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Microeconomic Evaluation of Farm Risk Management Decisions in Kentucky

Murali Kanakasabai, Carl Dillon and Jerry Skees*

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Introduction

Agriculture remains a high-risk industry. Numerous past studies have focussed on the critical importance of risk in the decision-making process (Anderson, Dillon and Hardaker, Hardaker; Huirne and Anderson; Robinson and Barry). Combating risk in agriculture has been, and continues to be, one of the greatest challenges to producers and policy makers alike. The inherent biophysical nature of agricultural and livestock systems combined with various external stimuli makes it vulnerable to multiple sources of risk. These sources emanate from both the production environment, as well as from the market, technological and social environments that characterizes agriculture. Further, the nature of risk in the production environment is complicated by interaction between these multiple sources of risk. This interaction will ultimately influence the overall exposure to risk as well as choice of avenues for risk management. For example, low crop yields along with precipitation during harvest time could significantly increase total risk exposure that a producer might face. Hence, both the timing and severity of individual risk events is critical in assessing the overall risk that producers face in crop production. Modelers and decision-makers must be cognizant of the multiple facets of the agricultural risk environment for efficient decision making.

The second arena of interest to economists concerns the responses that producers make to the risk exposure i.e. risk management. Risk management is the systematic application of management policies, procedures, and practices to the tasks of identifying, analyzing, assessing, treating and monitoring risk. Farmers tend to select a portfolio of risk management strategies that maximize their expected returns subject to the degree of risk, which they are willing to accept (Tomek and Peterson). Individuals with higher risk aversion generally have a tendency to accept a lower but more certain equivalent of the gamble to the gamble itself.

The vital role played by agriculture in society has justified a sustained public investment in various avenues of farm risk management. Producers in a modern market based economy have had a number of alternatives for managing risks. These include enterprise diversification, self insurance, credit reserves, investments in loss mitigation's, or the use of market-based risk sharing arrangements (Skees and Barnett).

Two popular avenues that have been extensively researched include crop insurance and enterprise diversification. Crop insurance programs have been an inherent part of U.S. federal policy since 1930s (Goodwin) and were traditionally intended to protect producers against yield risks. Continuing innovation on the insurance front has yielded a wide range of insurance products designed to manage both crop yield as well as revenue risks, and to integrate other federal goals into the program. Enterprise diversification has remained another convenient avenue for risk management. While risk-taking producers generally prefer "market savvy" and high yielding crops, risk averse producers choose crops that have more stable yields. Numerous extant studies exist on the role of crop insurance (e.g. Ahsan; and Ray) and enterprise diversification (e.g. Dillon, Mjelde and McCarl; Misra and Spurlock; Teague and Lee and Barnes and Justus) on mitigating risk.

Producers however engage in other legitimate avenues of risk management that merit consideration. The use of a variety of alternative production practices and spatial management according to land types are some examples. Alternate production practices include the use of alternate planting dates (Larson *et al.*; Larson and Mapp; Dillon, Mjelde and McCarl), variety selection (Traxler *et al.*; Dillon; Grisley), altering plant population (Larson *et al.*; Sweeney, Granade and Burton; Polito and Voss), irrigation (Boggess and Ritchie; Boggess and Amerling; Harris and Mapp), pest management (Hurd; Szmedra, Weszstein, and McClendon) among others. Producers have also traditionally reduced uncertainties in crop production by planting crops, along with economic considerations, in the best parcel of land for that particular crop characteristics.

The purpose of the above discussion is to heighten the need for a holistic approach while handling risk issues in agriculture. The efficiency, structure, and performance of agriculture critically depends on the resources that producers make in managing risk and on the resilience of the system to adaptation. While ample studies exist on agricultural risk, most deal with models that incorporate single avenues of risk management. There is a genuine paucity of economic research that integrates multiple sources of production risk and the avenues to combat them. The primary motivation for the present study emerges out of a desire to model the whole farm environment along with multiple strategies to manage the risk in that environment. The direction taken by this research is an effort to arrive at a unified risk management strategy wherein producers across risk level are allowed to cope with risk through different modes. This will give an understanding of the optimal mix of risk management options that producers choose across different risk preference levels. This will also serve as an aid in designing better risk management tools for the producers.

The framework developed in the paper allows for uncertainty in crop yields along with suitable field day risk to be modeled. While many other sources of risk can be modeled, this will give an initial feel on the importance of considering a holistic approach while modeling the production environment. More interestingly, multiple modes for risk management are allowed: enterprise diversification, purchase of crop insurance, alternative production practices, and spatial management across different land zones in the field. A detailed discussion on risk management tools incorporated is included under the methodology section in the paper.

The other facet of the study emerges as a function of the design of the risk management tool and especially concerns the design of crop insurance in the model. The history of crop insurance has been plagued by poor actuarial performance, low participation and more significantly by moral hazard and adverse selection problems. Skees *et al.*, implicate insurance contract design problems in creating opportunities for fraud and abuse in Southern soybean during the 1980s. Moral hazard and adverse selection problems arise when requirements of accidental or unintentional loss are violated. Specifically, Skees defines moral hazard as the condition when, as a result of purchasing insurance policy holders significantly increase the probability and/or extent of losses. This occurs as with the provision of insurance, producers able to better withstand risk, tend to assume greater risk. The rules for establishing yield guarantees in the crop insurance program are tied to producers and farms, and not to parcels of land or a particular production practice. Rational agents with the knowledge of insurable yields will strategically "manage" the insurance option and obtain coverage that is greater than the potential yields. The possibility of economic gain might induce producers to move to riskier crops, production practices, and cultivation on riskier regions (Hoffman, Campbell, and Cook). Recent research raises concerns over the unintended environmental damage resulting from subsidized crop insurance. Keeton, Skees and Long (2000) report 50 million new acres being brought into cultivation as a result of subsidized crop insurance, mostly on lands that would not be normally cultivated. Governmental agricultural support programs have played a significant role in changing land use patterns in the United States (Griffin, Skees). Similarly, producers might also strategically manage insured crop to induce indemnity payments. Smith and Goodwin demonstrated that fertilizer and chemical usage for Kansas wheat producers tended to be negatively correlated with insurance. The provision of multiple avenues for risk management in the present paper along with traditional multiple peril crop insurance provides a genuine concern for such responses in the model. It is believed that rational producers might shift to riskier production practices and land types in an attempt to trigger payments. The second objective of the research is to study the impact of moral hazard on the optimal solution across risk levels.

