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The Effect of Crop or Revenue Insurance on Optimal Hedging

Keith H. Coble and Richard Heifner¹

The emergence of new risk management tools such as revenue insurance has dramatically expanded the tools from which producers may choose to manage revenue risk. Little is known regarding how these products interact with market-based risk management tools such as futures and options. Our analysis addresses this issue by examining optimal futures and put ratios under increasing levels of insurance coverage. Four alternative insurance designs are examined. Two are yield triggered and two reflect currently available revenue insurance designs. The analysis is conducted by using a revenue simulation model which incorporates four random variables; futures price, basis, county yield, and farm-county yield differences. Optimal hedge and at-the-money put options ratios are derived for an expected utility maximizing corn producer in four distinct geographical regions. Revenue insurance tends to result in slightly lower hedging demand than would occur given the same level of yield insurance coverage. To the extent that producers would switch from yield insurance to revenue insurance there would be a decline in the demand for hedging. If a person were to go from being uninsured to the purchase of one of the insurance designs, we find that the revenue products result in a hedge ratio that is at least as high as the uninsured case when considering the permissible levels of coverage.

The context in which farm program crop producers make futures marketing decisions has been dramatically altered by government policy in recent years. The elimination of deficiency payments ended a program which had many similarities to an option contract with fixed and nonrisk responsive production flexibility payments. This has been widely recognized as having an effect on the risk management decision environment for program crop producers. What has been less often addressed is the nearly simultaneous and rapid evolution of governmentally subsidized insurance products. The Federal Crop Insurance Corporation was renamed the Risk Management Agency (RMA) and given broader authority under the 1996 Farm Bill. At the same time, the agency began a pilot program offering gross crop revenue insurance and allowing private insurance firms to develop other revenue insurance products which were accepted for subsidy and reinsurance. To date, three different forms of revenue insurance have been offered. Others are likely to be developed. The acceptance of these revenue insurance products has been fairly dramatic. Iowa corn and soybeans insurance data indicates that revenue products represented more than 30% of insured acres in 1997.

Because these revenue insurance products subsume both price and yield risk, it is relevant to ask what implications these insurance products have for producer forward contracting demand. If they do affect the demand for forward contracting, then in what direction and magnitude. Further, these revenue insurance designs differ in the portion of the gross revenue distribution which is protected. Thus, it is plausible that the various revenue insurance designs could result in

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substantially differing hedging demand. In fact, this issue has become a matter of public debate between the futures industry and crop insurance companies in recent months.

These issues demand consideration of the interactions of price and yield risk management and the joint optimization of insurance and hedging decisions. Much of the literature on producer hedging decisions has assumed non-stochastic yields and a single risk market - futures (Myers and Thompson). Hanson and Ladd, as well as Lapan and Moschini have addressed the market for options assuming deterministic yields. Lapan and Moschini generalized from the assumptions of variance minimization to an expected utility framework and allow both futures and options to exist. Under their assumptions, options are dominated by hedging.

McKinnon and Grant have shown, in a variance minimization framework, that correlation between price and yield significantly affect the hedging decision. Where negative correlation exists then a natural hedge results in an optimal hedge lower than expected output. Sakong, Hayes, and Hallam extended the Lapan, Moschini, and Hanson work by introducing yield risk. In this context they found that options are no longer dominated in the choice set, particularly when expected correlation between yield and price is non-zero.

A natural extension of the previous work is to allow for both yield and price risk markets in a model of optimal hedging. Recent literature has started to address the components of revenue variability and incorporate the instruments which are choice variables in a preseason risk management decision process. Poitras has addressed the analytical issues associated with the likely asymmetries of terminal wealth when censoring instruments such as options or insurance are available. The combination of price and yield futures hedging has been addressed by Li and Vukina for corn in North Carolina, Tirupattur et al. for soybeans in Illinois, and by Heifner and Coble (1996) for corn across the United States. Combinations of forward pricing and crop yield insurance have been examined by Heifner and Coble (1997). Dhuyvetter and Kastens examined combinations of hedging with yield insurance and with a particular form of revenue insurance -Crop Revenue Coverage (CRC). However, they do not directly address hedging levels, but rather show comparisons of mean and variance of returns.

