County revenue trigger policies can be scaled.

To insure revenue an expected fall price is used along with an expected yield. The equation below demonstrates how pure revenue insurance policies work.

1. Revenue without harvest option (pure revenue insurance)

Revenue guarantee = coverage[5] × expected yield × expected harvest futures price in spring

- Realized revenue = realized yield × harvest futures price at harvest
- Loss = max (revenue guarantee – realized revenue, 0)
- Indemnity = loss × scale

Revenue policies with replacement price build on revenue insurance policies. For revenue policies with an harvest revenue option (HRO), a revenue guarantee is

[5] Works as a deductible would work. An example yields must fall 25% before a payment is made, and equals coverage of 75%.

generated by using the spring price, but if the fall price is higher, then it is substituted into the revenue guarantee formula. Again, after harvest, the realized yield is multiplied by the fall price. Revenues are based on Chicago, not actual farm revenues. If the realized revenue is less than the insured revenue, then an insurance payment is made. County revenue trigger policies can be scaled.

To insure revenue with a replacement price, an expected yield is used along with an expected fall price, and the option uses the actual fall price. The equation below demonstrates how harvest option revenue insurance policies work.

1. Revenue with harvest option
    - Revenue guarantee=coverage × expected yield × max (expected harvest price in spring, realized harvest price in fall)
    - Realized revenue=realized yield × harvest futures price at fall
    - Loss = max (revenue guarantee–realized revenue, 0)
    - Indemnity=loss × scale

The biggest difference between the policies is the trigger yield or revenue index. County policies trigger on county yield and revenue, while farm unit policies trigger on actual farm insurance yields and revenues. Farm trigger insurance policies also include coverage for preventative planting, replanting, and quality. Table 1 shows a breakdown of the different features offered by each insurance policy[6]. For both county trigger and farm unit insurance, if a farm is going to insure a crop, all acres of that crop in a county have to be insured using the same policy and cover level. Farmers cannot pick and choose which farm units they want to insure.

[6] RA and CRC are relatively the same. They differ in how rates are created and discounts offered for different unit types (optional, basis, and enterprise).

Table 1

Crop Insurance Policy Attributes

Insurance Type	Farm Trigger	County Trigger	Scale Options	Spring Price	Fall Price	Quality	Prevented Planting	Replant	Units	
									Basic	Optional
APH	Y		1.0	Y		Y	Y	Y	Y	Y
RA	Y		1.0	Y		Y	Y	Y	Y	Y
RA-HRO/CRC	Y		1.0	Y	Y	Y	Y	Y	Y	Y
GRP		Y	0.9-1.5	Y						
GRIP		Y	0.9-1.5	Y						
GRIP-HRO		Y	0.9-1.5	Y	Y					

The APH policy allows a farmer to insure yield based on their yield history. APH is the traditional yield insurance policy that has been in place in its current form since the mid-1980s. APH guarantees are based on farm units. Losses, should they occur, are calculated for each farm unit. Optional farm units are approximately a section with ownership, irrigation, and rental arrangements that also enters into the definition. Thus, a medium-sized farm business may have several farm units, each of which has a separate base for establishing yield guarantees and determining indemnities associated with yield shortfalls.

RA and RA-HRO incorporate revenue insurance to APH. With RA insurance, the APH base yields are used, but the yields are multiplied by a spring estimate of fall prices to generate guaranteed revenue. After harvest, the realized yield is multiplied by the realized fall price. If the realized yield multiplied by the fall price is lower than the APH yield multiplied by spring price time coverage, then an indemnity payment is made. RA-HRO works the same way as RA does, except that if the fall price is higher than the spring price, it is substituted for the spring price when calculating revenue is guaranteed. If the substitution occurs, the revenue guaranteed per acre will increase. Remember, revenues are based on Chicago, not actual farm prices.

GRP policies take a different approach than do APH policies; GRP insurance triggers on a county yield index instead of the farm yield. Since county yield is typically less variable than the farm yield, smaller deductibles (greater coverage) are permitted under GRP than are permitted under the APH policy. With the GRP policy, farmers are able to scale up and insure 1.5 times the expected county yield. By allowing farmers to change scale factors, they are able to match better their yield shortfalls to county yield index shortfalls.

GRIP and GRIP-HRO add revenue coverage to GRP. With GRIP insurance, the county-predicted yield is used, but the yield is multiplied by a spring estimate of the fall price to generate guaranteed revenue. After harvest, the realized county index yield is multiplied by the realized fall price. If the realized yield, multiplied by the fall price, is lower than the county trigger yield multiplied by spring price multiplied by coverage, an indemnity payment is made[7]. GRIP-HRO works the same way as GRIP, except that if the fall price is higher than the spring price, it is substituted in place of the spring price when calculating revenue guaranteed. If the substitution occurs, the revenue guaranteed per acre will increase. Remember, prices are based on Chicago, not actual farm prices. Again with the GRIP policy, farmers are able to scale up insurance and insure 1.5 times the regular amount.

Comparison of County Index Policies and Farm Unit Policies

Advantage of County Index Policies

County policies have several advantages when it is compared to farm unit insurance policies. Four advantages are:

1. The premium is typically lower for similar levels of effective coverage; GRP at 90% coverage is frequently similar to APH at 75% coverage. County policies are usually less money because they do not have the risk classification and "hidden action" problems that occur under individual farm trigger policies.

[7] The prices used to establish the revenue guarantee are based on the Chicago Board of Trade prices. Every farm will face a different local basis. Actual prices for a farm are not used when calculating revenue contracts.

2. The county trigger policy requires less paperwork because information required for proving yields is not needed.

3. The county trigger policies may be better suited to farmers who rent significant amounts of land, particularly if they have only controlled many tracts for a short-time period and do not have a history of good established yields.

4. As farms grow and spread across counties, farm yields typically track county yields better. With improved tracking, county policies transfer more risk.

Disadvantages of County Index Polices

Insurance policies that trigger on county indexes have three significant shortcomings:

1. The first shortcoming is inherent in the definition of the policy; there is a yield basis risk because farm yields and revenue indices imperfectly track county yields and revenue indices. To receive an indemnity payment, a farm does not have to have a shortfall; the county can have a shortfall at the same time the farm has a normal year. Conversely, a farm can have a shortfall and not receive a payment because the county had a normal year. There is no guarantee that a farm will receive a payment when it needs one.

2. County trigger policies have not prevented planting or replant provisions; however, APH, RA, RA-HRO, and CRC policies have these provisions.

3. County trigger policies do not have grain quality provisions; however, APH, RA, RA-HRO, and CRC policies have quality provisions, although for some crops quality must fall significantly before the quality provisions apply.

Research Objectives

The following research objectives are needed in the following areas to increase knowledge and appropriate use of county trigger policies:

1. To provide practical procedures and guidelines that farmers, lenders, insurance agents, and academics can use to evaluate insurance policy choices, including the choice of no insurance
2. To understand how spatial diversification and location in a county changes a farm's correlation to the county index
3. To understand and illustrate how different tracking and correlation conditions influence the risk transfer provided by different insurance policies
    a. To establish risk-minimizing scale factors for county trigger insurance policies on the case study farms
    b. To evaluate county trigger insurance risk transfer verses no insurance
    c. To evaluate county trigger insurance risk transfer verses farm unit insurance
4. To illustrate how effective coverage levels increase with farm unit trigger policies with multiple farm units.

The organization of the paper is as follows. The Literature Review has three parts: (1) outreach publications, (2) insurance agency and extension software, and (3) journal articles and research reports. The Methods section has four main parts: (1) the Monte Carlo simulation model, (2) establishing conditions where GRP warrants consideration, (3) scale factors, and (4) methods used to evaluate the financial impact of risk control instruments. The Results section follows the Methods section. The results show how correlation affects net farm yields and revenues. The Results section has three main parts: (1) simulations using yields per acre, (2) simulations using revenues per acre, and (3) points to consider before making crop insurance decision. Finally, there is a Conclusion with two parts: (1) summary of objectives and (2) further research needs.

LITERATURE REVIEW

Programs administered by the Risk Management Agency (RMA) have provided crop insurance to farmers since 1938, and insurance designs have evolved over time. The concept of policies that trigger on county indexes was proposed in the late 1940s (Halcow, 1949), but was not put into practice until the 1980s in Canada and Sweden. RMA introduced index products in 1990s for counties in the United States (U.S.) with adequate acreage over a 30-year historical period. County trigger contracts are relatively new to U. S. farmers, lenders, and insurance agents. Rigorous, but applied, literature on county trigger insurance policies that is readily applicable to farmers, insurance agents, and lenders is scare. There are three types of literature: (1) university, RMA, and insurance industry outreach publications; (2) insurance agency and extension software; and (3) journal articles and research publications. Relatively few industry friendly guidelines have been established; the most useful information is tracking software and a single, large multi-state study of farm data that show the variance reduction associated with GRP and the associate farm-county yield correlations.

Outreach Publications

There have been a number of publications that describe crop insurance policies and how the policies work. Cain (2004) and Crane (2004) addressed all the crop insurance policies for field crops and then used scenarios to expand one's understanding of how crop insurance policies work, as well as their benefits. Schnitkey (2005) is a representative of publications that show how the county-trigger policies work and their potential risk reduction. Edwards et al., (2000) described insurance policies and addressed year-to-year cash-flow issues that insurance can help solve. Even though these articles are good, farm yield to county yield correction is not addressed. In addition, decision rules are not included for country trigger policies. Farmers are left wondering which policies would be the most beneficial for them. Farmers need more in-depth information because they know what risk, if any, the insurance policies will transfer.

Chaffin, Black, and Cao (2004) presented an approach to evaluate the performance of GRP insurance policies on farms that was based on the concepts developed in this paper. The evaluation focused on how farm yields track to county yields. Case studies were used to demonstrate actual examples of tracking. A Monte Carlo simulation model was used to simulate net yields. Empirical cumulative distribution functions (CDFs) were utilized to compare GRP, APH, and not insuring. Chaffin, Black, and Cao (2004) included actual decision guidelines. Chaffin and Black (2004) built a spreadsheet to evaluate the ability of GRPs to reduce risk for a farm. In the spreadsheet, a common mean is used to compare county and farm yields. Chaffin, Black, and Cao used CDFs to show the probability of outcomes to farmers based on Black's success with Hilker, Baldwin, and Black (1997) using CDFs. Chaffin, Black, and Cao might consider expanding there approach to include county trigger revenue products and show the mechanics how to back up their recommendations.

Farm Docs staff have developed a model to evaluate each insurance policy by using a long-run context. The Farm Docs Crop Insurance Evaluator (2005) shows net returns to each insurance program during the last 30-plus years before insurance premiums were used. The policies were evaluated on outcomes. The insurance policies can be ordered by expected revenue, the amount of time the expected revenues are below a threshold, and the mean returns. The downfall of this program is that when evaluating the insurance policies, the effect of having more than one farm unit is not captured. By not capturing the effect of multiple farm units that influence effective coverage, the program is biased toward county trigger policies. Even though it does not capture farm units, the program does a good job when evaluating how county trigger policies would have preformed. The evaluation shows how each insurance policy would affect farm revenue. The analysis also shows that farm unit trigger policies have a net loss to producers, while county trigger policies have a net gain to producers dependent upon coverage level.

Insurance Agency and Extension Software

Spreadsheet programs are available at some insurance agencies to show payouts of county trigger policies and how farm yields track to county yields. Chaffin and Black (2004) standardize farm yields to show better how it was tracked. Silveus Insurance Group (2005) has a program that shows what the county trigger indemnity payments might have been in the past. Many programs evaluate county trigger policies by looking at how they would have worked in the past. The spreadsheet programs take past county yield figures and show how payouts would have been distributed. A downfall of some spreadsheets are that they are limited in approach, such as only looking at how much a farmer would have made from the insurance and not farm cash flow. Also the spreadsheets do not reveal how much risk was transferred. The spreadsheets developed by extension staff and insurance agencies look at the past as a way to predict future payouts for county trigger insurance. After the payouts are figured, some programs add payouts to farm revenue to determine net farm revenues. Looking at past payouts may be helpful, but it does not predict future yields or cash flows.

Journal Articles and Research Projects

Considerable literature has developed concerning the concept and use of yield and revenue indices as a basis for insurance policies. However, Barnett et al. (2004) is the only large multi-state study that looks at the correlation of farm and county yields and the associated risk transfer. The study was motivated by the Nebraska Commissioner of Insurance, saying that GRP is a lottery. Barnett compared the variance of farm yields under GRP at 90% to APH at 65%, 75%, and 85% coverage levels. He also worked to find the optimal scale for county trigger policies. He concluded that county trigger policies are not a lottery because risk is transferred. Skees, Black, and Barnett (1997) focused on design and rating of the policies. While working on a policy design scale, factors are addressed.

Wang, Hanson, and Black (2003) evaluated crop insurance programs using maximum expected utility. Their findings shed light on how utility-maximizing people would make crop insurance decisions. The shortcoming of both Barnett et al. (2004) and Skees, Black, and Barnett's (1997) research is that neither did not include decision rules. In Wang, Hanson, and Black's (2003) research, the concept of utility does not relate to farmers, lenders, and insurance agents.

Wang, Hanson, and Black (2003) included a wedge[8] to take into account any adverse selection, moral hazarded, and cheating when looking at farm unit policies. By taking into account these problems, their analysis of county trigger policies, when compared to farm unit policies, show how farms are affected by risk misclassification. Stokes, Barnaby, Waller, and Outlaw (1999) and Barnett, Black, Hu, and Skees (2004) agree that county trigger policies are usually less money than APH "farm unit trigger" policies for the same level of effective coverage. This confirms the research by Wang, Hanson, and Black that there are wedges. Since the policies do not have the same price for the same levels of effective coverage, there is evidence of a wedge. Articles written to this point for the industry are user friendly, and they do a good job showing/demonstrating how insurance policies work. Missing are decision rules, farm yield correlation to county yield, and long-run impacts for county yield and revenue trigger products. Insurance agencies and extension staff have looked at past payouts of county insurance policies to show how they could pay out in the future. Policies should not be sold to farmers as a risk transfer tool, based on how much they paid out in the past and the probability of future payouts. Journal articles and research projects have focused on expected utility, policy design, scale factors, and risk transfer, and while these concepts are good, most farmers, insurance agents, and lenders do not understand them. They need decision rules. Wang, Hanson, and Black (2003) did a good job including wedge, but most farmers, insurance agents, and lenders do not comprehend the concept of utility maximization.

[8] Wedge is the difference between actuary fair premiums and the charged insurance premiums. Risk classifications problems, along with moral hazard, lead to some farms paying as much or more than double the fair insurance premium for the amount of risk they have.

The research to this point is good, but it needs to be expanded to give farmers, insurance agents, and lenders decision rules to use with when making insurance choices. This paper's niche is that the research will show risk insurance transfers, over time, in terms that farmers, bankers, and insurance agents will understand. In the research, it is shown how county trigger policies work with different farm to county yield correlations that are based on spread in a county. A wedge will also be included in the simulation for farm unit policies, and an example farm will be used to demonstrate the affect of a wedge. Decision rules are given, based on farm to county yield correlations, and CDFs are used to illustrate how different insurance policies transfer risk. The primary focus of this paper is on county trigger policies, but farm unit trigger policies are also addressed.

METHODS

Monte Carlo Simulation Model

A Monte Carlo simulation model is used to reveal how different insurance policies work. Simulation was used because a closed-form model does not exist. A year-by-year evaluation of insurance policies also was not used because there is not a long-run time series of data to capture most weather events. By using a Monte Carlo simulation, random events can be evaluated. Simulation will also show how events, such as weather, can affect outcomes. In the model, 10,000 draws are used to create the CDFs and generate outcomes. In a given year, any crop insurance policy, or no insurance, can be the best choice. By simulating many outcomes based on yield, yield standard deviations, and correlation it is shown which policies, given certain criteria, will have the most risk reduction for a farmer over time.

Two goals of the simulation are to evaluate policies on an out-of-sample basis, and capture the effect of farm unit diversification and correlation. The out-of-sample estimation will be able to portray accurately county trigger policies advantages and disadvantages. The Monte Carlo simulation model will also capture the effect of farm unit diversification and correlation. With lower farm unit correlations, the higher the effective coverage will be with farm unit insurance. The model is designed to capture the affect of multiple units.

Model Setup

In the simulation, 10,000 random draws were used to estimate measures of central tendency and generate CDFs. The model was checked with 5,000 draws, 10,000 draws, and 15,000 draws. The CDF for 5,000, when compared to CDF with

10,000 draws, had some variation. When 10,000 draws were compared to 15,000 draws, the outputs were about the same.