The locale selected of the present study is Henderson county in the western end of Kentucky. The county is considered an excellent location for the study considering it stood fifth out of 120 counties in overall crop cash receipts in 1997. It was also the lead county under the above categories for the crop reporting district two, which is a primary row crop producing region of Kentucky. Henderson ranked second, fourth and tenth among Kentucky counties for soybean, corn and wheat production respectively in 1997.

In the following sections, a description of the underlying agronomic and economic model will be first enumerated. Later, the model results and discussion followed by conclusions will be discussed.

Methodology

Objective 1: To integrate various avenues for risk management to provide a unified risk management strategy for the Kentucky producer.

Objective 2: To study the impact of moral hazard on the optimal solution across risk levels.

The research methodology selected for justifying the above objectives necessitated the integration of biophysical simulation with mathematical programming techniques. In the following section, the procedure is elaborated. The different modes of risk management allowed are also discussed concurrently under appropriate headings

The Agronomic Model

The agronomic component of the modeling is focussed on three crops of corn, soybeans and wheat and on four enterprises of corn, full season soybeans, wheat and double-cropped soybean with wheat. Corn, soybean and wheat are important crops to Kentucky's economy ranking third, fourth and fifth respectively with $446, $333, $122 million of total value product for 1997 (Kentucky Agricultural Statistics 1997-1998). In 1997, the selected crops represented 35% of the total crop value for Kentucky. Biophysical simulation using CORNF (Stapper and Arkin) for corn, SOYGRO (Wilkerson *et al.*) for soybean and CERES (Ritchie and Otter) for wheat was used to simulate respective crop yields. Biophysical simulation involves using process models that explicitly account for the biological and/or physical components of agricultural production, generating production response surfaces for empirical production research (Musser and Tew, Boggess). Twenty years of weather data (daily maximum and minimum temperatures and precipitation) were used to obtain the crop yields. Lack of daily solar radiation data necessitated the use of data from neighboring county of Evansville, Indiana.

Crop production was carried under a no-till dryland condition, as is representative of the region. The model allowed for existence of multiple fertility zones within the field to facilitate crop management spatially across the farm. This was modeled by inclusion of four representative soil types of the region. Resources from the National Resource Conservation Service data bank were used to identify the representative soil classes and biophysical simulation yields were generated by soil types for each crop. The predominant soil class in the region was loam. Based on careful examination of the soil characteristics and consultation with experts four general soil categories were selected for the simulation. These were medium silty loam, Sharkey clay, deep silty loam and Loring silt loam soil types. The next section discusses the modeling of the alternative production practices included in the study.

Alternative Production Practices

A wide range of management options in terms of planting dates, variety, alternative plant populations and maturity classes were incorporated into the analysis as reflected by the Kentucky Agricultural Statistics for all the crops. Corn included early, medium and late maturity groups and was planted in weekly intervals from March 29 through May 24 for nine planting dates. Plant populations included low, medium and high populations of 20,000, 24,000 and 28,000 plants per acre respectively. Soybean represented by three maturity groups namely, MG 3, MG 4 and MG 5 planted in nine weekly intervals from April 26 through June 21. Additionally, six plant and row spacing combinations were incorporated for alternative plant populations. Wheat planting dates ranged from September 27 to November 22 in nine weekly intervals. The model allowed for both single as well as double crop cultivation of soybean and wheat. The agronomic parameters for double cropping mirror those for single cropping in both soybean and wheat cultivation. Under double crop cultivation, soybean was planted five days after the harvest of wheat. The other major avenue for risk management in the model is through purchase of crop insurance, which is discussed next.

Crop Insurance

The design of crop insurance in the model was based on traditional multiple peril crop insurance (MPCI). This type of insurance provided producers protection against yield losses caused by a range of natural occurrences. The program requires atleast four years of actual production history and violations are dealt with lowered protection per unit premium. Similar to other crop insurance programs, MPCI is administered through a public-private sector partnership. The Risk Management Agency (RMA) of the United States Department of Agriculture is responsible for the design and rating of the MPCI product, which is then sold by private concerns to producers. In recent years, the premiums and indemnity payments are calculated based on the actual production history of the individual producer as opposed to production history in the producers geographical area. However, these estimates are based on production yields alone and not tied to the land type or particular production practice that the producer employs. Consequently, incentives for income enhancement from the insurance program exist when producers strategically shift practices to benefit from the contract.

The structure of the MPCI insurance is presented in the following equations used to calculate the indemnity and the premium.

Indemnity = Guaranteed Price *Max [0, Guaranteed Yield – Actual Yield)]

Insured crop are paid based on the shortfall from the guaranteed yield for the years that trigger payments and receives nothing otherwise.

Premium = Guaranteed Price* Guaranteed Yield * Rate

In the present study, the guaranteed yield for each crop was estimated as the average yield of that crop under the base case scenario. The guaranteed yield, therefore, is based on the set of management strategies that a producer would have employed prior to the introduction of the insurance option. The guaranteed price and the rate for each crop is determined for each state, depending on relative risk, by the RMA and was used by the study. The MPCI is usually sold at the coverage levels of 50%, 65%, and 75%. The present study models and compares all the above coverage levels.

The above discussion has constructed the decisional framework for action by the rational agent. However, the response of the individual to this environment will be based on economic considerations. Crucial among these is the profitability as well as riskiness of the competing choices. The economic framework of the study is explained next.

The Economic Model

The economic model is constructed as a quadratic programming model embodying an expected value-variance (E-V) framework to incorporate profit and risk considerations of the producer. This technique maximizes risk adjusted net returns where a penalty related to the variability of net returns is subtracted from the mean net returns (Dillon). The E-V results have also been shown to be consistent with the expected utility hypothesis (Meyer, Freund). The model used in the study extends beyond conventional considerations of yield risk alone by including uncertainty in field days. Many extant studies have discussed the importance of field time availability (Acharya, Haynes and Brown, Babeir, Colvin and Marley) as a potential constraint in production risk. Indeed, variations in weather apart from impacting yield, also influence the number of days suitable for fieldwork and consequently on the employment of production resources. The interaction effect of various sources of risk as explained earlier is also critical. Recognizing the importance of changing risk environment, the model considers field time availability as a constraint to crop production. Most models that predict suitable field days utilize soil moisture content in conjunction with precipitation in order to predict the suitability of performing fieldwork on a given day. The present study estimates the field availability per week using historical weather data and a soil water simulation developed using a modified procedure by Dillon, Mjelde and McCarl. A detailed definition on arriving at the suitable days can be had from Dillon (1998).