There are several challenges to modeling the interactions of insurance with forward pricing instruments. Insurance and futures options censor the underlying distributions. As will be shown later, some of the insurance designs now being offered to producers are of a mixed type which combine components of revenue and price guarantees or price and yield guarantees. Further, the underlying distributions may be inherently asymmetric, which leads one away from the tractable case of joint normality. Nelson and Preckel have given strong indication that yields often appear to be non-gaussian. When modeling the joint distribution of price times yield, care must also be given to the potential for correlation of price and yield to influence outcomes. Babcock and Hennessy, as well as Heifner and Coble (1996) have shown empirically that covariance between farm-level price and yields may be non-trivial.

In this paper, we analyze the relationship of four insurance designs at various coverage levels to the optimal hedge ratio of a risk averse corn producer. In particular, we show the sensitivity of optimal hedge and put ratios to varying quantities of insurance. Numerical procedures are used to allow simultaneous evaluation of the insurance designs under realistic empirical representations. In particular, we are able to incorporate farm-level yield information which more accurately characterizes yield variability and its effect on optimal decisions The analysis is replicated across four regionally diverse representative farms. This allows comparisons of how differences in yield variability and yield-price correlation affects outcomes and shows the diversity of outcomes across regions.

The Insurance Tools Examined

Four insurance products are modeled to reflect the insurance products that are now appearing in the crop insurance market. Two of the designs examined are yield triggered, while the second two are revenue triggered. A brief explanation of each instrument follows.

Multi-peril crop insurance (MPCI), is the 'traditional' crop insurance program which is generally available for major crops in most states. MPCI indemnifies yield losses when an insured acreage's yield falls below the guaranteed level. These losses are valued at a preseason price selected at sign up time. Thus, variation in market prices during the season are not taken into account. The indemnity equation for MPCI may be written as follows:

$$NI = f_0 * Max [\gamma * y_0 - y_1, 0] - P$$

where NI is the net return to insurance purchase, f_0 is the preseason price for a harvest month futures contract, γ is the insurance coverage level, y_0 and y_1 are respectively the expected farm yield at planting and realized yield at harvest.² The insurance premium (P) reflects the producer paid insurance premium cost for the policy.

The Market Value Protection (MVP) design, shown in equation 2, is also yield triggered. However in this case losses are valued at the maximum of either springtime expected price or the actual harvest time price, f_1 . Price is multiplied by 0.95 to reflect basis from the futures market.

(2)
$$NI = 0.95 * Max[f_0, f_1] * Max [\gamma * y_0 - y_1, 0] - P$$

In 1997 and 1998, three types of revenue insurance have been offered to U.S. producers -Crop Revenue Coverage (CRC), Income protection (IP), and Revenue Assurance (RA). All three of these products insure the gross revenue of the insured crop. The products differ in rate setting procedures and location where they are offered. All three are reinsured and subsidized by the USDA and use harvest month futures prices at sign up and at harvest to compute losses. Because of similarities in design, IP and RA are treated as a single insurance type designated as RI. Equation 3 shows the net return from RI. Here, shortfalls in harvest revenue $(f_1 * y_1)$ trigger losses rather than y_1 , as in the case of yield insurance.

(3)
$$NI = Max [\gamma * f_0 * y_0 - f_1 * y_1, 0] P$$

The fourth insurance design is Crop Revenue Coverage (CRC). This insurance design combines the revenue insurance protection of RI with the 'upside' price protection of MVP. Ninety-five percent of the maximum of preseason price expectations or the actual harvest time futures are used to compute the coverage.

² The MPCI price guarantee used for MPCI is based on internal USDA forecasts rather than directly tied to the futures markets. However, preseason futures prices are used here.

(4)
$$NI = Max \left[\gamma * 0.95 * Max \left[f_0, f_1\right] * y_0 - f_1 * y_1, 0\right] - P$$

The returns from futures marketing are modeled in equation 5. As shown, futures hedging protects against price risk on a given quantity hedged. The futures marketing hedge ratio is represented by α and represents the proportion of the expected yield which is protected. In this case the cost of risk protection, *P*, reflects commissions and interest charges to carry out the hedging transaction.

(5)
$$NF = \alpha * y_0 * (f_0 - f_1) - P$$

The returns from a put option contract are shown in equation 6. In this case, the put option ratio is represented by α and represents the proportion of the expected yield which is price hedged. The option strike price relative to the futures price is γ . The cost of a put option, P, includes the option premium and commissions and interest charges.