When establishing a yield density function for the units in the example county, corn yields from 1970 to 2003 were used from Lenawee, Branch, and Monroe Counties in Michigan. These counties were used because they are in one area of Michigan, and their soils are similar. Using three counties gave a more representative density function than if a single county was used. Steps developed by Xu (2004) were used to generate the yield density function:

1. De-trend each county's yield
2. Standardize each county's yield to 2003
3. Use kernel density estimators to generate residuals
4. Combined data from each county to generate one yield density function

In the simulation, 31 yields were drawn for each unit. The first 30 yields were averaged to establish a county estimated mean yield. RMA used a history of at least 30 years to establish the estimated county yield. The average of the last 30 years can be used because all the yields are standardized to 2003 yields. To build farm unit policies, data of the last 10 years was used to establish the expected yield. In the model, the number of years can be varied. APH policies state that at least four years of history is needed or else T yields[9] would be used. For the farm unit research in this paper, 10 years of history was used to generate the farm units' historical yield.
The model was set up to evaluate out-of-sample results. The model drew 31 outcomes for each unit. Then county yields were established, using the first 30 draws and farm

[9] A T yield by Edwards (1998) "is equal to the Farm Service Agency (FSA) established yield for that unit times the county adjustment factor, which is usually a value between 90 to 100 percent."

unit yields were established using draws 21–30 draws. A smaller number of data were used for farm unit policies because of shorter farm-yield histories. After yields were established, the results from draw 31 were used to calculate whether there was an indemnity, and if so, how much. The results were out-of-sample because the outcomes from draw 31 were not used in calculating the farm unit or county predicted yields. Also, draws 1–30 were not used to calculate insurance indemnities.
The spring price, yield standard deviations, and correlations were based on a discussion with James Hilker (personal communication, October. 15, 2004). The revenue policies have a constant assumed spring price of $2.40 per bushel of corn. With the spring price being set, the fall price varied based on a log normal distribution having a mean of $2.40 per bushel and standard deviation of $.50 per bushel. By using a log normal distribution, there is a tendency for price to have more upside potential than a downside risk. Yields and prices are uncorrelated. In Michigan, since the correlation between farm yields and market price is low, the correlation is not included.

The basis price and standard deviation were based on a discussion with James Hilker. A basis was added to the futures price that is representative of the county where the actual data were collected. It is important to include a basis because county prices vary from futures based on local demand and transportation costs. The basis is normally distributed with a mean of 30 cents and a standard deviation of 10 cents. The spring price of $2.40 plus the basis, which is negative, were used to convert bushel policy losses to dollars. This conversion is needed when yield policies are converted to revenues. Revenues are used to show how insurance products influence farm cash flow.

Rates for county trigger policies are treated as being "actuarially fair[10] [11]." To establish the breakeven rates, the amount paid out equals the gross premium charged over time. With the USDA subsidy, farmers pay 45% of the breakeven premium with 75% farm unit coverage and 90% county trigger coverage. The USDA also subsidizes all the administration costs to carry out crop insurance.

Wedge

Farm unit trigger policies have a wedge added to the actuarially fair premium. A wedge is the difference between actuarially fair premiums and the premiums actually charged before subsidy. The wedge captures moral hazard[12] and adverse selection[13] problems that accompany farm unit trigger policies. County trigger insurance policies do not have a wedge because the rates are set out of sample and farmers should not know more about county yields than RMA.

On case farm one, over the last ten years, an APH policy with 75% coverage using a whole farm unit approach would have cost the farm $15 an acre before subsidy, but case farm one would have only received (1.8 bushels @ $2.30 price/bushel) or $4.14 an acre. With case farm one only getting $4.14 an acre, and paying an unsubsidized premium of $15 an acre, there is evidence of a wedge that is equal to $3.62. The wedge is calculated by taking the cost of insurance before subsidy

[10]Rates over time will break even, meaning that they take in as much as they payout. With insurance subsidies, actuarially farm premiums are fewer indemnities.

[11] The rates for the farmer are treated as being actuarially fair. The rates are not actuarially sufficient for the insurance pool.

[12] An example of Moral Hazard is that since the crop is insured, use less fertilizer because if the crop fails, it is insured.

[13] With rates being generic across a county farms with less risk will choose not to insure because of the higher costs.

and dividing it by net benefit. The wedges will vary on each farm, but on case farm one, the farm would have paid $6.75 an acre after subsidy and received $4.14 an acre. Even with the government subsidy, case farm one would not have received a net benefit. With the government subsidy for APH at 75% coverage, case farm one should double their investment in insurance over time.

Possible reasons that cause the wedges to vary are planting dates, moral hazard, adverse selection, and cheating. One way of cheating is in a situation when a farmer lies about either actual or past crop yields. Crop planting dates affect possible yields, as well as risk associated with production. An example is: if beans are planted too early in Michigan, there can be frost that will kill the plants. In the insurance policies, it is prohibited to plant before April 15. However, a farmer may plant after April 15, and transfer the risk to the insurance pool, but the farmer would still have replant coverage if a late frost should occur. The typical time to plant soybeans in Michigan is the first week of May. Moral hazard can cause wedges to vary between farms. If there is an insect problem, and one farmer treats the problem while the other farmer does not, and the farmer who did not treat for the insects lets the insurance pool stand the poor yields, the farmer who treated for the insect problem will cost the insurance pool much less resulting in a bigger wedge on his/her farm. By not forcing farmers to buy insurance policies, adverse selection can occur; this is where farmers with more systemic risk choose to be insured because the policies are under priced for them. If a farm with less systemic risk than average selects a farm unit policy, their wedge will be greater than one. If a farmer cheats on the insurance policy, the wedge will be less than one, leading to the most honest farmers having a wedge that is greater than one.

With these problems, an honest farmer who is not taking advantage of adverse selection, moral hazard, or abuse of planting dates should have a wedge that is over one. This is why a wedge was added to the farm unit policies. The wedge brings observed rates in the simulation into line with actual rates charged. The wedge is backed up by findings on case farm one.

Hypothetical County

A hypothetical county is used in the simulation exercise. The exercise is used to explore how a farm's geographic spread in a county affects the tracking between farm yield and county yield.

The hypothetical county is represented by 16 locations as shown in Table 2. Each location has a weight of 1/16 in calculating the country average yield per year. For all graphs shown, a yield of 140 bushel per acre with a standard deviation of 40 was used.

Table 2:

Map of Example County

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

An individual farm is represented by the amount of land it has in each of the 16 locations. For example, a farm could have ½ of its acreage in location 1 and ½ in location 2. Clearly, the more representative the farm is of the county, the more farm and county yields will be move together. Indeed, if a farm has land in all of 16 locations, its yield will track to the county yield perfectly, except for sampling error. Sampling error refers to the error in the correct county yield when compared to the realized county yield. Usually realized county yields closely relate to the National Agricultural Statistics Services (NASS) estimates of county yield, but there can be some variance between the actual yield and the NASS estimated yield.

The analysis assumes that the closer the locations are in a county, the higher their correlation. Yields from nearest-neighbor points are assumed to have a 0.85 correlation; the correlation falls the further locations are apart, dropping to 0.50 for locations that are farthest apart (e.g., points 1 and 16).

Yield correlations between locations are imperfect because weather events do not occur in all locations equally; the greater the distance between locations, the lower the likelihood of having the same weather event in any given location. Also, the same weather event will not have the same impact on different soils in different locations and soils tend to have a spatial distribution in a county.

Locations in the center of the county will correlate to the county yield better than locations on the perimeters of the county. If a farm is on the perimeter, an extreme weather event can affect the farm yield and not have the same influence on county yield. On the other hand, if an extreme weather event occurs in a location that is in the center, it is likely to occur in more than just that location.

The yields and standard deviations of each location for the example county are shown in Table 3. The layout of the county is important because some counties have locations that vary in expected yield and yield variability. Different yields and variability of locations are not taken into account in any of the graphs.

Table 3:

Units Mean Yields and Standard Deviations

North ↑

Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40
Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40
Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40
Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40	Mean 140 Std 40

Establishing Yields

Yields for each location and the county are generated simultaneously to take into account the correlations between locations. The location yields are averaged to generate the county yield.

To take into account the sampling error when county yields are estimated, there is an error term added. The error term is based on a discussion with J. Roy Black (Personal communication, October 16, 2004). The error term is normally distributed with a standard deviation of 3. Yield estimates by NASS for the county are not perfect. Over time, the mean estimation error mean will be 0, but the errors can affect net farm yields or revenue when using county trigger policies.

The error term is added to county insurance policies because NASS uses surveys to get yield data. When surveys are sent out randomly to farmers in a given county one year above average yielding, farmers might get surveyed and the next year below average yielding farmers get surveyed. With random surveys, it is possible to get slightly skewed result. With many draws, the estimation error will average 0, but in any year the actual and surveyed county yields will vary.

A unique aspect of county trigger policies is that they have a disappearing deductible. The deductible on county trigger policies disappears as the yield or price goes lower. The deductible is lessoned because the loss (guarantee–actual, 0) is divided by county yield and coverage is then multiplied by county yield, scale, and spring price. It is possible not to have a deductible if the county yield is zero. Please see Appendix 1.

Model Setup Example

1. Draw 30 yields for each location in the county[14]
2. Establish county yields for each draw
3. Calculate mean county yield based on an average of the last 30 draws
4. Establish yield history for each location based on an average the last 10 draws
    a. APH has to have at least four year of history or T yields are substituted in. The maximum amount of yield history used for APH is 10 years
5. Establish spring prices: $2.40 for revenue policies and $2.40 + basis for yield policies
6. Draw one more yield for each location[15]
7. Draw a fall price
    a. Lognormal with a mean of $2.40 and a standard deviation of $0.50
8. Draw a basis
    a. Normal with a mean of $-0.30 and a standard deviation of $0.10.
9. Establish the realized county yield
    a. The average of the 16 units that make up the county

[14] Location yields drawn are correlated based on distance.
[15] Draw 31.

10. Calculating indemnity for GRP

a. Indemnity=max(county 30 year average yield[16] x coverage[17]–county realized yield,0)/(county 30 year average yield x coverage) × county 30 year average yield x scale factor x spring price.

11. Calculating indemnity for APH

a. Indemnity=max(farm unit 10 year average yield x coverage–farm unit realized yield,0) x spring price

12. Calculating indemnity for GRIP

a. Indemnity=max(county 30 year average yield x spring price x coverage–county realized yield x fall price,0)/(county 30 year average yield x coverage × spring price) x county 30 year average yield x scale factor x spring price

13. Calculating indemnity for RA

a. Indemnity=max(farm unit 10 year average yield x coverage x spring price–farm unit realized yield x fall price,0).

14. Calculate indemnity for GRIP-HRO

a. Indemnity=max(county 30 year average yield x max(spring price, fall price) x coverage–county realized yield x fall price,0)/(county 30 year average yield x coverage x max(spring price, fall price) x county 30 year average yield x scale factor x max(spring price, fall price)

15. Calculating indemnity for RA-HRO

a. Indemnity=max(farm unit10 year average yield x coverage x max(spring price, fall price)–farm unit realized yield x fall price,0)

16. Calculating farm revenue

a. Farm revenue without insurance=average yields of locations farmed[18] x (fall price + basis)

[16] This is also called county predicted yield.
[17] Works as a deductible would work; its yield must fall 10% before a payment is made. This equals a coverage of 90%.
[18] Simulation model assumes equal percentage of land farmed in each location.

b. Farm revenue with county trigger policies=farm yield x (fall price + basis) + county policy indemnity–premium

c. Farm revenue with farm unit insurance=farm yield x (fall price + basis) + indemnity for each unit farmed–premium for each farm unit

For county trigger policies the above equations are the way policies are technically delivered by RMA. In the model, the county indemnity equations were shortened to Indemnity=Max(county 30 year average yield x× coverage–county realized yield,0) x scale. Even though the equations were shortened, they will still generate relatively the same result without the disappearing deductible. If the disappearing deductible were included, there would be an increase in the cost of the policies accompanied by a larger net benefit.

Generating Yield and Insurance Indemnities

When using county insurance policies, the realized county yield is compared to the county established yield multiplied by coverage which equals the trigger yield. If the county realized yield were below the trigger yield, an indemnity payment is made. In the simulation each set of 31 years generated varied county predicted yields and county realized yields. Net farm yield with GRP equals the average yield of locations farmed plus the GRP indemnity in bushels minus GRP premium[19] in bushels.
When using APH, each location in the county is also treated as an optional farm unit. With APH insurance, the realized farm unit yield is compared to the farm unit's historical average yield and multiplied by coverage that equals trigger yield. If the farm unit's realized yield is below the trigger yield, an indemnity payment is made. The APH indemnity payment equals APH trigger yield–farm unit yield. When establishing historical farm unit yields, an average of the last 10 years yields was used.

[19] The subsidized cost of GRP insurance is used because this is the price that farmers actually pay.

Each set of 31 years in the simulation generated varied historical farm unit yields and realized net farm unit yields. Net farm yield with APH equals the average of locations farmed, plus APH indemnity for each location, minus APH premiums[20] for each location.

The net farm yield takes into account subsidized insurance premiums and actual indemnities when evaluating the different insurance policies. To evaluate the different insurance policies, it is assumed that higher yields and/or less yield variation would be preferred by farmers. It is important to see how net farm yields and revenues are changed with different risk management practices.

Actual Correlations vs. Correlation Matrix Used

Table 4 shows actual correlations for real farm unit data are more variable than what is generated in the simulation model. The observed data had correlations as high as .9734, and as low as .4778. The model used a high correlation of .85 and a low of .5. With more observations, outliners in observed farm unit data are assumed to converge on a central tendency, and thus reducing, if not eliminating, the spread in the observed verses actual correlation.

[20] The subsidized cost of APH insurance is used because this is the price that farmers actually pay.

Table 4:

Actual County and Unit Correlations

	County	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F	Unit G	Unit H
County	1.0000								
Unit A	0.6920	1.0000							
Unit B	0.9021	0.4778	1.0000						
Unit C	0.8792	0.5022	0.9777	1.0000					
Unit D	0.8480	0.5879	0.8926	0.9734	1.0000				
Unit E	0.9697	0.5659	0.9211	0.9607	0.9609	1.0000			
Unit F	0.7572	0.5621	0.8271	0.4702	0.6110	0.6902	1.0000		
Unit G	0.9166	0.7654	0.9225	0.8828	0.8272	0.9178	0.7303	1.0000	
Unit H	0.7971	0.6731	0.8803	0.7911	0.8609	0.9107	0.7484	0.9482	1.0000

County Rates Charged vs. Rates Generated in Model

In the model, generated insurance premiums for county trigger policies are near to the actual insurance premiums charged in the county where the case farms are located. Unlike actual rates, rates in the model do not have a safety factor added to them because the rates are generated out of sample. It is assumed that the actual rates charged have a built in safety factor for estimation error**.** The model's insurance premiums are generated out of sample so they should be more accurate than the way RMA establishes its insurance premiums; therefore, a safety factor is not added. When rates from the model for county trigger policies are compared to actual rates minus the safety factor, they are very similar.

Similar rates suggest that the correlation matrix and yield assumptions are valid. This is an important double check for the model. If the rates generated were not close to county rates charged, the model could be viewed as inaccurate and information generated from the model would be suspect.

In the model, the same government subsidy of 55% was used for both county and farm unit trigger insurance policies[21]. The model does not include preventative plant, replant, and quality provisions that are in farm unit policies. If these previsions were added, the insurance premium charged would go up.

When running the model, APH insurance premiums were about half the actual price charged. It is doubtful that preventative plant, replant and quality provisions would double the cost of farm unit insurance. A wedge was added to account for the discrepancy between actual price charged and the price in the model. The wedge brings farm unit prices that are charged in the model back in line with those charged in

[21] The 55% subsidy applies to 90% GPR coverage and 75% APH coverage.

reality. The wedge accounts for moral hazard and adverse selection. With the high probability that the price of APH is out of line for an average farmer, county trigger policies might be a better alternative to provide risk transfer.

Test of County Means, Standard Deviations, and Correlations

Experiments were run with different yield means, standard deviations, and correlations. The correlations varied as they were based on yield variability and distance. The county was divided into three groups; each group had a different standard deviation and mean. Above-average soil had a mean of 150 with a standard deviation of 30. Average soil had a mean of 130 with a standard deviation of 40. Below-average soil had a mean of 120 with a standard deviation of 45. When all the different variables were taken into account, the results were nearly the same. The layout of the example county with yield variability is shown in table 5. Since results were nearly the same as the model based on distance to determine correlation, the distance model was used for all the calculations.