The mathematical formulation of the E-V model used is the following:

Max $Y - \phi\, \sigma^2_y$

Subject to the following constraints

1). $\Sigma_E\, \Sigma_V\, \Sigma_P\, \Sigma_S\, UX_{E,V,P,S,LT} + \Sigma_E\, \Sigma_V\, \Sigma_P\, \Sigma_S\, IX_{E,V,P,S,LT} \leq \text{ACRES}_{\text{LT}} \qquad \forall\, LT$

2). $\Sigma_E\, \Sigma_V\, \Sigma_P\, \Sigma_S \Sigma_{LT}\, LAB_{E,S,WK}\;\; UX_{E,V,P,S,LT}\; +$

$\Sigma_E\ \Sigma_V\ \Sigma_P\ \Sigma_S \Sigma_{LT}\ LAB_{E,S,WK}\ \ IX_{E,V,P,S,LT} \leq FLDDAY_{WK,LT}$ $\quad \forall\ WK, LT$

3). $\Sigma_E\ \Sigma_V\ \Sigma_P\ \Sigma_S\ \Sigma_{LT}\ EXPYLD_{C,E,V,P,S,LT,YR}\ \ UX_{E,V,P,S,LT}\ +$

$\Sigma_E\ \Sigma_V\ \Sigma_P\ \Sigma_S\ \Sigma_{LT}\ EXPYLD_{C,E,V,P,S,LT,YR}\ \ IX_{E,V,P,S,LT}\ -SALES_{C,YR} = 0$ $\quad \forall\ C,YR$

4). $\Sigma_E\ \Sigma_V\ \Sigma_P\ \Sigma_S\ \Sigma_{LT}\ REQ_{I,P}\ \ UX_{E,V,P,S,LT}\ +$

$\Sigma_E\ \Sigma_V\ \Sigma_P\ \Sigma_S\ \Sigma_{LT}\ REQ_{I,P}\ \ IX_{E,V,P,S,LT}\ -PURCH_I = 0$ $\quad \forall\ I$

5). $\Sigma_E\ \Sigma_V\ \Sigma_P\ \Sigma_S\ \Sigma_{LT}\ INDPAY_{E,V,P,S,LT,,COV}\ IX_{E,V,P,S,LT} - INDEMNITY_{C,YR,COV} = 0$ $\quad \forall C,YR,COV$

6). $\Sigma_E\ \Sigma_V\ \Sigma_P\ \Sigma_S\ \Sigma_{LT}\ PREMPAY_{E,V,P,S,LT,,COV}\ IX_{E,V,P,S,LT} - PREMIUM_{C,YR,COV} = 0$ $\quad \forall\ C,YR,COV$

7). $\Sigma_I\ IP_I\ PURCH_I + \Sigma_c\ PREMIUM_{C,YR,COV} - \Sigma_c\ INDEMNITY_{C,YR,COV}\ -$

$\Sigma_C\ P_C\ \ SALES_{C,YR} + Y_{YR} = 0$ $\quad \forall\ YR, COV$

8). $\Sigma_{YR}\ 1/N\ Y_{YR} - Y = 0$

where,

Y = Mean expected net returns above variable costs across years

Y_{YR} = Net returns above variable cost by years (net returns)

$UX_{E,V,P,S,LT}$ = Production of uninsured enterprise E of variety V with population P under sowing date S in acres under land type LT.

$IX_{E,V\ P,S,LT}$ = Production of insured enterprise E of variety V with population P under sowing date S in acres under land type LT.

$SALES_{C,\ YR}$ = Bushels of crop, sold by year

$PURCH_I$ = Purchases of input I

$INDPAY_{E,V,P,S,LT,,COV}$ = Indemnity received for crop enterprise E of variety V with population P under sowing date S in acres under land type LT for coverage level COV.

$PREMPAY_{E,V,P,S,LT,,COV}$ = Premium payments for crop enterprise E of variety V with population P under sowing date S in acres under land type LT for coverage level COV.

$INDEMNITY_{C,YR,COV}$ = Total indemnity payments for crop C under coverage level COV received in year YR

$PREMIUM_{C,YR,COV}$ = Total premium payments for crop C under coverage level COV paid in year YR

ϕ = Pratt risk aversion coefficient

P_C = Price of crop C in dollars per bushel

IP_I = Price of input I

$EXPYLD_{C,E,V,P,S,LT,YR}$ = Expected yield of crop C for enterprise E of variety V planted in population P on sowing date S under land type LT in bushels per acre.

$REQ_{I,P}$ = Requirement of input I for production in row and plant spacing P in units per acre

$LAB_{E,S,WK}$ = Labor requirements for production of enterprise E planted on sowing date S in week WK in hours per acre.

$FLDDAY_{WK,LT}$ = Available field days per week at varying levels of certainty for land type LT.

The objective function maximizes the certainty equivalent of net returns or the net returns above variable costs (NRVC) less the product of Pratt risk aversion function coefficient and the variance of net returns (σ^2_y). The Pratt risk aversion function coefficient, formulated using methods by McCarl and Bessler, measures the risk aversion of the hypothetical grain producer. Here, the producer is assumed to maximize the lower limit from a confidence interval of normally distributed net returns. The risk aversion parameters were selected by increasing the Z score from 50%, which depicts that of the risk neutral situation (ϕ=0). A general expression for calculating the risk aversion parameter is given below.

$$\phi = 2Z_\alpha / S_y$$

Where ϕ = risk aversion coefficient

Z_α = Standardized normal Z value of α level of significance

S_y = Relevant standard deviation from the risk neutral profit maximizing base case scenario.