(6)
$$NF = \alpha * y_0 * Max[\gamma(f_0 - f_1), 0] - P$$

The Behavioral Model

To analyze the effect of revenue insurance products on the demand for hedging, we examine the planting time optimization behavior of a producer offered combinations of insurance and hedging strategies. The producer is assumed to maximize expected utility according to a von Neumann-Morgenstern utility function defined over end of season wealth (W) and which is strictly increasing, concave, and twice continuously differentiable. The components of gross revenue, harvest time price and crop yield, are assumed stochastic and potentially correlated. All other parameters of the decision are assumed non-stochastic.

For ease of illustration, price basis and basis risk are omitted in the following equation, but incorporated in the later empirical simulation. The wealth dynamic for a producer evaluating growing season risk management strategies may then be written as:

(1)
$$W_0 + A[f_1 * y_1 - C + NI(\gamma, P, f, y) + NF(\alpha, y_0, f)]$$

where the insurance and forward pricing decisions are respectively γ and α . Initial wealth is represented by W₀. Crop acres is A and production costs are denoted as C. The function NI(γ_i , *P*,*f*,*y*) represents the net return to insurance and is generally conditional upon random price and yield, the premium charged, and the quantity of insurance, γ_i chosen. The function NF(α , y_{o} , *f*) represents the generalized net returns to either futures or put option purchase.³

Stochastic Specification

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³ Producers obviously have a choice among insurance products which is a straightforward generalization of this model. We have chosen to examine each insurance design separately to concentrate on the relationship of hedging with each insurance design rather than finding the optimal design for a particular producer.

The numerical integration model used in the analysis is a function of four random variables, county yield deviation from expectation, deviation of farm yield from county yield, price change from planting to harvest and harvest time basis risk. At decision time, expected yield, current futures price for the harvest month contract f_0 , and the historical harvest time basis are assumed known. Harvest time futures prices are generated assuming a multiplicative shock such that

$$\mathbf{f}_1 = \mathbf{f}_0 * \mathbf{\epsilon}_1,$$

where ϵ_1 is the relative futures price movement from planting to harvest time and assumed to follow a log-normal distribution.

Local harvest time prices are generated as follows,

$$(9) p_1 = f_0 * \epsilon_1 + b_0 + \epsilon_2$$

here b_0 reflects the expected harvest time basis and ϵ_2 equals deviations in the realized basis from the expected basis. Basis risk, ϵ_2 , is assumed normally distributed.

Farm yields are generated assuming that farm yield may be decomposed into a systematic portion correlated with county yields and non-systematic idiosyncratic individual variation. This approach is taken to augment fairly short available farm yield series with the added information available at the county level. This relationship may be written as,

(9)
$$y_1 = y_0 + \beta_1 \epsilon_3 + \epsilon_4$$

where y_0 is the expected farm yield, β_1 reflects the systematic relationship between the individual and county yields as shown in Miranda, ϵ_3 is the deviation in county yield from expectation, and ϵ_4 is the non-systematic variation in farm yields. Given that we are constructing a representative farm for a particular county from data for several individuals, the acre-weighted average of all farm-county yield differences will equal zero. Miranda also shows that the acre-weighted average of all β 's within a county equals 1. Thus equation 9 may be rewritten as,

(10)
$$y_1 = \mu_c + \epsilon_3 + \epsilon_4$$

where μ_c is the expected county yield. The potential non-normality of yields is assumed to be captured by ϵ_3 . Following Miranda again, we assume that the non-systematic variation of farm-county yields, ϵ_4 , are normally distributed.

Parameterization of the Model

The joint probability distribution of the four random shocks, ϵ_1 , ϵ_2 , ϵ_3 , and ϵ_4 determine the density of gross revenue and thus, the effects of risk management tools. Given the nonnormal marginal density of ϵ_1 and ϵ_3 , transformations to approximate normality are used to allow the specification of a multi-variate normal distribution which is used to estimate the probabilities of different outcomes. Product moment correlations between the four transformed random variables are estimated following the suggestion of Fackler (p. 1093). Transformation of the price distribution is achieved by using the logarithms of price. The transformation of ϵ_3 is made using the hyperbolic tangent transformation proposed by Taylor. The transformation to normality involves first expressing the cumulative density as a hyperbolic tangent function of yield,

$$F(Y) = 0.5 + 0.5 + \tanh(\beta_0 + \beta_1 Y + \beta_2 Y^2 + \beta_3 Y^3)$$

where the β_k are estimated with maximum likelihood, and then finding the standard normal value with cumulative probability of F(Y). Prior to estimating the β_k , the yields are detrended by regressing on a 2nd order polynomial of time. Heteroskedasticity is corrected by using weighted least squares and by assuming the variance of the ϵ_t is also a 2nd degree polynomial of time.