Table 5:

Farm Units Mean Yields and Stand Deviations for Varied Counties

North ↑

Mean 130 Std 40	Mean 130 Std 40	Mean 150 Std 30	Mean 130 Std 40
Mean 120 Std 45	Mean 130 Std 40	Mean 150 Std 30	Mean 150 Std 30
Mean 120 Std 45	Mean 150 Std 30	Mean 130 Std 40	Mean 130 Std 40
Mean 150 Std 30	Mean 150 Std 30	Mean 130 Std 40	Mean 120 Std 45

County Insurance Policies

County insurance policies that are subsidized and have Actuarially Fair Premiums being charged, the Net Cost over time will be negative. It is assumed that estimated county yields and rates are fair[22] for the GRP programs. If estimated county yields and rates were actuarially fair and the USDA subsidized 55% of the break-even cost and the costs to administer the programs, over time the programs should offer a net benefit to farmers

If county trigger policies offered a net gain, will farm unit policies that have the same subsidy factor and fair rates have a net benefit? No, they would not because of asymmetric information and moral hazard problems. Most farmers who use farm unit trigger policies will not experience the same net benefit as with county trigger polices. Some farms have a net financial gain when using farm unit policies, but most farms do not. The long-run net benefit of county trigger programs should be positive; which makes the programs more attractive to some farmers.

Establishing Conditions Where GRP Warrants Consideration

This section covers a series of steps that should be undertaken to determine whether county trigger policies are potentially a good insurance policy for a given farm. That is, is it a policy that provides a desired risk transfer at a reasonable price? Case study results are shown in this section in order for knowledge of tracking and scale factors are determined before the optimal scale factor is found.

[22] Fair rates are break even over time, with government subsidies being included for premiums and all administration costs.

Step 1: (To find if GRP is Acceptable) Graph Farm Yields vs. County Yields. Do farm yields correlate with the county yields from year to year? If not, county trigger insurance is not an adequate risk transfer tool for a farmer. The first step is to graph farm yields vs. county yields. Four case farms are used to illustrate what tracking means and its affect on risk reduction.

There are many factors that determine how farm yields will correlate to county yields. The factors include: soil types farmed vs. a representative sample of county soils, drainage on the farm compared to the county drainage, management, irrigation on farm vs. the county, microclimates, and spatial diversification of the farm across the county.

The case farms vary in size and geographic spread. The case farms and county are real, but their location will remain undisclosed. Farm 1 is spread over 9/16 of the townships in the county. The soils on farm 1 match up well with the county. Also, Farm 1 uses irrigation on some of its coarser textured soils. Farm 2 is spread over 3/16 of the townships in the county, and its soils are about the same as the county to slightly heavier. Case Farm 3 is spread out over 3/16 of the townships in the county, and its soils are heavier than average for the county. Case Farm 4 is in 1/8 of the townships, and is limited in geographic scope. The soil makeup of Farm 4 is more coarsely textured than average for the county.

Table 6 shows the location of land farmed by the case farms. Spatial diversity is important to consider when deciding if county trigger policies should be used. The locations farmed by the case farms are shown to add to the discussion of spatial

Table 6:

Case Farms Spatial Diversity

North ↑

			1	1			
		1		1	1	3	1
			1	1 & 4		3	1 & 3
2		1	1 & 4	1		3	
2	2		1	1		3	
2	2			1			3
2				1			

diversity. If a farm were more spatially diversified, it would have less risk of small, adverse weather events, such as hail.

Figure 1 shows Farm 1's corn yields graphed against the county yields. The graph uses historical yield data that begins in the mid-1980s.

Farm 1 yielded above the county yield for 19 of the last 20 years. More importantly, the farm's yields tended to track the county yields; but it is hard to tell how well without further standardization. To show better how farm yields track the county yields, farm yields were standardized to have the same mean yield as the county. This was done by taking the average of county yields together with the average of the farm's yields to find the difference. For Farm 1, its average yield was 17.9 bushels higher than the average county yield; therefore, 17.9 bushels were subtracted from each year's farm yield. The results are plotted in Figure 2.

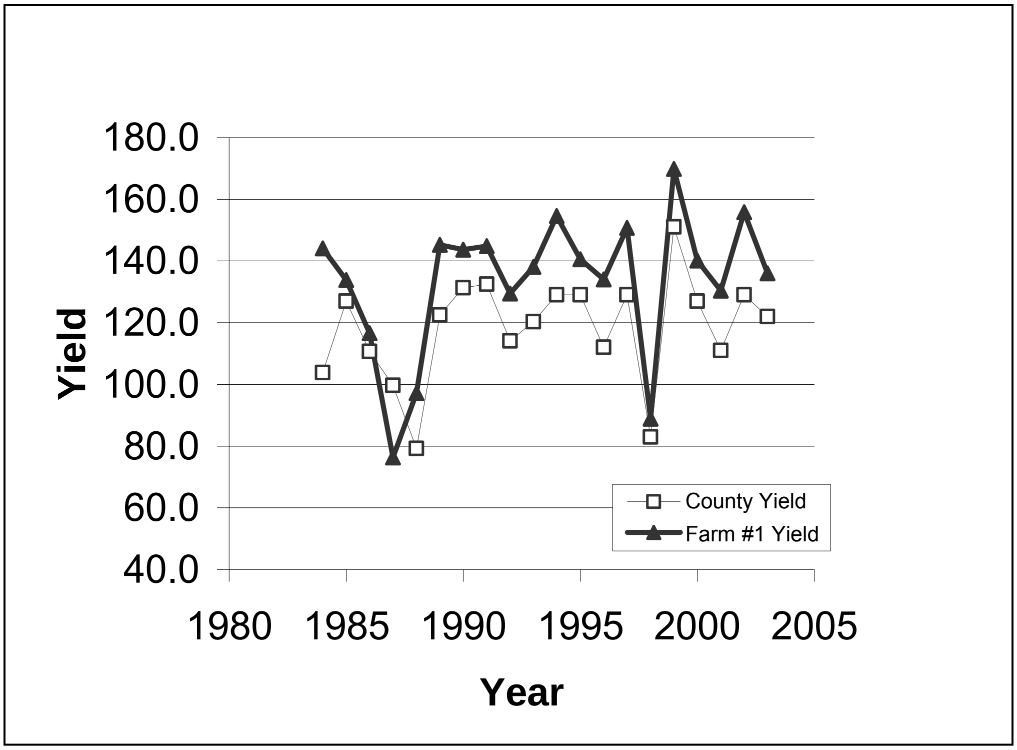

Figure 1: Farm 1's corn yield and county yield

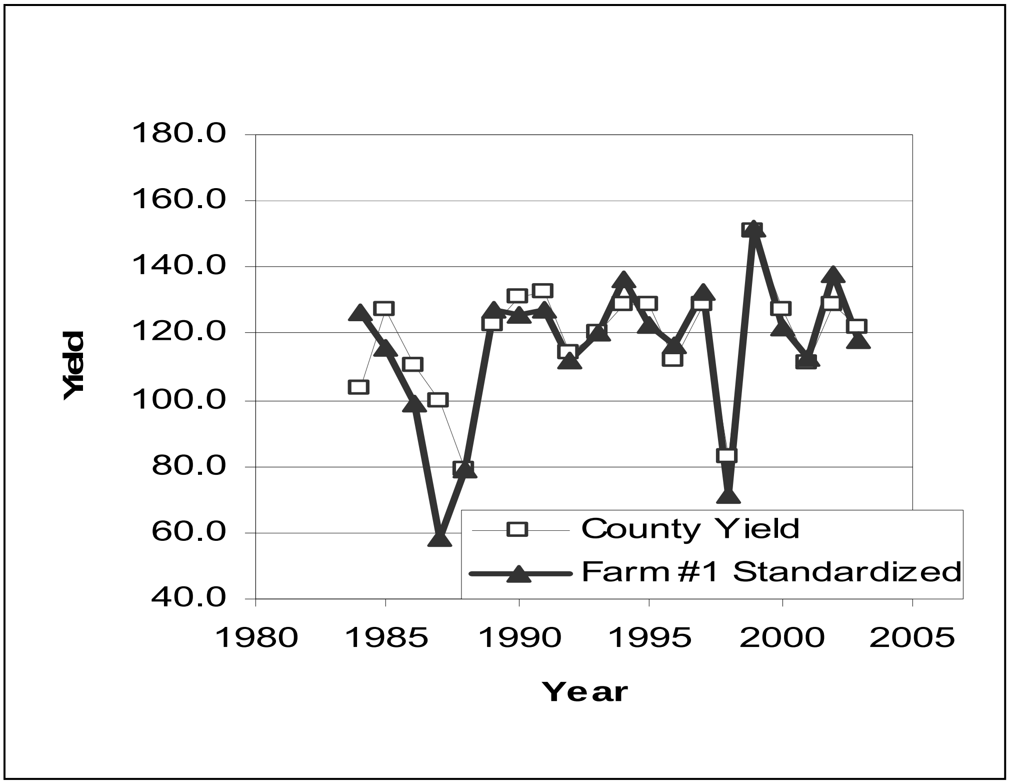

Figure 2: Farm 1 standardized yield vs. county yield

Farm 1's standardized yields track the county yield in most years (shown in Figure 2). From 1988–2003, the county trigger policy would have worked well; the year-to-year changes in farm and county yields track. When farm yields were below average, county yields were below average by a similar amount, and scaling up would further improve the match. But, 1987 would have been problematic because the farm yield was about 50% of average, while the county yield was down only modestly. This would have led to the farm's getting a small insurance indemnity payment in a year when money was needed. The correlation between Farm 1's yields and county yields was .85 from the 1984 to 2003 period and 0.96 from the 1994 to 2003 period.

Farm 2 has 10 years of yield history that is shown in Figure 3. The yields were standardized to the county average yield and graphed. The farm and county yields tracked well in 1998, but there would have been a problem in 2001 when standardized farm yields were substantially below county yields. This would have led to the farm's needing a large indemnity payment, but receiving an inadequate payment. This contrasts with Farm 1 where farm yields tracked county yields in 2001. The correlation between Farm 2's yields and county yields was .93.

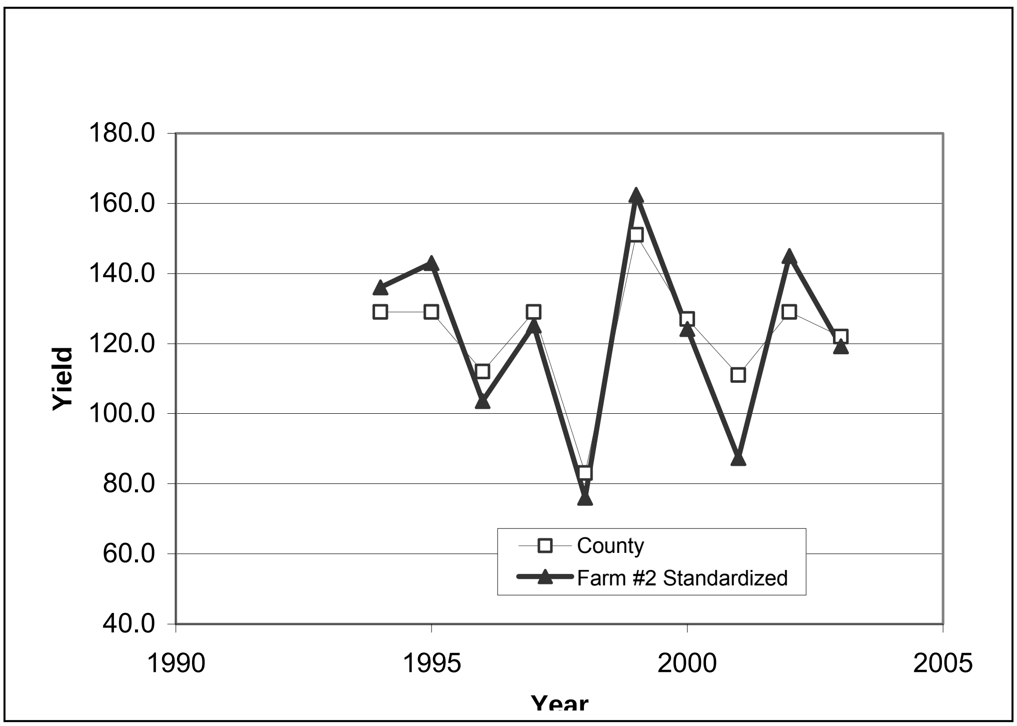

Figure 3: Farm 2 standardized yield vs. county yield

Farm 3 had 10 years of yield history that is shown in Figure 4. In 1998, both the farm and the county yields fell significantly, but the drop in the farm yield was less than the drop in the county yield. With the farm's having less of a drop than the county had, a GRP policy would have provided excellent risk transfer. Unfortunately, the yield series does not go back to 1987 so it is unknown whether or not Farm 3 would have had the same problem in 1987 as Farm 1 had. The correlation between Farm 3's yields and county yields was .78.

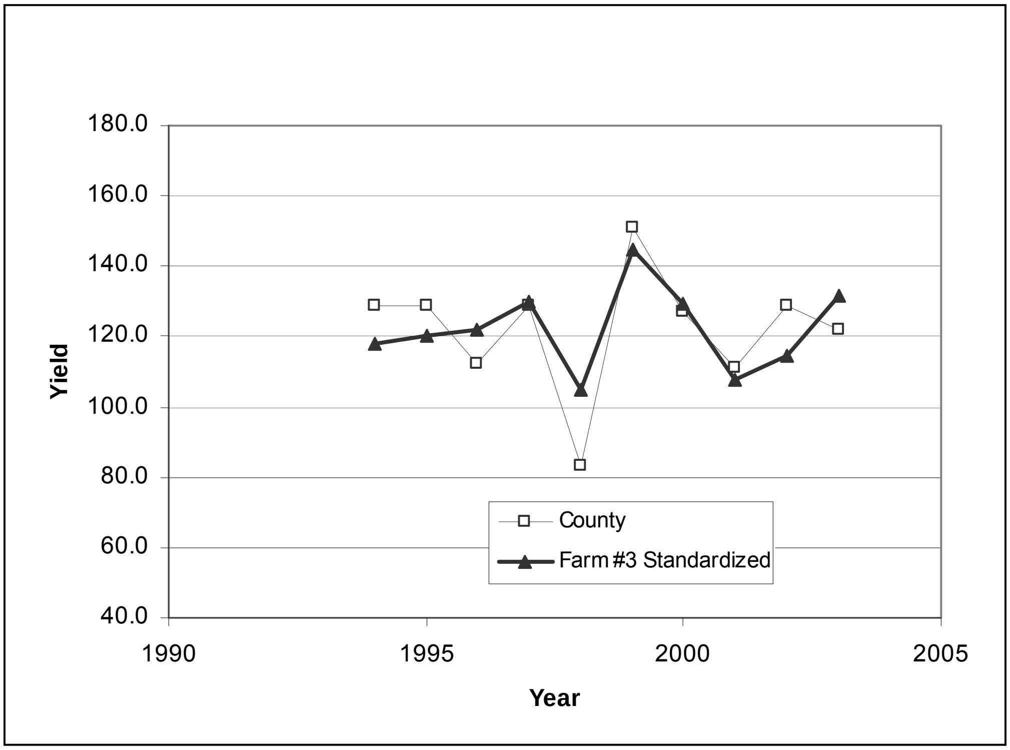

Figure 4: Farm 3 standardized yield vs. county yield

Farm 3 showed there was more for farms to evaluate than just correlation. On Farm 3 its yields were less variable than the county's yields, and the farm-to-county yield correlation was low. The percent loss[23] of farm yields in 1998 was less than the percent loss in the county. When a farm's yields are less variable than the county yields, correlation will not show adequately which insurance policy a farmer should choose.

[23] Percent loss = realized farm yield/expected farm yield × 100 – 100.

Farm 4 is shown in Figure 5. Standardized yields were significantly below the county yield in 1998 and 2001. Both farm and county yields were down, but the farm yield was down substantially more than the county yield. This illustrates why the ability to "scale up" is important so shortfalls in the county yield better match shortfalls in farm yield. The correlation between Farm 4's yields and county yields was .93.