The objective function is constrained by a set of resource constraints 1-8. Constraint (1) defines the land resource limitation according to land type. The farm is restricted to operate on total of 1350 acres of cultivable land. This was derived by rounding the average tillable acres for an Ohio valley grain farm of 1346 acres up to 1350 acres (Morgan). Further, the total acreage is divided into four land types representing different fertility zones in the total farm. The four land types as mentioned earlier are deep silty loam, medium silty loam, Loring silty loam and Sharkey clay and account for 337.5 acres each. Constraint (2) defines the suitability of field days according to land type. The inclusion of different land types in the model necessitates modeling appropriate suitable field days according to land type. The procedure for arriving at suitable field days involved the use of a soil water simulation as mentioned earlier. The number of suitable field days for each land type occurring in a week serves as an appropriate labor constraint in the model. A 50% likelihood of a given number of days suitable for fieldwork occurring in any particular week was specified as the appropriate labor constraint for all scenarios. However, adjustments of the suitable field days according to the appropriate resource base need to be carried out. This would involve a more complex joint modeling procedure than used in this study, and is subject to future research. Constraint (3) restricts the labor employed in the farm. The labor requirements per week, input prices and per acre input requirements were taken from representative Tennessee not till enterprise budgets (Gerloff and Maxey). Labor requirement were adjusted to weekly data and shifted by planting dates. Statistical computations of simulated harvest dates allowed for adjustment of harvest time by maturity class. Constraint (4) defines the total input purchases for the whole farm enterprises including both the insured and uninsured crops. These are estimated using per acre input requirement, total acres under production and management strategy (e.g. plant population). Constraint (5) defines the indemnity payments that have been received by year, for a given insured crop and coverage level. Constraint (6) defines the premium payments that have been paid for insurance purchases by year for a given crop and coverage level. Constraint (7) defines the NRVC by year. While a distinct possibility of price risk exists, it was not modeled due to the predominant focus of the research on production risk and due to the uncertainty in predicting future price distributions. Hence, the 1993-1997 Kentucky average season prices for crops i.e., \$2.79/bu for corn, \$6.70/bu for soybean and \$3.48/bu for wheat (Kentucky Agricultural Statistics 1997-1998) was included as being appropriate. Constraint (8) estimates the mean net revenues above variable costs in the chosen crop enterprise.

Results and Discussion

The following section presents the results from the three different coverage levels of MPCI (50%, 65% and 75%) that were simulated along with a base case that did not possess the insurance option. The alternative production practices as well as land types were of the standard design, explained earlier, under all the scenarios. The study results were obtained across ten different levels of risk preference. However, three levels risk significance: slight risk aversion (Z = 65%), moderate risk aversion (Z = 75%) and high risk aversion (Z = 80%) along with a risk neutral case (Z = 50%) will alone be discussed. The section will continue elaborating the finding from each scenario. This is followed by a section on conclusions along with the major recommendations.

Base Case

The optimal solution for the risk neutral base case scenario provided a mean net returns above variable costs (NRVC) of $ 378,983 with a coefficient of variation (C.V.) of 17.6%. The NRVC ranged from a minimum of $236,493 to a maximum of $459,179. The optimal crop management strategy involved cultivation of soybean and corn only. The total available land was split equally among these two crops. Further producers exhibited good land management by allocating land zones optimally across the cropping portfolio. While half of the total soybean cultivated was in deep silty loam with the other half cultivated in medium silty loam soils, corn was predominantly cultivated in Loring silty loam and Sharkey clay soils. Statistical examination of biophysical simulation yields proved that these land types to be best suited to the selected crops. A summary of economic returns and management strategy under scenario is provided in table 1.

Alternate planting dates for soybean production ranged from April 26 to May 10. However, predominant planting was done during the April 26 (39%) and May 3 (38%) planting dates. The range of planting dates suggests a critical need to spread harvesting requirements across critical time periods. Soybean was planted with nine-inch row spacing and two plants per foot across all optimal planting dates. Alternate soybean varieties used in the risk neutral base case scenario consisted of mostly MG 5 (50%) and MG 4 (49%) varieties with very little MG 3 (1%) being cultivated. Corn cultivation was spread across four planting dates of March 29, April 5, April 12 and April 19. The LATE cultivar planted with a high plant population was the predominant cropping practice under the risk neutral base case. The complete set alternative production practices employed in the base case is provided in table 2.

Risk averse producers compensated losses in NRVC with declining C.V.s as expected. Producers who were slightly risk averse compensated losses in NRVC by 1.1% from base case levels with a lower C.V. of 15%. A similar trend was observed with increasing risk aversion. Producers who were highly risk averse had a mean NRVC of only $341,685 (5.5% below risk neutral level) but enjoyed a significantly lower C.V. of 13%. The cropping strategy with increase in risk aversion lead to greater corn acreage, and wheat entering the optimal decision at extreme levels of risk aversion. Specifically, while the cropping strategy at the slight risk aversion mirrored that of the risk neutral case, moderately risk averse producers devoted 746 acres under corn and 603 acres under soybean.

Alternate production strategy for soybean under higher levels of risk aversion showed a shift to later planting dates, reflecting a move to reduce risk of frost associated with earlier planting. Producers were also exhibiting greater diversification in planting dates to manage risk. Hence, a range of planting dates from April 26 to June 21 was noticed. However, no significant change from the risk neutral case was noticed with respect to soybean plant population or variety, with increase in risk aversion. Soybean cultivation was also carried out in deep silty loam and medium silty loam soils as in the risk neutral case. Substitution of soybean for corn, at higher levels of risk aversion, led to acreage decreases in medium silty loam soils. Corn exhibited a similar trend, as soybean, with greater diversification in planting dates. Corn population also were more varied with low, medium and high plant population entering the optimal solution. However, as noticed in the risk neutral case, only the LATE cultivar of corn was grown under all risk aversion levels. Increase in corn acreage with higher level of risk aversion necessitated inclusion of medium silty loam soil type for corn cultivation along with Loring silty loam and Sharkey clay soils. Therefore, medium silty loam was found optimal for both soybeans as well as corn cultivation under higher risk aversion.

The set of optimal decisions arrived under the base case scenario serves as a benchmark for comparison with scenarios that incorporate insurance along with the other management avenues. In the following section, the three scenarios depicting different coverage levels of MPCI are presented in comparison to the base case.

Multiple peril crop insurance: 50% coverage scenario

The results of the MPCI at the 50% coverage, also called the catastrophic coverage (CAT), are presented below. Both the NRVC and the C.V. for the risk neutral case under CAT was identical to the results obtained for the risk neutral base case. This is not surprising as the risk neutral producer, who is not affected by variability in net returns, chose not to invest in premiums for crop insurance. Consequently cropping portfolio, land management as well as all other production practices were identical to the risk neutral base case.