The expected futures price was set at \$2.80 and price variability over the growing season at 19% respectively, based on March 1998 observations in the Chicago Board of Trade corn futures and implicit volatility from the options markets. Expected basis and basis risk measures were constructed by comparing differences in NASS data reporting monthly state prices received by farmers and the monthly average futures price at harvest over the 1975-1995 period.

NASS county yield data over the years 1956-1995 were used to estimate each county yield distribution.⁴ The variances of farm-county yield differences were estimated by combining 1985-94 farm yield observations provided by the RMA with corresponding county yield observations and pooling all farms in the county. The correlations between county yield, futures price, and basis were estimated using transformed data over the 1975-1995 period. Correlations between the farm-county yield differences and other variables were set to zero, as they must be on average for all farms in the county (Heifner and Coble, 1997). Commission and other trading costs are set at \$50 per contract, margin deposits at 8%, the farmers interest on margin deposits and options premiums at 8% and the interest rate for pricing options at 6%. The insurance subsidy for each type of insurance is assumed to be equal to 23.5% of the premium for 75% MPCI coverage.

Representative Farms

The underlying price, basis, county and farm yields were available for a large number of U.S. counties (Heifner and Coble, 1996). Because price variability tends to differ little among farms and basis risk is small relative to price risk, regional differences are most apparent in yield variability and yield-price correlation. Four counties were chosen to represent farms from areas with differing levels of yield variability and yield-price correlation. Statistics for these counties are reported in Table 1. Iroquois County in east central Illinois, was chosen to represent the typical Corn belt case of relatively low yield variability and yield-price correlation that is strongly negative. Shawnee County in east central Kansas, represents an area with relatively high yield variability and high yield-price correlation. Lincoln County in west central Nebraska, is an irrigated area with low yield variability and low yield price correlation. Pitt County in east

⁴ Jerry Skees of the University of Kentucky assembled the county yield observations prior to 1972.

central North Carolina, is representative of an area with high yield variability and low yield price correlation.

Numerical Integration

The numerical integration procedure used allows unequal sampling intensity from each of the four random variates. The range of each normal variable from -4 to +4 standard deviations is divided into m_i equal length intervals. The numbers of intervals used for the results reported here were 39, 10, 20, and 20 respectively for futures price, basis, county yield, and farm-county yield difference. This gives approximately equal attention to farm-level price and yield dispersion and reflects the smaller variation in basis than in futures prices.

Midpoints of the intervals, z_{ih} , i=1,2,...4, $h=1,2,...m_i$, are determined. Each combination is assigned a probability proportional to its multi-variate normal density,

$$\omega_j = \frac{r^n}{m} f(z_j), \quad j=1,2,\dots,m.$$

where r^n/m is the proportion of the total probability space represented by each set of midpoints, and $f(z_i)$ is its probability density,

$$f(z_j) = (2\pi)^{-n/2} (\sigma_1, \sigma_2, ..., \sigma_n)^{-1} |R|^{-1/2} e^{-1/2\epsilon' R^{-1}\epsilon}$$

where σ_i is the standard deviation of the ith normalized variable, *n* is the number of variables, R is the correlation matrix, $\epsilon_{ij} = (z_{ij} - \mu_i)/\sigma_i$, i = 1, 2, ..., n, and μ_i is the mean for the ith normalized variable. Farm-county yield differences are assumed to be uncorrelated with the other variables. Inverse transformations are applied at each midpoint to obtain corresponding values in original units.

Expected Utility Assumptions

Certainty equivalent gains are estimated for two combinations of initial wealth and risk aversion using constant relative risk aversion (CRRA) utility functions. Initial wealth levels for a farm with 500 acres of corn is set at \$400,000. Relative risk aversion is set at 2 to represent moderate risk aversion and 4 to represent high risk aversion. The certainty equivalent measures show how the individual's initial wealth and degree of risk aversion affect the gains from alternative strategies. However, the estimated certainty equivalent dollar gains are not necessarily representative because they rest on assumptions about wealth and risk aversion.