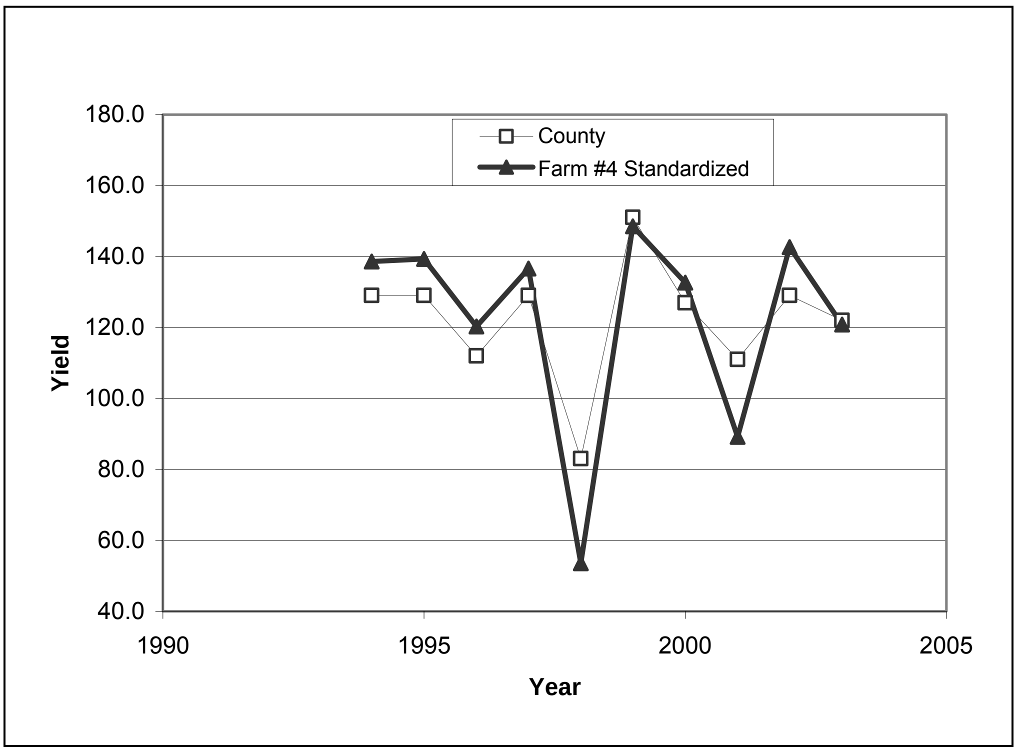

Figure 5: Farm 4 standardized yield vs. county yield

Farm 4 is probably not a good candidate for county trigger policies, even though the match between farm and county yield is good. Because Farm 4 covers a small area in the county, there is a possibility that it will face events that other areas of the county do not experience to the same extent.

In all the examples, at least 10 years of data were used, but 20 years are recommended. While 20 years of farm yields are often not available, farmers generally have a recollection of poor yield years and these can be checked against county yields.

The closer farm yields track county yield indexes, the better county trigger policies will work. If farm yields do not track county yields, this will lead to years when a crop insurance indemnity is needed, but a payment might not be received.

Step 2: Calculate Farm Yields with Insurance Indemnities:

If tracking is acceptable, the second step in the GRP evaluation process is to evaluate what the yield would be if the insurance payment were added to the realized farm yield. Most of the time, there will not be an insurance payment, so farm yields plus indemnities are the same as realized yields.

GRP permits farms to scale up coverage to compensate for the fact that the farm yield is typically more variable than county yields and a farm's average yield can be greater than the expected county yield. Calculating the scale factors for each case farm that will minimize risk will be shown after the affect of different scale factors are demonstrated.

Figure 6 shows how scale factors affect Farm 1's net corn yield in years when there would have been a county insurance indemnity. When insurance payments are made, bigger payments will be made with a bigger[24] scale factor. Figure 6 shows how scaling up changes insurance indemnities. In Figure 6, yields with GRP at scale factors of 1.0 and 1.5 are compared to no insurance and county trigger yields.

[24] Cost of insurance will increase with bigger scale factors.

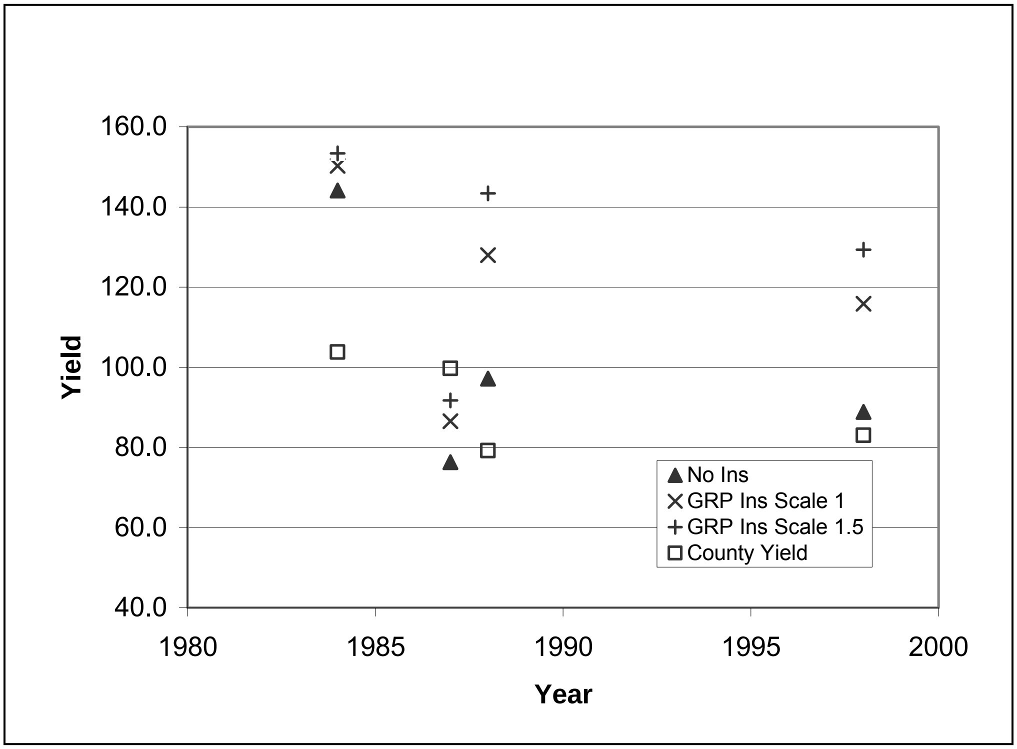

Figure 6: Farm 1 Yield without insurance vs. yield + GRP with scale of 1 vs. yield + GRP with scale of 1.5 vs. county yield.

Figure 6 shows how farm yields, plus indemnities, change with different scale factors. With a higher scale factor, the lower the county yield, the higher the farm yield, plus indemnity, will be. Depending on correlation of farm yields to county yields, different scale factors will transfer the most risk. Risk transfer is measured by risk reduction[25] and higher net yields.

Figure 7 compares farm yield plus indemnities for Farm 1 with and without insurance from 1995 to 2003. APH has 75% coverage while GRP has 90% coverage with a 1.5 scale factor. For calculating APH insurance indemnities, 6 actual farm units

[25] Smaller variances and downside variance.

from Case Farm 1 were used. Recall that Farm 1 had exceptional tracking from the 1994 to 2003 period with a correlation of 0.96 between farm and county yields.

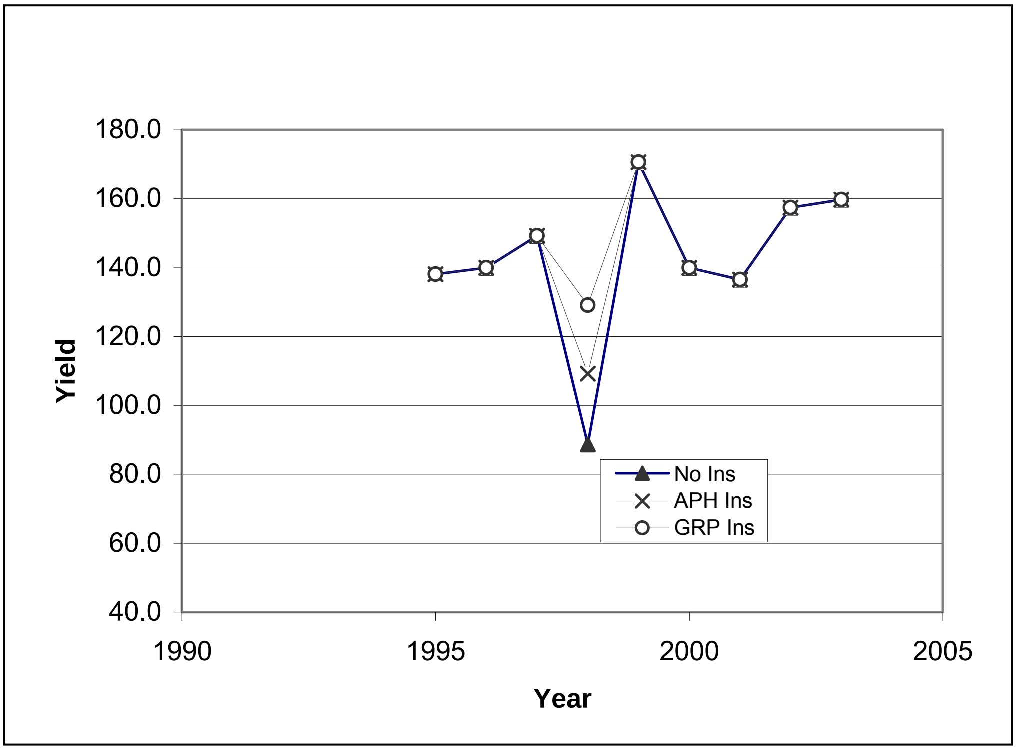

Figure 7: Farm 1 yield without insurance vs. farm yield + APH insurance vs. farm yield + GRP insurance scaled 1.5.

Figure 7 reveals how the different insurance programs would have affected the farm in 1998 when there was a drought. As expected, GRP with 90% coverage performed very well because the tracking was outstanding. APH insurance was intermediate between self-insurance and the GRP insurance. The cost of crop insurance was not incorporated into this graph; however, it would be unusual for GRP coverage to cost more than an APH policy for similar levels of effective coverage[26].

[26] APH at 75% cover and GRP at 90% coverage.

Figures 8, 9, and 10 show farm yields without insurance with GRP insurance. Farms 2, 3, and 4 are shown in that order.

GRP would have worked well for farm 4 during the last 10 years even with its limited geographical scope. Nevertheless, with scale factor being limited, it results in a below-average net yield for Case Farm 4 in 1998. Also, as noted earlier, with the limited spatial diversity, GRP would typically not be recommended for Farm 4.

Scale Factors

This section covers how to calculate the scale factor that will minimize variance in farm yields and revenues. It is important for farmers, lenders, insurance agents, and those in academia to understand how a farm can minimize risk with county trigger insurance policies. The optimal scale factor for each farm will be revealed, and its effect on risk will also be shown.

Variance Minimization Equation Used to Find the Optimal Scale Factor

To find the optimal scale factor, yields before insurance are compared to yields with insurance indemnities. To find insurance indemnities prior to 1997, estimated trigger yields were used. Indemnities were calculated from onward 1980. Coverage level was fixed at 90% so indemnities could be an input into the equation.

The equation minimizes variance in farm yields by optimizing the scale variable.

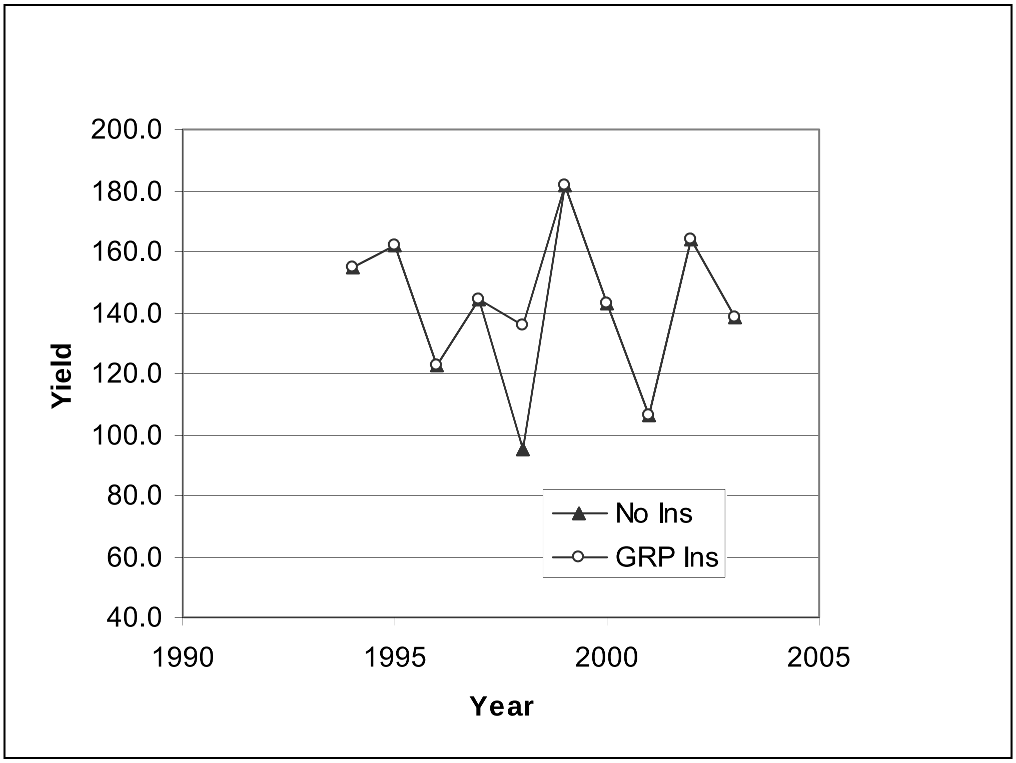

Figure 8: Farm 2 yield without insurance vs. farm yield + GRP insurance.

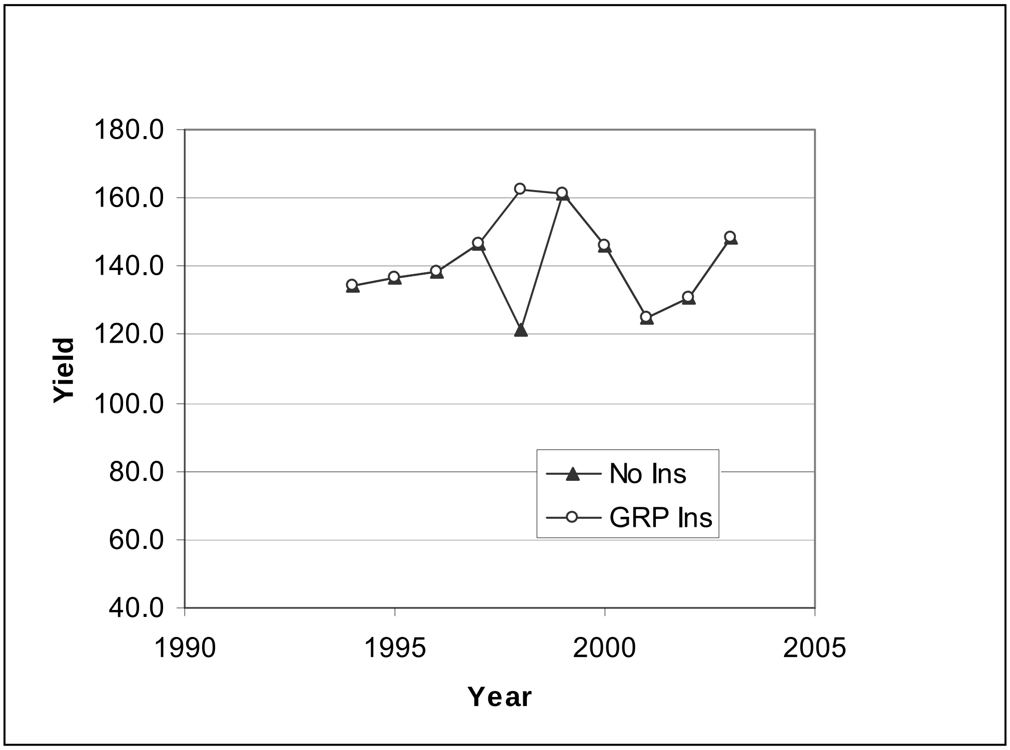

Figure 9: Farm 3 yield without insurance vs. farm yield + GRP insurance.