With increasing risk aversion, CAT contracts were purchased for soybean alone. However, comparison with base case results suggests little decreases in C.V. were realized. At moderate levels of risk aversion producers realized a lower C.V. of 13.83% with a mean NRVC of $365,488 in comparison to a C.V. of 13.89% and mean NRVC of $369,873 for a similar risk level under the base case. Cropping portfolio under risk aversion indicated producers across risk levels choosing to devote greater acreage to soybean, and hence lower corn acreage, when compared with the base case. This was because soybean is the more profitable crop but has higher variability in the model. Provision of CAT contract makes it feasible to grow more soybeans with lower risk, making it an attractive option for insurance purchases. This trend was especially noticed with higher levels of risk aversion devoting greater acreage to insured soybeans. For example, under moderate level of risk aversion a total of 675 acres under soybean was divided as 165 under insured crop and the remaining 510 acres being uninsured soybean. However, under high-risk aversion, insured soybean accounted for 180 acres out of the total 620 acres planted with the crop. Land management of the soybean differed little form the base case results. Soybean continued to be grown primarily in deep silty loam and medium silty loam soils for both the insured as well as the uninsured crops. Table 3 provides a summary of economic returns and management strategies followed under the scenario.

Alternative production practices for uninsured soybean was similar to base case results and will not be discussed. However, the production practices for the insured crop revealed some differences. All the insured soybean were grown during the late planting date of June 21 under the CAT. Comparison with June 21 planting in the base revealed further that producers were opting for greater diversification in variety and soil type under insurance. For example, June 21 planting of soybean was mainly done in deep silty loam soils with the MG 5 variety for risk aversion under the base case while with insurance, diversification with MG 3 and MG 5 varieties grown in deep silty loam and medium silty loam land types was noticed.

Corn cultivation under the scenario was slightly different from that of the base case whenever insured soybean was purchased. This was mainly due to the structure of the resource constraints as modeled in the study. The ability across risk levels, with insurance, for planting additional acreage under soybean and its impact on field time availability, labor etc. was responsible for some changes in the corn-cropping portfolio. For example, moderate risk averse producers almost doubled soybean acreage under the early planting date of April 26 while reducing May 24 planting by almost 23% from similar results under the base case. A detailed table of alternate crop production strategies is presented under table 4.

In summary, the results of the 50% MPCI coverage scenario showed little difference from those of the base case. Insurance purchases were made only for the soybean crop and increased with increase in levels of risk aversion. Alternative production practices and land management strategies were also similar. The next section covers the results from the 65% and 75% coverage levels. These findings indicated sufficient shifts in agronomic practices, and changes in economic benefits from insurance accruing to producers. The results indicate sufficient reason to believe that producers strategically respond to the insurance contract, in many cases leading to existence of moral hazard.

Multiple peril crop insurance: 65% coverage scenario

Mean NRVC's were higher along with lower C.V. across all risk levels under the scenario when compared with the base case results. The risk neutral case recorded a NRVC of $383,128, which was 1.1% higher than the base case. This was accompanied with a lower C.V. of 14% as against 17.5% in the base case. Interestingly, the risk neutral producer also purchased insurance. Risk neutral producers as modeled are interested only in the magnitude of mean profits and are not affected by its variability. This suggests that the observed increase in the NRVC was primarily a result of producers gaining additional economic profits along with risk management from the insurance contracts. The cropping portfolio of the risk neutral producers at the 65% coverage had total land acreage being equally divided among corn and soybean (675 acres each) as in the base case, however one half of all soybean acreage was insured. Table 5 presents the summary of economic returns and management strategies followed in the scenario.

Further comparison of the crop and land management revealed producers to be changing production practices and land types to profit from the contract. As stated earlier, underwriting of the MCPI contract is not based on yields from a certain production practice or land type but on the historical yields from the farm alone. This provides sufficient latitude for producers to shift to riskier production practices and land types, and profiting from the insurance. This behavior was most evident from change in production practices at the 65% coverage level, especially for the insured crop. In comparison to the base case, there was a distinct movement to later planting dates for the insured soybean. Insured soybean were grown in three planting dates of June 7, June 14 and June 21 at risk neutrality. Producers also choose to cultivate the uninsured soybeans in medium silty loam and the insured soybeans in deep silty loam soils. Plant population at the risk neutral level remained unchanged at nine inches spacing with two plants per foot. Optimal decision for corn remained unaffected and resembled results arrived at the risk neutral base case.

Increases in risk aversion had expected results of lowered mean NRVC and C.V. from the risk neutral case. However, unified risk management strategy at this coverage level had substantial effect in lowering the variability of net profits. Slightly risk averse producers had a mean NRVC of $381,677 along with a C.V. of only 13.5% at the coverage level. This meant a 1.8% increase in mean profits from the base case along with a lowered C.V. This trend continued with higher levels of risk aversion. For example, at high levels of risk aversion, a C.V. of 9.7% could be achieved with a mean NRVC of $354,869 in comparison to a C. V of 13% for a similar level in the base case.

There were some interesting differences in cropping strategy under risk aversion. Moderate and highly risk averse producers insured both soybean as well as corn. In general, there was a decrease in total soybean acreage and increase in total corn acreage when compared to similar risk levels under the base case. Soybean acreage under moderate levels of risk aversion decreased 11.8% from base case results to 533 acres under the 65% coverage.

The changes in alternative production strategies for the insured crop showed a great deal of variation from the base case and uninsured crop. For example, the base case and uninsured soybean at the 65% coverage level followed a plant population of 9 inches with 2 plants per foot. While insured soybean included lower populations of nineteen inch row spacing with combinations of both 4 plants per foot and 6 plants per foot, and thirty inch row spacing with six plants per square foot. Insured soybean was also cultivated in late planting dates of June 7, June 14, and June 21 with mostly longer cultivar of MG 5. Insured soybean continued to be grown under soil types similar to the base. These shifts in production practices were also noticed for insured corn crop. Insured corn under the 65% coverage was mostly grown under late plantings dates of May 10, May 17 and May 24. Further, it involved strict cultivation of EARLY maturing variety planted with low plant population. The particular combinations of production practices were not noticed under either the base case or the uninsured crop giving reason to believe that producers were changing practices in response to the insurance contract. While detailed analysis of the risk involved under each combination of production practice has not been performed by this study, there is evidence that producers move to riskier combinations of practices in order to profit from the contract. This abuse of the insurance contract or moral hazard is also exhibited through land management as shown for insured corn. While corn has been cultivated under Loring silty loam and Sharkey clay soils under the base case and uninsured cultivation of corn, insured corn under the 65% coverage involved deep silty loam and medium silty loam soils. These soils represent "marginal" yields for corn as shown by the biophysical simulation yields. Cultivation in these soils indicates the strategic management by the producer resulting in existence of moral hazard. A detailed summary of alternate production strategies is presented in table 6.