Two rounds of numerical integration are performed. The first round estimates the insurance premium, expected values of crop sales, prices and yields. In the second round, insurance costs are applied and deviations from respective means are computed. Our assumption is that insurance rates are actuarially fair before subsidy and overhead costs are not loaded into the rates. The optimal hedge and put ratio is found by a grid search of forward pricing ratios ranging from 0 to 1 in 0.1 increments. At each grid point the certainty equivalent gain is evaluated and the optimal hedge is chosen based on the hedge ratio which maximizes the certainty equivalent gain.

Results

We begin by examining the optimal hedge ratio without insurance for each of the four representative farms. Table 2 shows the optimal planting time hedge ratio and certainty equivalent gain from hedging in each location. The differences in the underlying yield variability and yield-price correlation result in optimal hedge ratios ranging from no hedging up to hedging 60% of the expected crop under both moderate and strong risk aversion. The highest hedge ratio results in the location where yield-price correlation is low and yield variability is relatively low as compared to other regions due to the predominance of irrigation in this county. Conversely, the lowest optimal hedge ratio occurs in the location where yield-price correlations bear out that the demand for hedging is negatively correlated with yield variability and yield-price correlation. Certainty equivalent gains, which reflect the increased producer welfare from risk reduction, are also reported. They reveal a generally small gain relative to the per acre crop value. However, the greatest gain does come in Nebraska where the hedge appears most effective.

The two other locations are representative of areas where yield-price correlation and yield variability produce a mixed effect. The Iroquois County, Illinois, farm has a ten percent hedge ratio which is held low by the strongly negative yield price correlation, in spite of a relatively low yield variability. The North Carolina farm's base case hedge ratio is 30%. Here the natural hedge does not exist to limit the optimal hedge ratio, but the relatively large yield variability appears to be a more significant factor in revenue variability.

To address the effect of various insurance designs, the model was estimated with insurance coverage varied from zero to 100% of expected yield in 12.5% increments. This allowed us to examine the potentially nonlinear response of the optimal hedge as insurance quantities were increased. Although insurance coverage above the 75% coverage is not allowed in any of the programs investigated here, the analysis was carried to the 100% level to more fully reveal the relationship between a particular insurance program and the optimal hedge ratio.

Figure 1 shows the relationships found for each insurance design for each of the four locations. First, very low levels of insurance protection had no effect on the optional hedge ratio in all four representative farms. The Pitt County, North Carolina farm saw the earliest change in the optimal hedge ratio at 12.5% insurance coverage. The Lincoln County, Nebraska, optimal hedge was unaffected by insurance coverage until coverage reached the 62.5% level. Given the relevant range of insurance coverages offered in the U.S. is the 50% to 75% levels, little change in observed hedging demand would be expected from any of the designs in the Nebraska case.

As the insurance coverage is increased for each of the four locations, a consistent relationship is found as one compares across the four insurance designs. For each of the locations, at higher coverage levels, MVP is always associated with the highest optimal hedge. MPCI is the second highest, with revenue products, CRC, and RI ranked third and fourth respectively. The two yield insurance designs, when they do cause a change in the optimal hedge, always result in an increased optimal hedge. Thus, it appears that the yield insurance designs are found to be purely complementary to hedging in all four cases. It would appear that the MVP component which indemnifies producers at the greater of preseason price or harvest time price does provide a slightly greater optimal hedge than MPCI. This is most obvious in the Anderson County, Kansas, case. MVP results in a 10% increase in the optimal hedge as compared to MPCI when coverage is 62.5% and higher.

The revenue insurance designs show a more complex relationship with the optimal hedge. The "MVP like" component of CRC results in an optimal hedge for CRC that is always equal to or greater than that of RI. In fact, CRC is found to always increase the optimal hedge over the uninsured case in three of the four locations. The Lincoln County, Nebraska, case is the exception with CRC resulting in lower than uninsured hedging levels when CRC coverage reaches the 62.5% of expected revenue. Interestingly, results for RI reveal a distinctly nonlinear relationship with hedging in Illinois and North Carolina. Here, an increase in hedging occurs over the mid-range of coverages, but as RI coverage increases, the optimal hedge ratio begins to fall. It appears that RI has the strongest substitution effect on hedging of the four insurance designs.