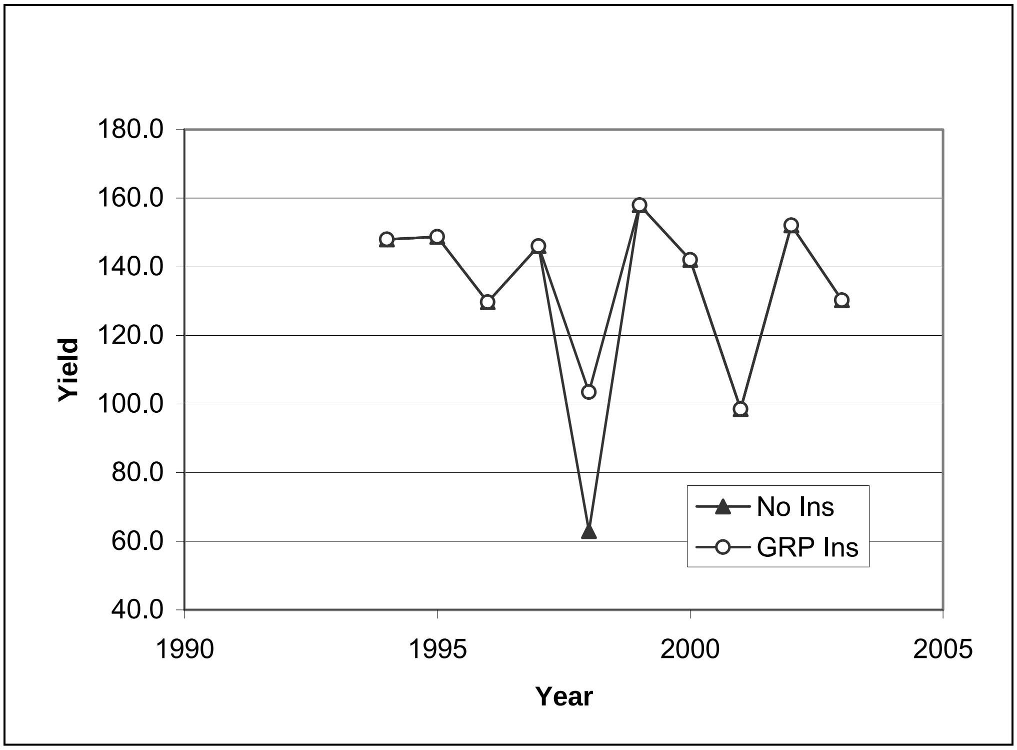

Figure 10: Farm 4 yield without insurance vs. farm yield + GRP insurance.

When the scale variable is optimal, net farm yields with county trigger insurance have the lowest amount of variance possible. The equation works as follows:

$$NFY_{WI} = NFY_{NI} + scale \times (indemnity - premium)$$

Where:

NFY_{WI} = Net Farm Yield with insurance
NFY_{NI} = Net Farm Yield without insurance
Premium is a constant
Coverage is fixed at 90%

The Variance of net farm yield is shown by the following formula:

$$\sigma^2_{Y_f^{WI}} = \sigma^2_{Y_f^{NI}} + scale^2 \times \sigma^2_{indemnity} + 2 \times scale \times \sigma_{indemnity, Y_f^{NI}}$$

The first order conditions for minimizing variance are given by solving the formula for scale.

$$\frac{\partial(\sigma^2_{Y_f^{WI}})}{\partial(scale)} = 2 \times scale \times \sigma^2_{indemnity} + 2 \times \sigma_{indmenity, Y_f^{NI}} = 0$$

Generated as a result of regressing farm yield on yield indemnities:

$$Scale = -\mathrm{cov}\, Y_f^{NI}{}_{indemnity} / \sigma^2{}_{Indemnity}$$

With a negative correlation between a drop in farm yields and getting an indemnity payment, the equation will give a scale factor that is larger than 0. The size of the scale factor depends on the relationship of farm level yield losses compared to the indemnity. If farm yields have more variation than indemnities, the scale factor will be greater than 1. If farm yields have less variation than indemnities, the scale factor will be less than 1.

The equation shows how the optimal scale factors were calculated. When calculating the optimal scale factors for each Case Farm, at least 10 years of data were used. Case Farm 1 used 20 years of data.

The optimal scale factor is used to optimize county trigger insurance policies. The scale factor shows how much insurance a farm should buy in order to have the most risk reduced. By choosing the optimal scale factor, the maximum amount of risk is being transferred. There is no other scale factor that will transfer more risk than the optimal scale factor.

Case Farms Optimal Scale

Case Farm yields are influenced by the distance farms are spread out, and the soil types farmed. Different scale factors are optimal for the Case Farms. In the Case Farm examples, the maximum (1.5) scale factor was used. For three of the four Case Farms, the maximum scale factor was the best choice allowed by the insurance policies. For Case Farm 3, the optimal scale factor was constrained by the minimum scale factor allowed. The Case Farms optimal scale factors for corn are given in Table 7.

Table 7:

Shows the case farms optimal scale factor and how the cap on scale affects the standard deviation

Case Farm	Optimal Scale Factor	Yield Standard Deviation at Optimal Scale	Yield Standard Deviation at Best Available Choice	Yield Standard Deviation without Insurance
#1	1.8	15.9	16.2	23.0
#2	1.9	21.4	21.7	26.8
#3	0.7	10.3	10.5	11.9
#4	2.8	16.8	20.3	29.3

The optimal scale factors for the four Case Farms show that there is a wide range in scale factors that minimize risk. None of the Case Farms optimal scale factors fell within the county trigger insurance policies range of allowable scale factors. It is shown that Case Farm 4 is hurt the most by not being able to scale the insurance to the optimal level. Case Farm 4 could lower its yield standard deviation by an additional 3.5 bushels if it could use its optimal scale factor.

Methods Used to Evaluate the Financial Impact of Risk Control Instruments

This section will explain why Monte Carlo simulation was used. The methods used to present outcomes will be addressed, followed by how to interpret the CDF. Lastly, how to interpret the results and their financial impact on a farm business will be revealed.

Reasons for Monte Carlo Simulation

Monte Carlo simulation was used to show how insurance policies worked under varied situations. A Monte Carlo simulation model was used because a closed form model does not exist. There is not one concrete answer when Mother Nature is at work as outcomes are constantly changing. Without a Monte Carlo simulation, it would not be possible to show all the possible outcomes. Usually, the average outcome is shown when simulation is not used. Farmers need to know how much risk they are taking without insurance and how risk can be reduced with insurance. If a farmer just looked at the average return to the cost of insurance, it does not reveal the risks involved with production agriculture. That is why Monte Carlo simulation is used to show probable returns over time.

The Monte Carlo simulation model simultaneously evaluates the 16 farm units that make up the example county. While evaluating each farm unit, a county yield is generated. The county yield is a composite of the 16 farm unit yields. The simulation model is used to test policies under diverse circumstances. Using a simulation model constraints and inputs are changed to find their effect on outcomes. By changing constraints, stakeholders are shown how sensitive the results are to location and size of the farm.

The Monte Carlo simulation model is an efficient way to generate CDFs that show how the insurance programs performed under random yields and prices. The simulation takes into account the correlations between farm units. By running the Monte Carlo simulation and taking numerous draws, CDFs are generated and shown for each insurance policy.

Presentation of Outcomes

To have the results meaningful for farmers, lenders, and insurance agents, CDFs are used to show the advantages and disadvantages of each insurance policy. A CDF shows the risk that a random outcome (yield) will be at a given level or lower. The CDFs show the cumulative probability on the vertical axis and outcome levels on the horizontal axis.

An important part of the CDF approach is that farmers are shown how variable yields and revenues are. With outcomes presented using CDFs, farmers are able to see first hand how insurance policies affect net yields and revenues. With the effects of crop insurance presented in a clear, concise way, stakeholders are able to make sound financial choices in regards to risk management.

Reading a CDF with Yield as the Random Variable

When looking at a CDF, it is important to take into account that outcomes are random and results are not known until harvest. The CDFs show the probability of outcomes, but when insurance is purchased, it is unclear what the yield and price outcomes will be for a given year.

Figure 11 compares the CDFs of farm yields without insurance to net farm yield[27] with APH and GRP insurance. The CDF is developed by ordering outcomes for each variable from smallest to largest. The CDF shows how the values of yields change with insurance policies overtime compared to not having insurance.

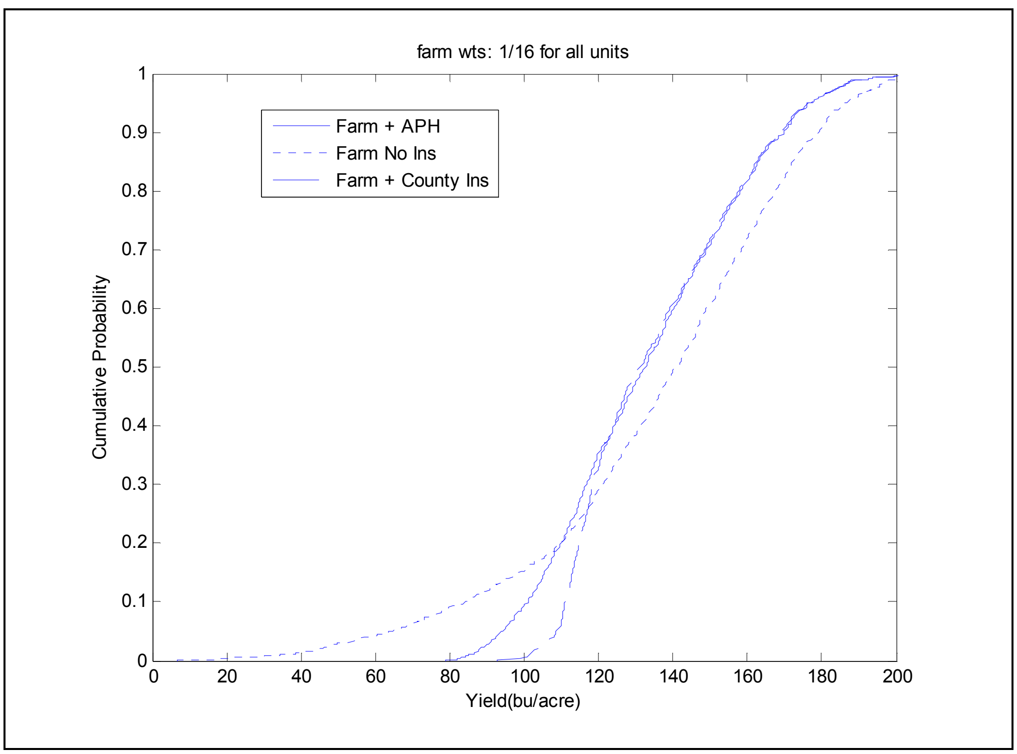

Figure 11: Farm yields with and without insurance for a farm in all 16 locations

[27] Net Farm Yields = Farm Yields + Indemnities – Premiums.

To find the probability of yields being less than 100 bushels per acre without insurance in Figure 11, Hilker (2005 B) would draw a line from 100 up to the curve. Make a mark on the curve. From the mark go to the left and find the probability (≈15%). To find the probability that yields will be over 100 bushels per acre, take the probability found above, and subtract it from one (≈85%). The advantage of CDFs is that they show the probability of a value being equal to or less than a threshold with and without insurance.

The CDF in Figure 11 shows the different levels of yield generated at a given probability for different insurance products: no insurance, GRP insurance, and APH insurance. The CDF reveals the chance that each policy will generate a yield that is at or below a given target level. To measure the yield difference between policies at a given probability level, go from the desired probability level to the right where each cumulative line is crossed. Then go straight down to find the yield generated. Compare the different yields for the given probability. The difference between the yields shows how much better the outcome is at a given probability. For example, if a farmer is worried about outcomes that occur at a frequency equal to or less than 1 in 10 years (refer to Figure 11), find 10% on the vertical axis and go to the right. The first line crossed is no insurance and then APH is followed by GRP. This reveals that GRP is the best policy for the given farm at stopping losses at a 10% probability. The above procedure works unless the lines cross below the given probability.

Financial Impact

To determine financial impacts, example balance sheets are shown to demonstrate how much risk a farmer is able to bear, and how crop insurance affects liquidity. Every farm will have different amounts of liquidity. As equity increases, a farm can withstand increased risk. Conversely, the more a farm is leveraged, the more cash is needed annually resulting in less ability to handle revenue shortfalls. By looking at their balance sheets, farmers are able to estimate the amount of risk they are able to handle, and how much money they need to generate yearly.

An example balance sheet is shown in Table 8 for a cash crop farm with the following characteristics.

- Producing 2,000 acres of corn
- Average farm yield is 140 bushels/acre
- Average farm standard deviation in yield is 40 bushels/acre

Table 8

Beginning Balance Sheet for 2005

Balance Sheet as of December 31, 2004			
Current Assets	$350,000	Current Liabilities	$165,000
Intermediate Assets	$425,000	Intermediate Liabilities	$275,000
Long-term Assets	$750,000	Long-term Liabilities	$300,000
		Deferred Liabilities	$200,000
Total Assets	$1,525,000	Total Liabilities	$940,000

- Current Ratio=2.12
- Debt to Assets=0.49
- Debt + Deferred Liabilities to Assets=0.62
- Net Worth before deferred liabilities 785,000
- Net Worth after deferred liabilities 585,000

Deferred liabilities are how much tax an operator would owe if all the assets owned by the operator were liquidated. Bankers will not include deferred liabilities on their balance sheet because they are owed to the government, and the bank will get their money before the government. After a farmer pays the bank, the government is next in line for payment. Farmers are sometimes unaware of the amount they owe the government for deferred liabilities. At retirement or going out of business, farmers liquidate there assets, and they might not be able to pay the government. If farmers are not able to pay the government, they will be forced either to find the money somewhere or file for bankruptcy.

When looking at balance sheets simultaneously with CDFs, farmers are able to get a well-rounded view of the financial risk. When using CDFs, farmers are able to evaluate probabilities of financial outcomes under different situations. If cash needs are known, along with price and yield probabilities, it is possible to figure out the probability of not being able to cover cash requirements. Lenders will usually work with businesses that cannot make principal payments, but lending institutions need to collect yearly interest payments. An optimistic farmer looks on the bright side and finds the probability that all bills will be paid, and that there will be a return to management and owner(s) equity.

To demonstrate how farmers can use CDFs to find the probability and severity of not being able to cover costs, refer to Figure 11. For the example, suppose a farmer wants to know the probability of not being able to cover cash requirements with different insurance purchases. Examples are used to show how insurance affects balance sheet liquidity.

To keep the examples clear, all values for expenses and assets values will remain constant as shown in Table 9. One could assume that taxes would change, based on the amount of income generated by the farm. However, for the example, taxes are assumed to be a constant. In addition, operating costs might drop with fewer bushels to truck and dry with the lower yields. Again, the change in operating costs will be ignored. The last assumption used is that assets values will not be changed from the beginning of the year to the end. Liquidity will change based on the income generated throughout the year.

Table 9:

Costs for Example Farm

Costs for 2005	
Variable Costs	$225,000
Operating Costs	$150,000
Interest	$45,000
Family Living	$30,000
Taxes	$15,000
Principal Payments	$65,000
Total	$530,000

Table 10 shows how the balance sheet would change for the farm on an average year. Farmers tend to look at averages, but with Mother Nature, average yields are not always achieved.

- Average Price $2.10
- Average year expected yield=140 bushels/acre
- Realized Total Revenue with GRP = $588,000

Table 10:

Expected Balance Sheet: Average Yields at a Price of 2.10

Balance Sheet as of December 31, 2005			
Current Assets	$350,000	Current Liabilities	$107,000
Intermediate Assets	$425,000	Intermediate Liabilities	$240,000
Long-term Assets	$750,000	Long-term Liabilities	$270,000
		Deferred Liabilities	$200,000
Total Assets	$1,525,000	Total Liabilities	$817,000

To get a feel for how Mother Nature can affect balance sheets and cash flows, Example 1 will have farm yield outcomes estimated at a 10% probability of occurrence. This results in the farm realizing a yield at 80 bushels/acre.

Expected Outcome:

- Expected Price $2.10
- Expected Yield 140 bushels/acre
- Expected Total Revenue $588,000

Realized Outcomes:

- Realized Price for all Scenarios $2.10
- No Insurance Realized Yield=80 bushels/acre
- Realized Total Revenue without Insurance=$336,000

Results are shown in Table 11.

Table 11:

Ending Balance Sheet Without Insurance

Balance Sheet as of December 31, 2005			
Current Assets	$350,000	Current Liabilities	$359,000
Intermediate Assets	$425,000	Intermediate Liabilities	$240,000
Long-term Assets	$750,000	Long-term Liabilities	$270,000
		Deferred Liabilities	$200,000
Total Assets	$1,525,000	Total Liabilities	$1,069,000

- APH Insurance Realized Yield=100 bushels/acre
- Realized Total Revenue with APH = $420,000
- GRP Insurance Realized Yield=110 bushels/acre
- Realized Total Revenue with GRP = $462,000

Results are shown in Table 12.