In summary producers with the 65% MPCI coverage were successful in managing risk across all risk levels effectively by integrating the risk management avenues modeled. However, the particular design of the insurance contract gave scope for moral hazard. The existence of moral hazard was mainly a result of changed production practices to riskier combinations under the 65% coverage level. However, some evidence of shifting to marginal soil for specific crop was evinced. Further evidence for such behavior is provided under the 75% coverage level discussed below.

Multiple peril crop insurance: 75% coverage scenario

Economic results from the 75% coverage level proved very profitable for producers across all levels of risk when compared against the base case. The high level of profit was also accompanied with lower variability in net returns across risk levels. The results prove again additional economic profits were accruing to producers because of the insurance contract along with risk management.

Risk neutral producers also purchased insurance under the scenario, like in the 65% coverage case. Mean NRVC for the risk neutral producer was $393, 802 with a C.V. close to 11% corresponding to an increase in NRVC by 3.9% from the base case. Interestingly, corn accounted for bulk of the available acreage under risk neutrality. Total corn acreage accounted for 1091 acres (81%) compared to 259 (19%) acres devoted to soybean. This contradicts expected trend where soybean would be preferred over corn due to profitability considerations. The reason rests in the insurance purchasing behavior of the producers. Bulk of the increase in corn acreage under risk neutrality can be attributed to producers choosing to purchase insurance for corn. Specifically, additional acreage of upto 416 acres was devoted in the scenario to corn from the base case levels. Further, all of this additional corn acreage was insured. Hence, it is clear that profit maximizing risk neutral producers were changing practices sensing insurance profits from corn. The presence of the contract and its indemnity payments makes corn a more profitable crop over soybean. Subsequently, soybean acreage at the risk neutral level decreased to 259 acres. A summary of the economic returns and management strategies under the 75% MPCI scenario is presented in table 7.

Further, it can be shown that producers strategically respond to the structure of the contract. Examination of the production strategy of the crops is the initial step in this analysis. This revealed some interesting results. While base case results suggest corn acreage increasing with risk aversion, an opposite trend was noticed under 75% coverage. This was accompanied by increasing soybean acreage with risk aversion. Production practices in soybean were more condensed that other scenarios with producers exhibiting a definite management behavior for the crop. Uninsured soybean was predominantly planted using the early planting date of April 26. However, all of the insured soybean was planted using the later planting dates. For example, risk neutral producers choose to cultivate 128 acres of uninsured soybean using April 26 planting date and an equal acreage under insured soybean using the late planting date of June 21. The MG 5 variety with nine inches rows spacing and two plants per square foot was the predominant practice. While soybean alternate practices reveal marginal differences from other scenarios, the corn planting showed the extent of moral hazard.

Management of corn production under the scenario showed shifts in both production practices and land types. In other words, while bulk of the shifts in management at the 65% coverage were due to production practices, the 75 coverage level exhibited both shifts in production practices as well as land types.

Insured corn continued to be planted in the late planting dates of May 10, May 17, and May 24. Again similar to the 65% MPCI coverage scenario insured corn always was planted with low plant population using the EARLY cultivar. The interesting difference in the 75 MPCI coverage scenario was production of insured crop in what can be classified as “marginal” lands for the crop. Insured corn was predominantly cultivated in deep silty loam and medium silty loam soils against the Loring silty loam and Sharkey clay soils as in the base case. While this trend was seen to some extent under the 65% MPCI scenario, it was much pronounced under the present case. A detailed account of the production strategy under the scenario is presented under table 8.

Summarizing results from the scenario, economic returns across all risk levels were significantly higher than base case results, along with lower variability in net returns. This suggests the insurance contract being "managed" by producers to accrue economic profits as well as to serve its classical purpose of managing variability. Producers across all risk levels purchased insurance contract in the scenario including the risk neutral producer. However, while the risk neutral and slightly risk averse producers choose to purchase insurance for corn, insurance purchases for soybean increased with higher levels of risk aversion. While producers indulged in shifting production practices for the insured crop from the base case, the most interesting aspect is the change in land types. Producers under the scenario tend to cultivate insured crop in land zones with low or marginal yields for that crop. This reflects the strategic responses of rational producers attempting to economically profit from the contract, in many cases leading to abuse of the contract leading to moral hazard.

Conclusions

Agricultural production environment is plagued by numerous risks. Furthermore, the interaction between independent sources of risks dictate the overall risks faced by producers. In turn, risk management by producers entails the employment of a number of avenues like enterprise diversification, crop insurance etc. The motivation for the present study was to holistically model the production environment by employing a number of sources for production risks as well as risk management. Overall risk environment in the present study is influenced both by uncertainties in yield as well as uncertainties in suitable field days. Further, four modes for risk management are modeled namely: enterprise diversification, multiple peril crop insurance, a host of alternative production practices and management across different land zones.

The results indicate that producers efficiently manage cropping decisions utilizing the risk management avenues provided to manage whole farm risks. This is proved by decreased variance in net returns across risk levels in the tested scenarios. Further, this result indicates the critical importance for applied economists to model the whole farm risk environment. The impacts of risk preference on the optimal cropping portfolio and the use of optimal mix of risk management strategies have been demonstrated in the study. However, rational economic agents purchasing insurance also indulged in moral hazard causing behavior. The degree of effect the design of insurance has on cropping patterns is a cause of concern. Producers across risk levels were shown to change both crop production practices as well as land types in response to incentives by the insurance contracts to riskier alternatives. However, more research is needed to examine this issue in its entirety. An important step for future research would be to quantify the value of moral hazard and design ways to better manage it.

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Table 1. Base Case Summary of Net Returns and Management Strategy Results by Risk Attitude

Section I. Summary of Net Returns above Specified Costs

	Risk Significance Level*			
Component	Risk Neutral	Slight Risk	Moderate Risk	High Risk
Mean ($)	378,983	374,935	365,695	358,279
Max ($)	459,179	442,764	431,505	422,176
Min ($)	236,493	269,568	262,566	259,191
Std. Dev. ($)	66,614	57,151	50,792	47,991
C.V.(%)	18	15	14	13
% of Profit Max.	100	99	96	95

Section II. Summary of Cropping and Land Management Strategy Results in Acres

		Risk Significance Level*			
Component	Land Type	Risk Neutral	Slight Risk	Mod. Risk	High Risk
a. Cropping Strategy					
Total Soybean		675	675	604	564
Total Corn acreage		675	675	746	776
Total Wheat		0	0	0	10
b. Land Management					
Soybean (ac)	Deep Silty Loam	338	338	338	338
Soybean (ac)	Medium Silty Loam	338	338	266	227
Corn (ac)	Medium Silty Loam	0	0	71	101
Corn (ac)	Loring Silty Loam	338	338	338	338
Corn (ac)	Sharkey clay	338	338	338	338
Wheat (ac)	Medium Silty Loam	0	0	0	10