The relationship between insurance coverage and at-the-money put option ratio is explored in Figure 2. Analyzed over the same range of insurance coverages as for futures, the put option percentages tend to follow a similar pattern. Comparing between the hedge and put ratios shows that, in general, the put ratio is higher. We surmise that the higher option ratios occur because options hedgers are not subject to such large losses in low yield-high price years as are futures hedgers who may have to buy back their contracts at a high price.

As for hedge ratios, the put ratios compared across insurance designs show that when differences appear, MVP results in the highest put ratio with MPCI, CRC and RI following respectively. The effects of purchasing insurance on the optimal put tends to not become pronounced until higher levels of coverage. In Nebraska, there is no change until insurance coverage reaches 75%. A different relationship is observed between CRC and put option levels than was found in the relationship of CRC and futures hadging. In Figure 2, it can be seen that CRC tends to be more competitive with puts than with hedging. For example, in Illinois, increasing CRC tended to increase futures hedging. However, it causes reduced put percentages at higher levels of coverage. This likely results from CRC being a lower-bounding activity, which competes more directly with puts, which are also lower- bounding. This is in contrast with futures, which are lower and upper bounding. In other words, the upside price protection provided by CRC is similar to a call option in that the payoff increases as the price rises. This complements a futures hedge given a net position similar to a synthetic put. Such strong complementarity is absent when CRC is combined with a put option.

Conclusions

The proliferation of new insurance products greatly changes the context in which hedging decisions are made. This study was conducted to provide empirical analysis of optimal futures and put hedging levels when producers have yield, price, and revenue risk management markets available to them. Because of the difficulty of jointly considering complex insurance designs and hedging we have taken a numerical approach to addressing the effect of alternative insurance programs on the optimal hedge ratio.

In general, revenue insurance tends to result in lower hedging demand than would occur given the same level of yield insurance coverage. However, the differences tend to be small (no more than a 10%) over the relevant range of insurance coverage. We also find a consistent pattern that the upside price protection of MVP and CRC design tends to be more complementary to hedging than the RI design. To the extent that producers would switch from yield insurance to revenue insurance, there would be a decline in the demand for hedging. One may also consider the hedging levels observed with the various insurance products as compared to the uninsured

case. That is, if a person were to go from being uninsured to the purchase of one of the insurance designs, we find that the revenue products result in a hedge ratio that is at least as high as the uninsured case when considering the permissible levels of coverage.

Because some of the insurance tools examined here are so new to producers and sufficiently distinct in their design, producers at this point may have difficulty evaluating the decisions modeled here. One might expect that as producers become more familiar with the implications of these alternatives, there will be an evolution in how producers utilize the combinations of insurance and forward pricing instruments.

We see several natural extensions to this work. Obviously, other crops and regions may be examined. It would also be useful to consider the joint optimization of acreage, insurance and forward pricing decisions. Possibilities of further risk reductions by combining insurance with the joint use of futures and options (or combinations of options at different strike prices) deserve exploration in light of the Sakong, Hayes and Hallam article, where insurance was not included.

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Parameter			Counties			
		Iroquois, IL	Anderson, KA	Lincoln, NE	Pitt, NC	
Basis, \$/bu	Mean	24	15	26	0	
	Std. dev.	.14	.17	.17	.20	
Futures price-basis	Correl.	28	27	46	.16	
County yield-basis	Correl.	.18	01	.06	44	
Farm price	Mean	2.61	2.70	2.59	2.85	
	CV	.19	.19	.18	· .20	
Farm yield	Mean	138.0	81.1	149.4	85.3	
	CV	.20	.39	.15	.41	
Revenue	Mean	354.15	213.65	384.80	239.20	
	CV	.22	.39	.22	.44	
Farm yield-price	Correl.	39	32	13	17	
Insurance subsidy	\$/acre	1.48	3.35	.34	3.90	
Table 2 – Optimal hec	lge ratio with	nout insurance [*]				
Location		CRRA=2 Wealth=\$400,00	0	CRRA=4 Wealth=\$400,00		
Iroquios County, IL		20% (\$0.42)		30% (\$1.21)		
Anderson County, KS		0% (\$0.00)		0% (\$0.00)		
Lincoln County, NB		60% (\$2.49)		60% (\$6.35)		
Pitt County, NC		30% (\$0.32)		40% (\$0.93)		

Table 1 -- Estimated parameters for counties included in the numerical analysis

*Certainty equivalent gains are reported in parentheses.







Figure 2.