Table 12:

Ending Balance Sheet with GRP Insurance

Balance Sheet as of December 31, 2005			
Current Assets	$350,000	Current Liabilities	$233,000
Intermediate Assets	$425,000	Intermediate Liabilities	$240,000
Long-term Assets	$750,000	Long-term Liabilities	$270,000
		Deferred Liabilities	$200,000
Total Assets	$1,525,000	Total Liabilities	$943,000

Table 13 shows the ending balance sheet without insurance is damaged much more than the balance sheet with GRP insurance. At the end of the year, both balance sheets at the 10% probability will have a lower current ratio. The balance sheet GRP with insurance has a positive change in net worth unlike the balance sheet without insurance. The farm without insurance would be forced to refinance some of its current debt into intermediate or long-term debt. Both balance sheets are hurt when compared to how the average year balance sheet.

Table 13:

Balance Sheet Ratio's

	Expected Outcome	No Insurance	GRP Insurance
Current Ratio	3.27	0.97	1.50
Debt to Assets	0.40	0.57	0.49
Debt + Deferred Liabilities to Assets	0.54	0.70	0.62
Net Worth before Deferred Liabilities	$908,000	$656,000	$782,000
Net Worth after Deferred Liabilities	$708,000	$456,000	$582,000

Comparison of Balance Sheet Ratio's with Expected Outcome, GRP Insurance, and Without Insurance

The example farm would be able to continue farming with each outcome. Crop insurance would not make or break the example farm's ability to handle a yield loss that happens once in ten years. The question remains: how would the farm have been affected by a one-in-fifty year outcome?

The previous examples used a one-in-ten-year event. To display how an extreme event can affect a farm, a one-in-fifty-year outcome is evaluated with and without insurance. For this example, the harvested farm yield is 40 bushels per acre. This unlikely outcome can happen, and has been observed in actual county data. The costs used are the same as in the prior example and are available in Table 9. Example 2 yield outcomes are estimated at a 2% probability of occurrence. The realized farm yield is 40 bushels per acre.

Expected Outcome:

- Expected Price $2.10
- Expected Yield 140 bushels/acre
- Expected Total Revenue $588,000

Realized Outcomes:

- Realized Price for all Scenarios $2.10
- No Insurance Realized Yield = 40 bushels/acre
- Realized Total Revenue without Insurance=$168,000

Results are shown in Table 14.

Table 14:

Ending Balance Sheet without Insurance

Balance Sheet as of December 31, 2005			
Current Assets	$350,000	Current Liabilities	$527,000
Intermediate Assets	$425,000	Intermediate Liabilities	$240,000
Long-term Assets	$750,000	Long-term Liabilities	$270,000
		Deferred Liabilities	$200,000
Total Assets	$1,525,000	Total Liabilities	$1,237,000

- APH Insurance Realized Yield = 85 bushels/acre
- Realized Total Revenue with APH = $357,000
- GRP Insurance Realized Yield = 105 bushels/acre
- Realized Total Revenue with GRP = $441,000

Results are shown in Table 15.

Table 15:

Ending Balance Sheet with GRP Insurance

Balance Sheet as of December 31, 2005			
Current Assets	$350,000	Current Liabilities	$254,000
Intermediate Assets	$425,000	Intermediate Liabilities	$240,000
Long-term Assets	$750,000	Long-term Liabilities	$270,000
		Deferred Liabilities	$200,000
Total Assets	$1,525,000	Total Liabilities	$964,000

Table 16 shows the balance sheet without insurance is devastating. The balance sheet with GRP insurance takes a hit, but it is manageable. Both balance sheets, at a 2% probability, show a lower current ratio and net worth at the end of year. The farm with GRP insurance will be able to survive. The farm without insurance, if it survives, will be forced to refinance and move a substantial amount of short-term debt to long-term debt. Both balance sheets are hurt when compared to the average year balance sheet.

Table 16:

Caparison of Balance Sheet Ratio's with Expected Outcome, GRP insurance, and Without Insurance

	Expected Outcome	No Insurance	GRP Insurance
Current Ratio	3.27	0.66	1.38
Debt to Assets	0.40	0.68	0.50
Debt + Deferred Liabilities to Assets	0.54	0.81	0.63
Net Worth before Deferred Liabilities	$908,000	$488,000	$761,000
Net Worth after Deferred Liabilities	$708,000	$288,000	$561,000

It is important for any business to know the risks and returns around an investment. By combining CDF with balance sheets, farmers get a glimpse at the risks and returns, and at the same time, see possible ways to lower gross revenue risk. It is important that farm managers are aware of revenue risks and possible ways to lower that risk.

RESULTS

The following section explores how farm unit and county trigger policies work for different degrees of spatial diversification.

Simulation Results Using Yields by Acre

One way to look at the impact of crop insurance on financial risk is to look at the probability that crop yield plus the net from insurance, indemnity less premium, will be less than a specified yield threshold. Indemnities and premiums are measured in bushels for yield policies to keep the scenarios simple. Cumulative probabilities sum up the probabilities to a specified point.

In Figure 12, when comparing yields without insurance to yields using GRP, it appears that GRP pays more than 40% of the time. However, this is not the case in practice because cumulative probability orders the net farm yields; it does not compare each year individually. The CDF does show that a farm's net yield will be better with GRP insurance than without it, at least 40% of the time.

Figure 12 is based on a farm with land in each of the 16 locations. It shows the CDF of yield equivalents, which are yields plus net yield indemnities–yield premiums from insurance. Three probability curves are shown: one, farm yield; two, farm yield plus net from APH; and three, farm yield plus net from GRP. Coverage for APH and GRP are 75% and 90%, respectively. This is the case where GRP performance is superior. As a matter of fact, GRP is second degree stochastic dominant over APH.

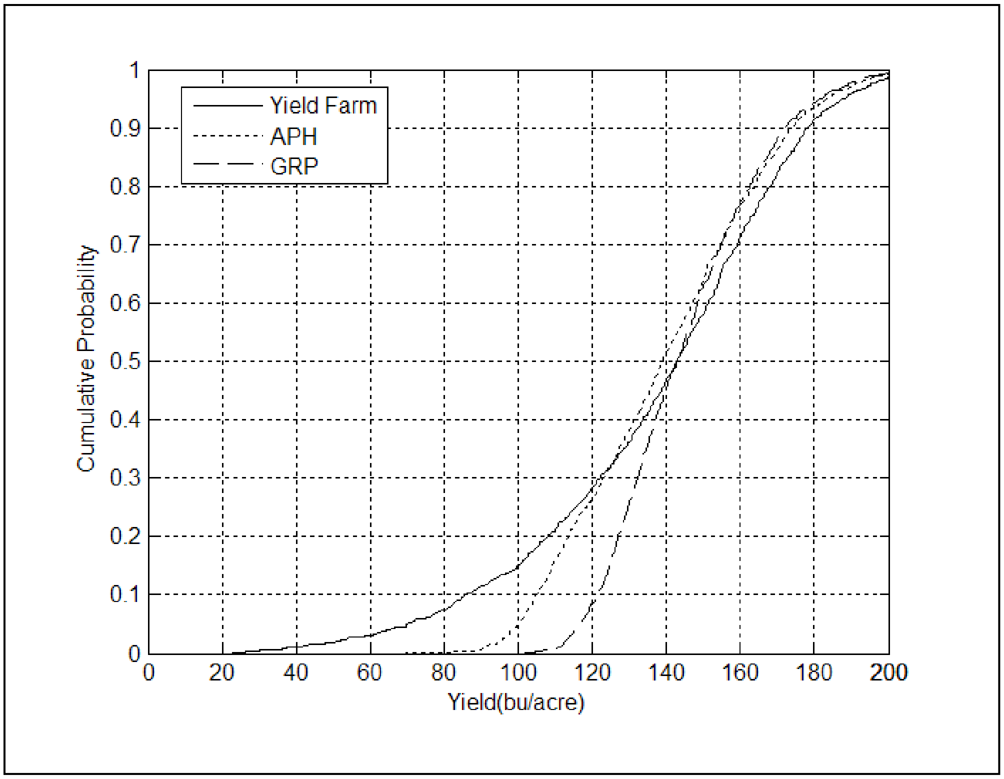

Figure 12: CDF of yield equivalents, yield plus net from insurance, for a farm with land spread over the entire county.

The cumulative probability is plotted on the vertical axis, while yield is plotted on the horizontal axis. For example, without insurance there is a 15% chance that yield will be less than 100 bushels. In contrast, the probability of getting a value of yield, plus the net from GRP insurance of 100 bushels, is zero. The probability of getting a value of yield, plus the net from APH insurance of 100 bushels, is 5%. The APH result assumes using optional farm units[28], which results in the farm having 16 farm units.

Insurance substantially reduces income risk with either policy, yet GRP would be preferred. For any yield probability plus the net from insurance, GRP yield is

[28] Each unit in the example county is treated as its own insurance pool. It is possible to collect on one unit and not on another. Optional units allow a farm to have more than one insurance contract.

always as large, or larger, than APH. This example reflects the best that one could expect under GRP, a farm that is spatially diversified across the county.

There are some features of Figure 12 that require additional discussion. The yield guarantee under APH is 105 bushes–140 bushels × 75%. However, the APH yield plus net from insurance cuts the farm yield probability curve to about 125 bushels, not 105 bushels. Why, you ask? This is the effect of farm units on effective coverage. The farm has 16 insurance units, one for each location in the county, and there are times when individual farm units are receiving an indemnity while others have higher yields.

When yield history is established for farm unit policies it uses an average of the last 10 draws. It is unlikely but possible to get a substantially different yield guarantee. With the last 10 draws being used to establish the yield guarantee for farm unit policies there is not a set floor for these policies.

Another way of looking at the APH policy for farms with multiple farm units is to say the "effective" risk transfer is greater than the coverage stated in the insurance policy. This difference is greatest when the correlation between yields on different farm units is low.

The impact of farm units is also reflected in the insurance premiums in three ways: frequency of collection, difficulties associated with risk classification, and hidden action. Based on farm records, there appears to be a significant number of farms where the presubsidy insurance premium is significantly higher than the farms' underlying risk[29]. This has been built into our example. On the other hand, there are

[29] How much a farm should collect over time in insurance indemnities.

farms whose presubsidy insurance premiums are less than their underlying yield risk; their yields, plus net from APH, would be shifted to the right in Figure 12.

Figure 13 considers the other side of the issue. The farm in Figure 13 is located entirely in location 16, the corner of the county. With only one farm unit, the farm is not spatially diversified.

The effectiveness of GRP is significantly less against catastrophically low yields than it was for the spatially diversified farm. In most instances, APH would be the preferred insurance policy for this farm.

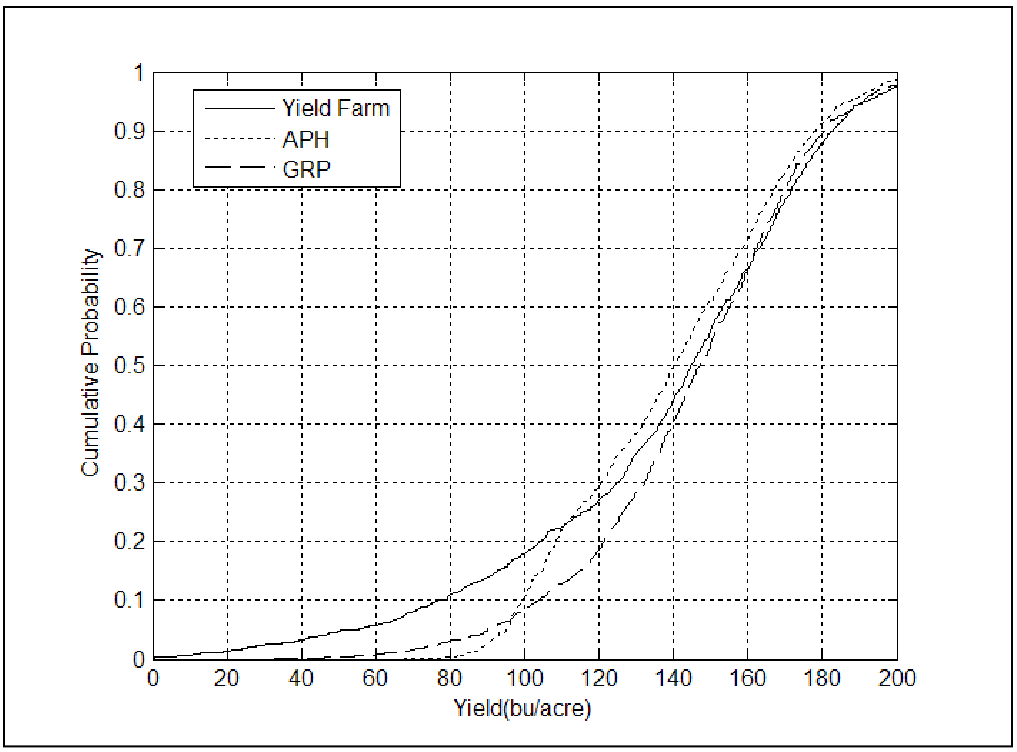

Figure 13: CDF of yield equivalents, yield plus net from insurance, for a farm with land in a corner of the county.

Figure 14 shows how farm yields track county yields for a farm located in the corner of the county using a 40-year, trend-adjusted[30] sequence. There are observations where the county and farm yields do not track. The graph shows why a farmer in this situation should be very cautious about using a GRP type policy. There were substantial farm yield shortfalls in years 7 and 32 that were not accompanied by county yield index shortfalls. The farm yield shortfall in year 12 was substantially larger than the county yield index shortfall. There were good matches in years 11 and 38. The correlation used is .8 which is if considering county trigger policies.

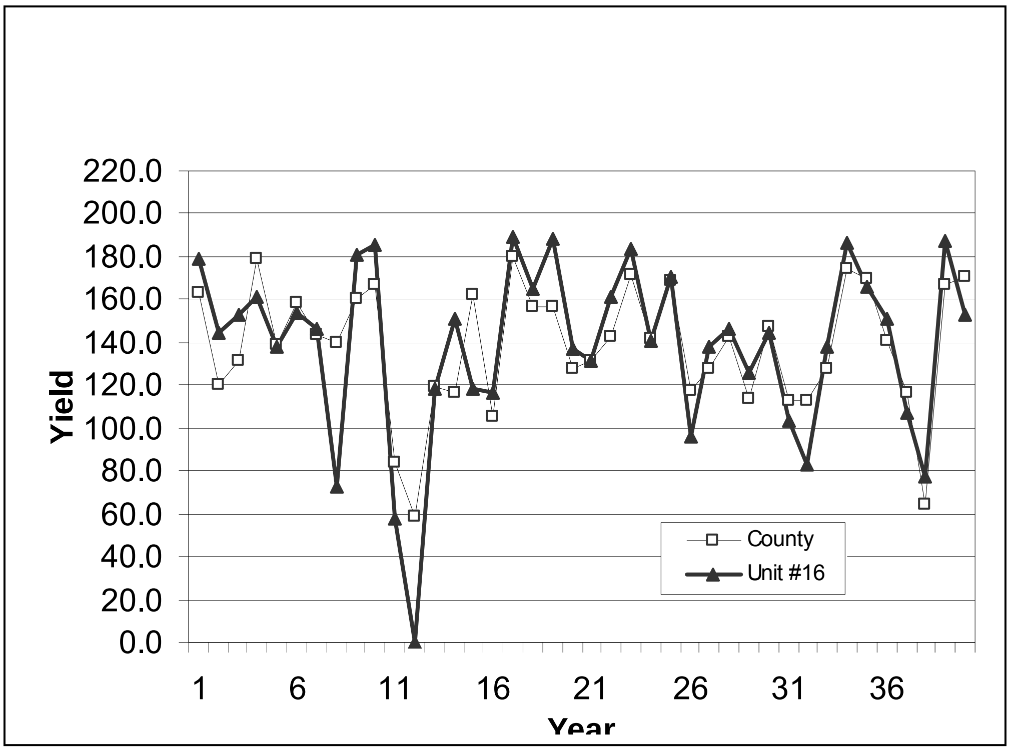

Figure 14: Farm vs. county yield for a farm in a corner of a county

[30] All the yields have the same mean because they were standardized to 2003. The graph just shows 40 different observations.