* Risk Neutral : Z = 50%
Slight Risk : Z = 65%
Moderate Risk : Z = 75%
High Risk : Z = 80%

Table 2. Base Case Summary of Alternative Production Practices by Risk Attitude in Acres

Crop	Planting Date	Maturity Class	Plant Population *	Land Type	Risk Significance Level			
					Risk Neutral	Slight Risk	Mod. Risk	High Risk
Soybean	April 26	MG3	R092	Med. Silty Loam	6.40	128.00	128.00	102.87
Soybean	April 26	MG4	R092	Med. Silty Loam	128.00	6.40	0.00	0.00
Soybean	April 26	MG5	R092	Deep Silty Loam	128.00	128.00	128.00	2.36
Soybean	May 3	MG3	R092	Deep Silty Loam	0.00	0.00	81.50	80.37
Soybean	May 3	MG3	R092	Med. Silty Loam	0.00	71.10	10.10	0.00
Soybean	May 3	MG4	R092	Deep Silty Loam	0.00	0.00	0.00	54.03
Soybean	May 3	MG4	R092	Med. Silty Loam	128.00	0.00	0.00	0.00
Soybean	May 3	MG5	R092	Deep Silty Loam	128.00	128.00	0.00	0.00
Soybean	May 10	MG3	R092	Deep Silty Loam	0.00	0.00	0.00	71.60
Soybean	May 10	MG3	R092	Med. Silty Loam	0.00	91.70	128.00	123.75
Soybean	May 10	MG4	R092	Med. Silty Loam	75.10	0.00	0.00	0.00
Soybean	May 10	MG5	R092	Deep Silty Loam	81.50	53.42	0.00	0.00
Soybean	June 14	MG5	R092	Deep Silty Loam	0.00	0.00	0.00	1.13
Soybean	June 21	MG3	R092	Med. Silty Loam	0.00	0.00	0.00	0.00
Soybean	June 21	MG4	R092	Med. Silty Loam	0.00	40.30	0.00	0.00
Soybean	June 21	MG5	R092	Deep Silty Loam	0.00	28.08	128.00	128.00
Soybean	June 21	MG5	R092	Med. Silty Loam	0.00	0.00	0.00	0.00
Corn	April 26	LATE	HIG	Sharkey Clay	0.00	84.00	0.00	0.00
Corn	May 17	LATE	LOW	Loring Silty Loam	0.00	103.38	103.38	103.38
Corn	May 17	LATE	LOW	Sharkey Clay	0.00	0.00	0.00	0.00
Corn	May 17	LATE	MED	Loring Silty Loam	0.00	0.00	0.00	0.00
Corn	May 17	LATE	MED	Sharkey Clay	0.00	0.00	21.85	27.35
Corn	May 17	LATE	HIG	Sharkey Clay	0.00	0.00	5.50	0.00
Corn	May 24	LATE	LOW	Med. Silty Loam	0.00	0.00	71.40	100.73
Corn	May 24	LATE	LOW	Loring Silty Loam	0.00	0.00	103.38	103.38
Corn	May 24	LATE	MED	Loring Silty Loam	0.00	103.38	0.00	0.00

Crop	Planting Date	Maturity Class	Plant Population	Land Type	Risk Significance Level			
					Risk Neutral	Slight Risk	Mod. Risk	High Risk
Corn	May 24	LATE	MED	Sharkey Clay	0.00	0.00	103.38	103.38
Corn	May 24	LATE	HIG	Sharkey Clay	0.00	46.73	0.00	0.00
Corn	March 29	LATE	HIG	Loring Silty Loam	103.38	0.00	0.00	0.00
Corn	March 29	LATE	HIG	Sharkey Clay	103.38	0.00	0.00	0.00
Corn	April 5	LATE	LOW	Loring Silty Loam	0.00	0.00	0.00	103.38
Corn	April 5	LATE	MED	Sharkey Clay	0.00	0.00	0.00	103.38
Corn	April 5	LATE	HIG	Sharkey Clay	103.38	103.38	103.38	0.00
Corn	April 12	LATE	LOW	Loring Silty Loam	0.00	0.00	54.86	27.35
Corn	April 12	LATE	MED	Loring Silty Loam	0.00	103.38	0.00	0.00
Corn	April 12	LATE	MED	Sharkey Clay	0.00	0.00	103.38	103.38
Corn	April 12	LATE	HIG	Loring Silty Loam	27.35	0.00	0.00	0.00
Corn	April 12	LATE	HIG	Sharkey Clay	103.38	103.38	0.00	0.00
Corn	April19	LATE	LOW	Loring Silty Loam	0.00	27.35	75.87	0.00
Corn	April19	LATE	MED	Loring Silty Loam	103.38	0.00	0.00	0.00
Corn	April19	LATE	HIG	Sharkey Clay	27.35	0.00	0.00	0.00
Wheat	Sept 27	N/A	N/A	Med. Silty	0.00	0.00	0.00	10.14

*R092 Soybean row spacing of nine inches with two plants per foot
R093 Soybean row spacing of nine inches with three plants per foot
R194 Soybean row spacing of nineteen inches with four plants per foot
R196 Soybean row spacing of nineteen inches with six plants per foot
R306 Soybean row spacing of thirty inches with six plants per foot
R309 Soybean row spacing of thirty inches with nine plants per foot
LOW Corn population of 20,000 plants per acre
MED Corn population of 24,000 plants per acre
HIG Corn population of 28,000 plants per acre

Table 3. 50% MPCI Coverage Case Summary of Net Returns and Management Strategy Results by Risk Attitude

Section I. Summary of Net Returns above Specified Costs

	Risk Significance Level*			
Component	Risk Neutral	Slight Risk	Moderate Risk	High Risk
Mean ($)	378,825	375,849	365,488	357,242
Max ($)	459,029	444,274	431,302	420,932
Min ($)	236,343	268,406	261,934	258,999
Std. Dev. ($)	66,612	57,310	50,532	47,397
C.V.(%)	18	15	14	13
% of Profit Max.	100	99	96	94