The next farm shown in Figure 15 shows a 40-year, trend-adjusted yield sequence for a farm that has land in locations 4, 7, 8, 10, 11, 12; the farm vs. county yield index correlation is 0.95 for the sequence. With the farm and county yields tracking closely, the GRP policy would be an effective yield-risk, transfer tool. In the graph, there is no time when the farm has a yield shortfall and the county does not. With the 0.95 correlation, the chance of a farm needing a payment, and not getting one, is small.

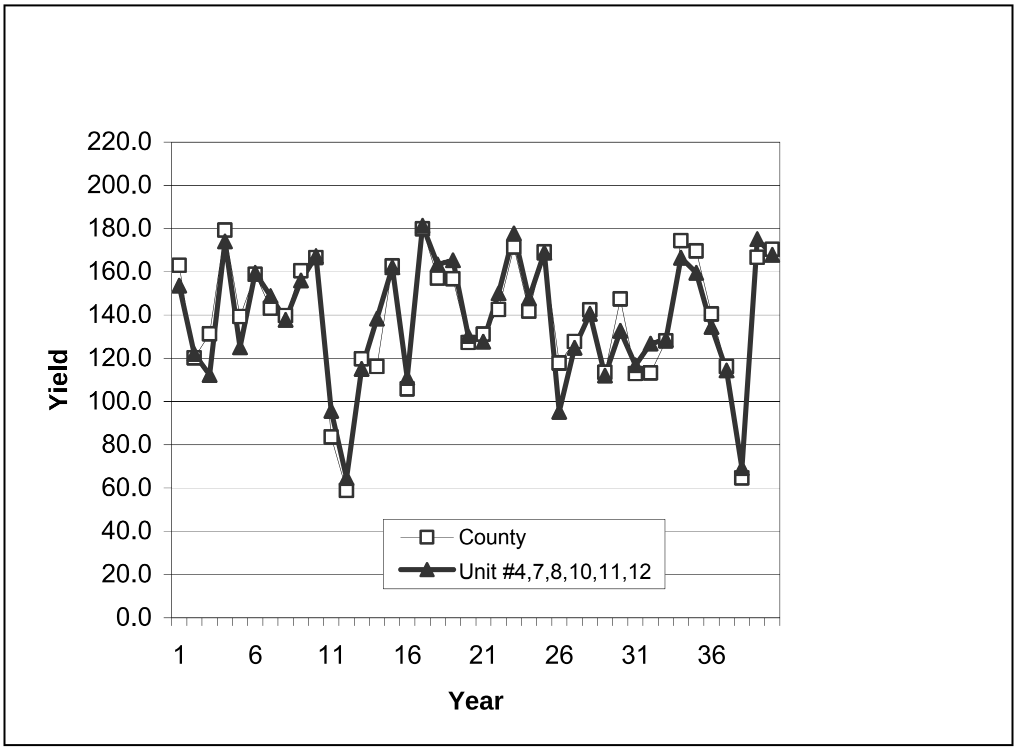

Figure 15: County yield compared to farm yield with land in locations 4, 7, 8, 10, 11, and 12. The farm-county yield correlation is 0.95.

Figure 16 shows the associated CDF for a farm that has land in locations 4, 7, 8, 10, 11, 12. The profile is almost as good as a farm spatially diversified across the entire county. The GRP policy is potentially a good choice.

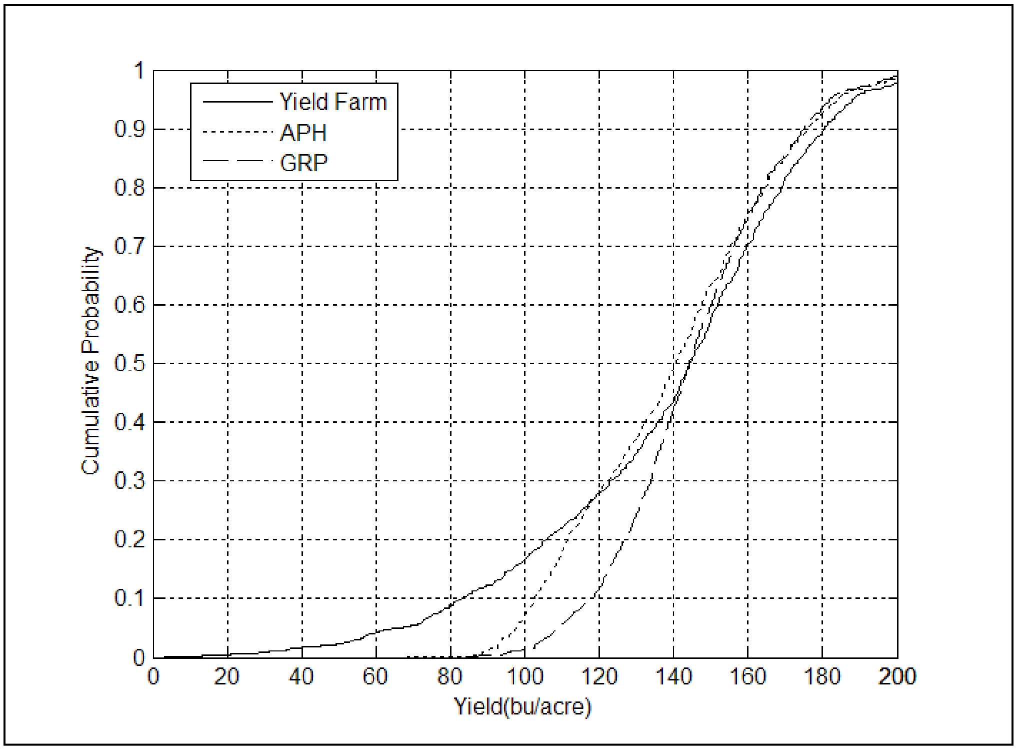

Figure 16: Cumulative probabilities of yield equivalents, yields plus net from insurance, for a farm with land in locations 4, 7, 8, 10, 11, and 12

Figure 17 is for a smaller farm in the center of the county with a 0.85 farm to county yield index correlation. The GRP policy works relatively well, although there is a large miss in year 27 and smaller misses in years 3 and 5. Yield basis risk is significant. Farms that have a farm-to-county yield index and correlations much below 0.85 would typically be better served with an APH insurance policy.

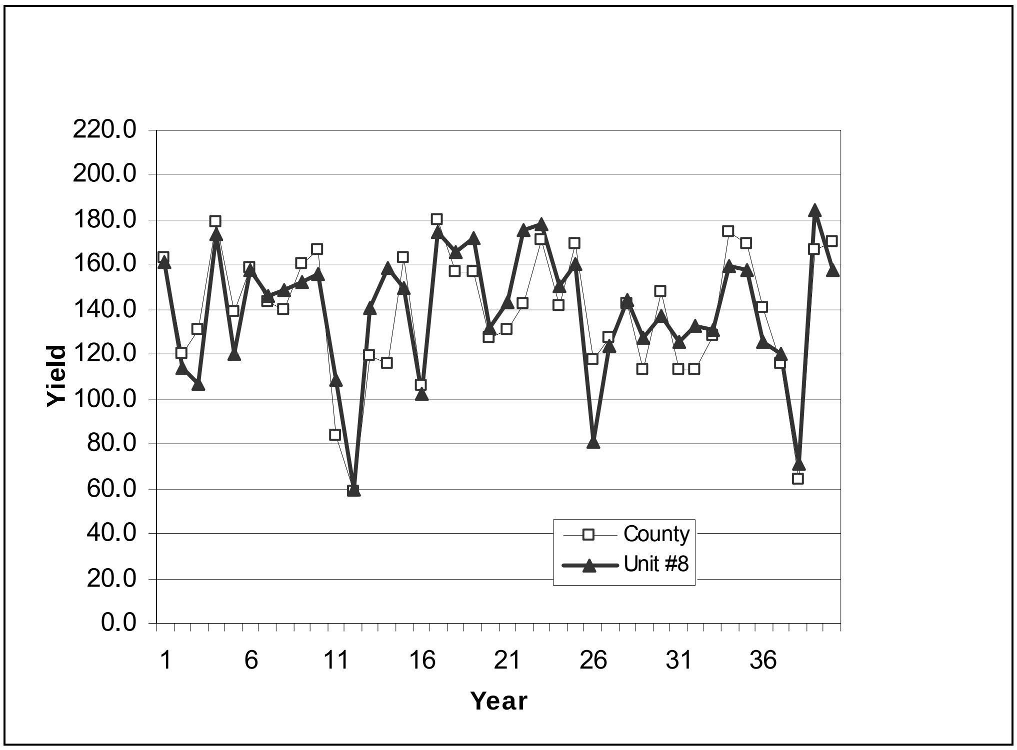

Figure 17: Farm vs. county yield with a 0.85 farm-county yield correlation

The above graphs are summarized in Table 17. The table shows how mean yields and downside variance were affected by correlation and insurance choices. Downside variance is the amount of variation that is below the mean. As expected, with high correlation GRP transfers the most downside risk. With low correlation, APH transfers the most downside risk.

Table 17:

The effects of crop insurance on mean and downside variance.

Corr.	No Ins. Mean Yield	No Ins. Down side var.	APH Ins. Mean Yield	APH Ins. Down side var.	GRP Ins. Mean Yield	GRP Ins. Down side var.
≈0.95	136.5	904	139.3	205	144.5	142
≈0.87	136.5	1015	139.3	240	144.5	360
≈0.80	136.5	1017	139.3	237	144.5	441

Simulation Results using Revenues By Acre

Building on the importance of correlation, as shown in the yield policy simulations, insurance policies with revenue insurance will be displayed. Revenue per acre will be used to compare the insurance polices, instead of yield per acre. The insurance policies compared are APH, RA, RA-HRO, GRP, GRIP, and GRIP-HRO. To compare revenues and yield products, all yields are converted to revenue. For simplicity, Crop Revenue Coverage (CRC) will not be included because of its similarity to RA-HRO.

To simulate revenues per acre, an estimate of fall price is generated, along with a yield for each farm unit and the county. Then a fall price is generated, along with actual yields for each farm unit and the county. With an estimate of fall price and yield, along with an actual fall price and yield, it is possible to solve how each insurance policy would perform for each draw. The results are then graphed, using CDFs to get the long-run effects of different insurance policies.

A way to look at the impact of revenue and yield insurance policies on financial risk is to look at the probability that revenues plus net from insurance will be less than a specified threshold. Since revenue policies are being used, indemnities and premiums will be measured in dollars.

Figure 18 shows that when 10,000 draws are ordered, GRIP and GRIP-HRO are almost indistinguishable. This does not mean that GRIP and GRIP-HRO will generate the same cash flow each year. It does show that with many draws the policies will generate relatively the same return for a farm. GRIP-HRO can never be worse than GRIP, except for the added premium cost. The higher premium cost of GRIP-HRO will offset its higher returns, over time, making GRIP-HRO close to GRIP. Since the lines on the graph are almost indistinguishable, GRIP-HRO and RA-HRO will be used to show how revenue insurances policies would perform.

When evaluating insurance policies, the farms' correlation to county yield indexes gives insight into which type of policy a farm should select to maximize risk transfer and net farm revenues. A farmer's insurance objectives will determine if a yield or revenue policy is appropriate. In years where insurance does not have an indemnity payment, revenue policies will have the largest negative impact on a farms' net revenue.

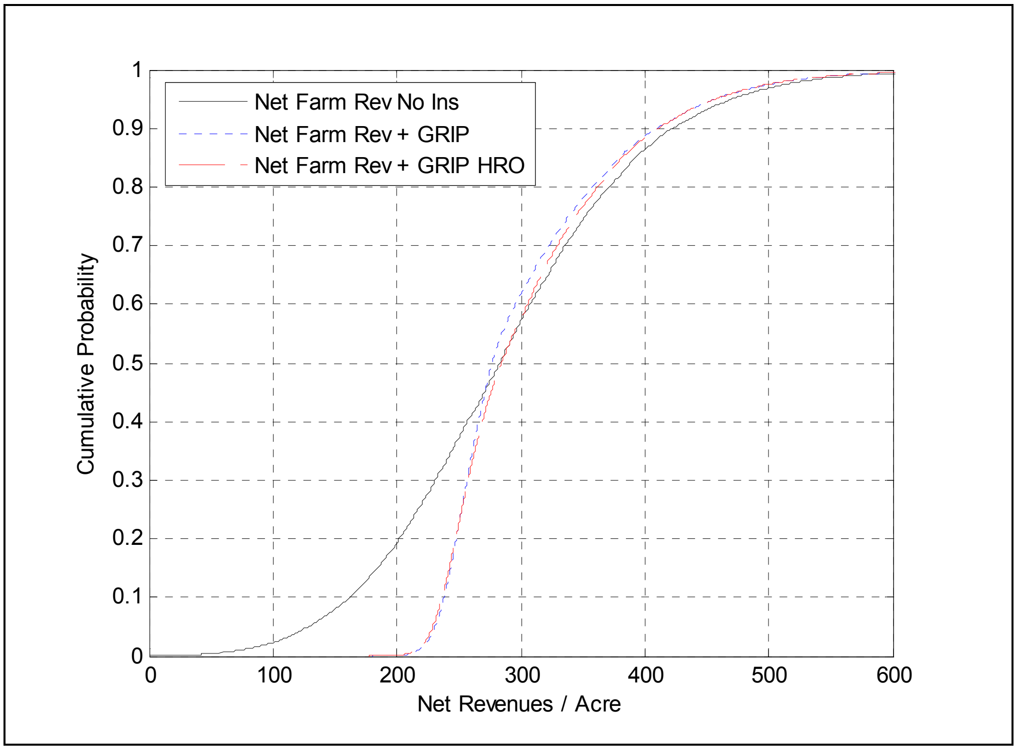

Figure 18: The performance of GRIP to GRIP-HRO on a farm that is composed of all 16 farm units is shown.

If a farmer is doing any preharvest pricing, an income policy with HRO should be favored over a policy without replacement price. The HRO policies will provide more protection if prepriced because if yields fall and prices goes up, HRO policies use the fall price to calculate the indemnity. The revenue option without HRO would just use the spring price, and there would be a smaller indemnity if price rises. With price already established, on some production a farmer would want to have the extra insurance income to offset earlier sales at lower prices. In some cases, the extra income could be used to buy back contracts if production were not available to fill them.

Figure 19 is based on a farm with land in each of the 16 locations. It shows the CDF of revenue, plus net cash flow from insurance**.** The graph shows how outcomes are changed with different county trigger policies. It is important to note that county revenue policies dominate county yield policies for the bottom 40% of outcomes.

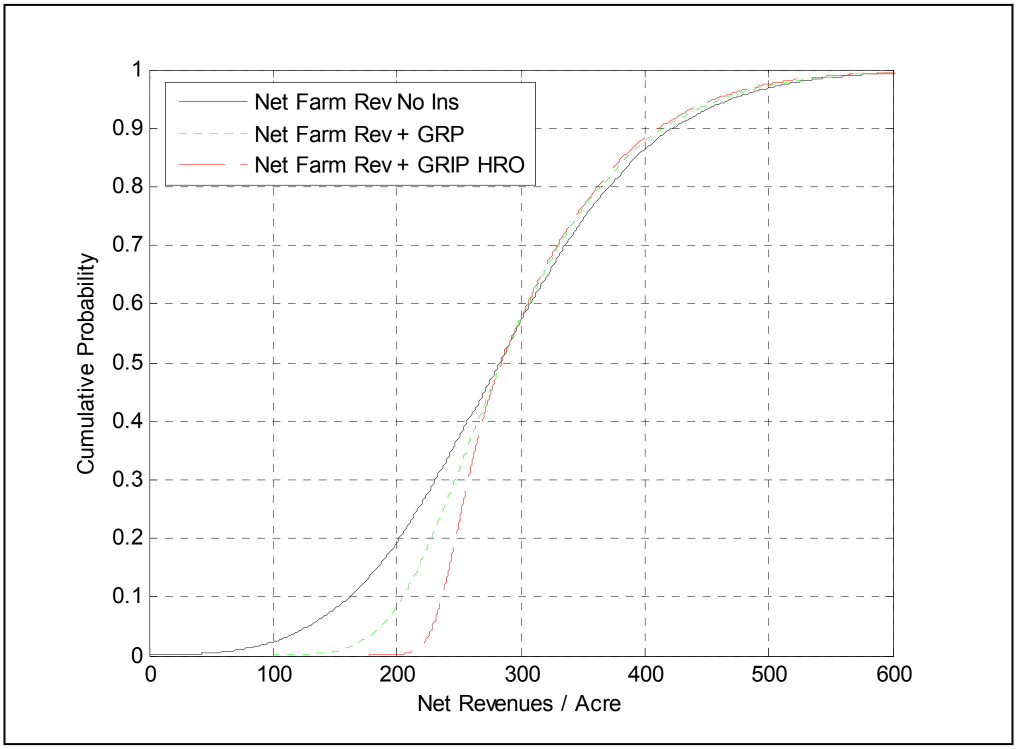

Figure 19: Performance of GRP, GRIP-HRO, and no insurance on a farm that is composed of all 16 farm units

By taking a county yield or revenue insurance policy average, net farm returns are increased when compared to not having insurance[31]. The average net farm return with county trigger insurance is increased by the actuarially fair rate multiplied by subsidy.

[31] That is, assuming fair rates are used for county trigger policies.

Figure 20 is based on a farm with land in each of the 16 locations. Three probability curves are shown: farm revenue without insurance, farm revenue with RA-HRO, and farm revenue with GRIP-HRO. Coverage for farm unit policies and county trigger policies are 75% and 90%, respectively.

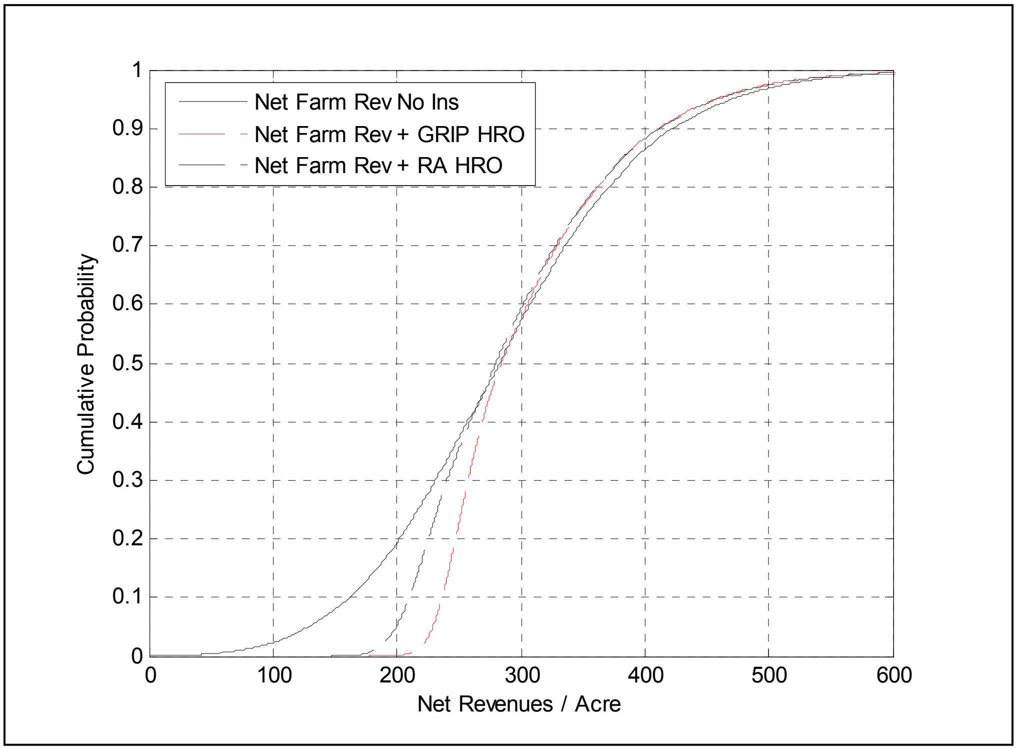

Figure 20: Performance of RA-HRO, GRIP-HRO and no insurance on a farm that is composed of all 16 farm units

As expected, county trigger policies out performed farm unit policies for a farm that is composed of all 16 farm units. With a correlation that is above 0.95, this is the case where county trigger policies will be superior to farm unit trigger policies. Figure 21 shows how yield policies will work when converted to revenue for a farm that is composed of 1 farm unit in the corner of the county. As expected, APH does a better job than GRP at compensating for small likelihood events. In the middle of the graph, GRP does out perform APH at times. With the low correlation of farm yields to county yields, APH is the preferred policy.

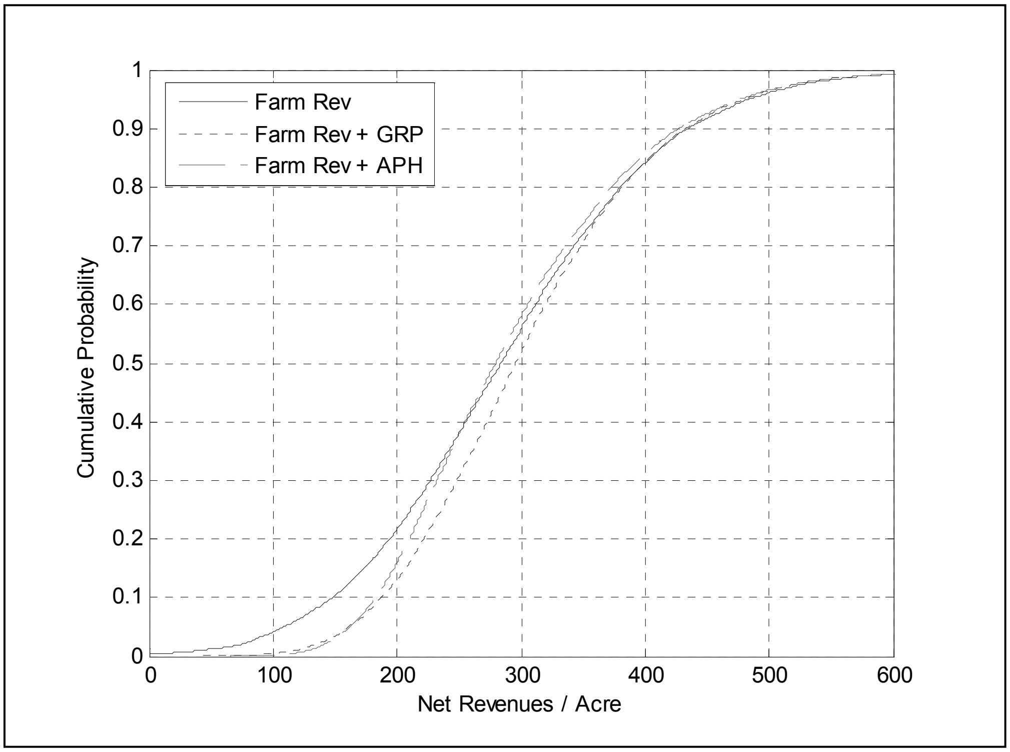

Figure 21: Performance of APH, GRP and no insurance on a farm that is composed of 1 farm unit in the corner of the county

Figure 22 also shows a farm composed of just 1 farm unit in the corner of the county. Farm unit revenue policies will transfer more risk than county trigger policies. The correlation is below 0.80. RA-HRO excelled at stopping the worst outcomes when compared to GRIP-HRO. Again, as in Figure 21, county trigger policies out perform farm unit trigger policies in the middle of the graph.

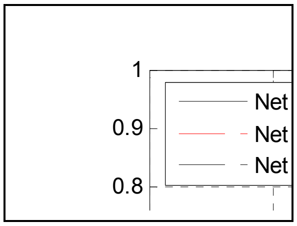

Figure 22: Performance of RA-HRO, GRIP-HRO and no insurance on a farm that is composed of 1 farm unit in the corner of the county

Figure 23 shows an intermediate graph falling between the two extremes of low correlation and high correlation. The farm in Figure 24 is composed of 2 farm units near the center of the county. The farm-to-county yield correlation is near 0.93. In this case, GRIP-HRO dominates RA-HRO. With GRIP-HRO dominating RA-HRO, county trigger policies are the clear choice for this farm. When comparing county trigger and farm unit policies, if one type of policy dominates the other, every policy of that type will dominate its counterpart.

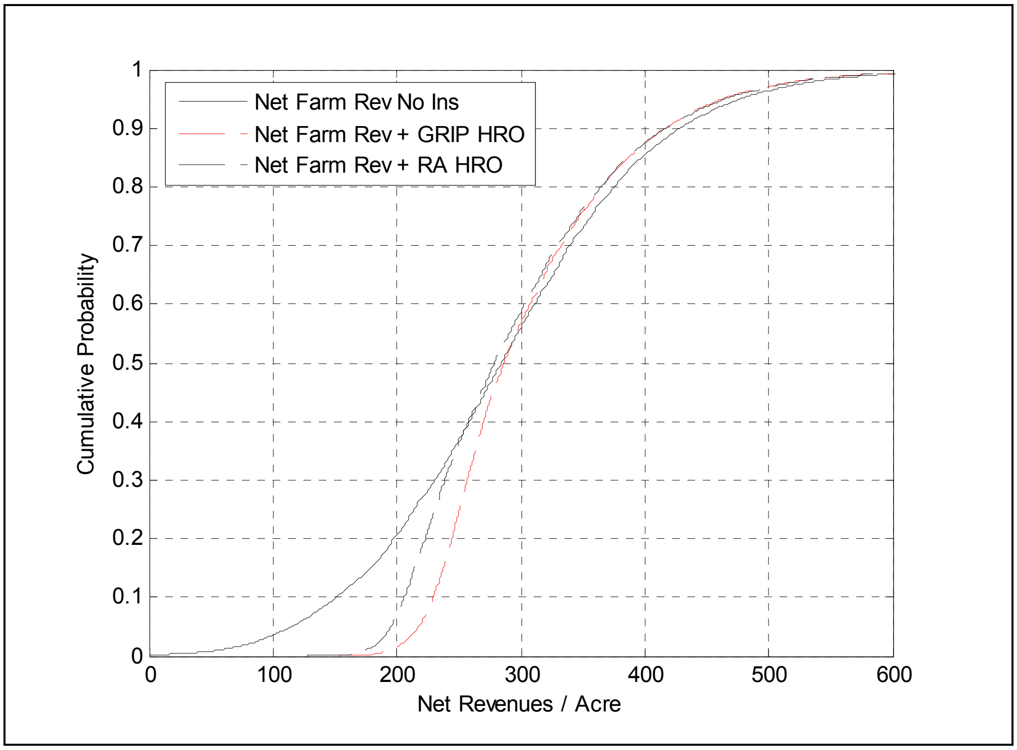

Figure 23: The performance of RA-HRO, GRIP-HRO and no insurance on a farm that is composed of 2 farm units near the center of the county

Points to Consider Before Making Crop Insurance Decisions

1. If low farm-yield correlation to county yield and higher systemic risk, then the county, or if tracking is unacceptable, a farm should go with farm unit policies. Remember the abnormal yield on Case Farm 3, it had low correlation, but would have got exception risk reduction with GRP because of lower systemic risk than the county. If the farm's correlation is high and tracking is acceptable, a farm should go with a county trigger policy.

    a. Rules of Thumb

        i. Correlation 0.90 or higher, use County Policies

ii. Correlation 0.85 - 0.90, use County Policies with caution in regard to yield basis risk

iii. Correlation 0.80 - 0.85, use Farm Unit Policies or County Policies. If using County Policies only do so with "Extreme" caution in regards to yield basis risk

iv. Correlation 0.80 or lower, use a Farm Unit Policies

2. Insurance objectives will determine if a yield or revenue policies are appropriate. It is shown that revenue policies will give more protection against below-normal-revenue outcomes than yield policies would give.

3. If preharvest pricing, an income policy with HRO should be used instead of a policy without replacement price. Wang, Hanson, and Black (2003) believe that HRO policies will provide more protection when prepricing because if yields fall and price goes up, HRO policies have the ability to replace bushels that were already priced. HRO policies use the fall price to calculate the indemnity.

CONCLUSIONS

Summary

Practical procedures to evaluate county trigger policies are presented which are expected to be useful farmers, lenders, insurance agents, and academics. If farm yields correlate to county yields at 0.90 or higher and the farm is spatially diverse, county trigger insurance should be an effective risk transfer tool. If the correlation is in the range of 0.85 to 0.90, county trigger insurance is typically a good risk transfer tool, but the farmer needs to think carefully about how to manage yield basis risk. There is an opportunity for a significant difference between farm and county yields, although at low frequency. If the range is 0.80 to 0.85, county trigger insurance should only be used with extreme caution because of yield basis risk. If the correlation is under 0.80, county trigger insurance is questionable as a risk transfer tool and typically inferior to farm unit trigger policies.

Results showed that the more spatially diverse a farm is, the higher the farm to county yield correlation. If a farm is composed of farm units in the center of the county, this will lead to a higher farm-to-county yield correlation than if the farm units were on the edge of the county. The Monte Carlo simulation model reveals that a farm located in the corner of the county will have the lowest farm-to-county yield correlation.

It is shown under what conditions county trigger policies have the potential to transfer more risk for a farm than farm unit trigger policies. The graphs also show how much risk is transferred in contrast to not insuring. Using a standardized yield series, it was shown how to evaluate tracking. Risk minimizing scale factors for county trigger policies are established for each case farm. The risk minimizing scale factors varied for each case farm. Lastly, net farm yields and revenues are shown as a potential way to evaluate county trigger policies, farm unit trigger policies, and not insuring. When evaluating insurance choices, cash flow and equity needs are considered and shown in the balance sheet examples.

Effective cover levels for farm unit policies varied based on the number of farm units and their correlation. The changes in effective coverage were shown in the CDFs. The more farm units a farm possessed, the higher the effective coverage. Also, if farm units are not highly correlated, the effective level of coverage will increase.

Further Research Needs

Continued research should address the cap on scale. Research should be conducted to determine if the cap on scale is too binding. Even though the cap could be binding, it was set by RMA because of concerns about individuals taking advantage of the subsidies.

In the model trend yields were eliminated by adjusting all yields to 2003 equivalents. Research could be done to address the effect of estimating expected yields into the future with unknown yield trends. RMA is forced to establish the expected yield for the county two crop cycles in advance.

Now that data has been generated for the insurance policies under varied situations, it is possible to rank them using stochastic dominance. Stochastic dominance could use the CDFs to rank the insurance policies as well as not insuring. Once the results are ranked using stochastic dominance, the rankings could be check by actual farmers. Farmers could be surveyed to see how they rank the outcomes. It would be interesting to see if farmers rank the results the same way as the stochastic dominance rankings do.

There also needs to be research on whole farm discounts and their affect on risk transfer. A whole farm discount is given to a farm if all insurance units of a crop are insured as one unit in a county. With each crop being insured as one farm unit, a producer does not get the advantages of farm unit diversification, but there are premium discounts.

To improve the Monte Carlo simulation model used for farm unit and county trigger policy research needs to be done with more than 16 farm units in the example county. An improved example county would include at least 36 farm units. It would also be helpful to understand the increase in the precision of our understanding as the number of units increases.

APPENDICES

APPENDIX

GRP Mechanic

The mechanics of GRP are as follows:

1. It is the yield at which GRP triggers are calculated by multiplying the "expected" county yield set by the USDA Risk Management Agency (RMA) by the desired coverage level. Coverage levels of 85% and 90% are typically chosen. For example, if the expected county yield is 120 bushels and the coverage level is 90%, the yield at which the policy triggers is 120 × 0.90, which is 108 bushels. If the county yield calculated from NASS/RMA information falls below 108 bushels, the farm will receive an indemnity payment.

2. The formula used to determine if a farm receives a payment is shown below: GRP pays if

$$\text{Payment yield} < \text{Trigger yield}$$

Where:

$$\text{Trigger yield} = \text{Expected county yield} \times \text{Coverage}$$

Payment yield is the RMA term for the realized county yield. GRP is a disappearing deductible policy. With a disappearing deductible, it is possible to get the whole deductible back with a 100% loss. The deductible is returned because percent loss is multiplied by protection that does not include a level of coverage. Disappearing deductible policies are also common for hail insurance. With a GRP policy, if there is a loss, the indemnity is calculated according to:

Indemnity = \$ Protection × % loss

Where:

\$ Protection = Expected county yield × Indemnity price × Scale factor

and

$$\% \, loss = \left(\frac{Trigger\ yield - payment\ yield}{Trigger\ yield} \right)$$

In summary, the value of the loss is calculated by multiplying the value of protection by the percent of loss. The GRP insurance policy calls the percent of loss the payment factor.

The GRP insurance policy defines the maximum protection that can be purchased as:

Max protection=Expected county yield ×Indemnity price × 1.5

Typically, the appropriate scale factor is in the range of 1.25 to 1.50. The expected county yield and the indemnity price are both established prior to insurance purchase. Case studies illustrated scale factors.

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REFERENCES

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