Section II. Summary of Cropping and Land Management Strategy Results in Acres

		Risk Significance Level*			
Component	Land Type	Risk Neutral	Slight Risk	Mod. Risk	High Risk
a. Cropping Strategy					
Total Soybean acreage		675	675	656	621
Total Corn acreage		675	675	694	720
Total Wheat acreage		0	0	0	9
Total Insured Soybean		0	128	182	180
Total Uninsured Soybean		675	547	474	440
Total Insured Corn acreage		0	0	0	9
Total Uninsured Corn		675	675	694	720
b. Land Management					
Uninsured Soybean	Deep Silty Loam	338	338	218	244
Uninsured Soybean	Medium Silty Loam	338	210	256	196
Insured Soybean	Deep Silty Loam	0	0	119	93
Insured Soybean	Medium Silty Loam	0	128	62	87
Uninsured Corn	Medium Silty Loam	0	0	19	45
Uninsured Corn	Loring Silty Loam	338	338	338	338
Uninsured Corn	Sharkey clay	338	338	338	338
Uninsured Wheat	Medium Silty Loam	0	0	0	9

* Risk Neutral : Z = 50%
Slight Risk : Z = 65%
Moderate Risk : Z = 75%
High Risk : Z = 80%

Table 4. 50% MPCI Coverage Case Summary of Alternative Production Practices by Risk Attitude in Acres.

Crop	Planting Date	Maturity Class	Plant Population *	Land Type	Risk Significance Level			
					Risk Neutral	Slight Risk	Mod. Risk	High Risk
Uninsured Soybean	April 26	MG3	R092	Deep Silty Loam	0.00	0.00	0.00	0.00
Uninsured Soybean	April 26	MG3	R092	Med. Silty Loam	6.40	128.00	128.00	107.50
Uninsured Soybean	April 26	MG4	R092	Med. Silty Loam	128.00	6.40	0.00	0.00
Uninsured Soybean	April 26	MG5	R092	Deep Silty Loam	128.00	128.00	128.00	5.60
Uninsured Soybean	May 3	MG3	R092	Deep Silty Loam	0.00	0.00	90.08	128.00
Uninsured Soybean	May 3	MG3	R092	Med. Silty Loam	0.00	75.10	0.00	0.00
Uninsured Soybean	May 3	MG4	R092	Deep Silty Loam	0.00	0.00	0.00	6.40
Uninsured Soybean	May 3	MG4	R092	Med. Silty Loam	128.00	0.00	0.00	0.00
Uninsured Soybean	May 3	MG5	R092	Deep Silty Loam	128.00	128.00	0.00	0.00
Uninsured Soybean	May 10	MG3	R092	Deep Silty Loam	0.00	0.00	0.00	104.22
Uninsured Soybean	May 10	MG3	R092	Med. Silty Loam	0.00	0.00	128.00	88.70
Uninsured Soybean	May 10	MG4	R092	Med. Silty Loam	75.10	0.00	0.00	0.00
Uninsured Soybean	May 10	MG5	R092	Deep Silty Loam	81.50	81.50	0.00	0.00
Insured Soybean	June 21	MG3	R092	Med. Silty Loam	0.00	0.00	0.00	86.92
Insured Soybean	June 21	MG4	R092	Med. Silty Loam	0.00	0.00	62.33	0.00
Insured Soybean	June 21	MG5	R092	Deep Silty Loam	0.00	0.00	119.42	93.29
Insured Soybean	June 21	MG5	R092	Med. Silty Loam	0.00	128.00	0.00	0.00
Uninsured Corn	April 26	LATE	HIG	Sharkey Clay	0.00	84.00	27.35	0.00
Uninsured Corn	May 17	LATE	LOW	Loring Silty Loam	0.00	103.38	103.38	103.38
Uninsured Corn	May 17	LATE	LOW	Sharkey Clay	0.00	0.00	0.00	0.00
Uninsured Corn	May 17	LATE	MED	Loring Silty Loam	0.00	0.00	0.00	0.00
Uninsured Corn	May 17	LATE	MED	Sharkey Clay	0.00	0.00	0.00	27.35
Uninsured Corn	May 24	LATE	LOW	Med. Silty Loam	0.00	0.00	19.17	45.30
Uninsured Corn	May 24	LATE	LOW	Loring Silty Loam	0.00	0.00	103.38	103.38
Uninsured Corn	May 24	LATE	MED	Loring Silty Loam	0.00	103.38	0.00	0.00
Uninsured Corn	May 24	LATE	MED	Sharkey Clay	0.00	0.00	103.38	103.38

Crop	Planting Date	Maturity Class	Plant Population *	Land Type	Risk Significance Level			
					Risk Neutral	Slight Risk	Mod. Risk	High Risk
Uninsured Corn	May 24	LATE	HIG	Sharkey Clay	0.00	46.73	0.00	0.00
Uninsured Corn	March 29	LATE	HIG	Loring Silty Loam	103.38	0.00	0.00	0.00
Uninsured Corn	March 29	LATE	HIG	Sharkey Clay	103.38	0.00	0.00	0.00
Uninsured Corn	April 5	LATE	LOW	Loring Silty Loam	0.00	0.00	27.35	103.38
Uninsured Corn	April 5	LATE	MED	Sharkey Clay	0.00	0.00	0.00	103.38
Uninsured Corn	April 5	LATE	HIG	Loring Silty Loam	103.38	0.00	0.00	0.00
Uninsured Corn	April 5	LATE	HIG	Sharkey Clay	103.38	103.38	103.38	0.00
Uninsured Corn	April 12	LATE	LOW	Loring Silty Loam	0.00	0.00	0.00	0.00
Uninsured Corn	April 12	LATE	MED	Loring Silty Loam	0.00	103.38	0.00	0.00
Uninsured Corn	April 12	LATE	MED	Sharkey Clay	0.00	0.00	103.38	103.38
Uninsured Corn	April 12	LATE	HIG	Loring Silty Loam	27.35	0.00	0.00	0.00
Uninsured Corn	April 12	LATE	HIG	Sharkey Clay	103.38	103.38	0.00	0.00
Uninsured Corn	April 19	LATE	LOW	Loring Silty Loam	0.00	27.35	103.38	27.35
Uninsured Corn	April 19	LATE	MED	Loring Silty Loam	103.38	0.00	0.00	0.00
Uninsured Corn	April 19	LATE	HIG	Sharkey Clay	27.35	0.00	0.00	0.00

*R092 Soybean row spacing of nine inches with two plants per foot
R093 Soybean row spacing of nine inches with three plants per foot
R194 Soybean row spacing of nineteen inches with four plants per foot
R196 Soybean row spacing of nineteen inches with six plants per foot
R306 Soybean row spacing of thirty inches with six plants per foot
R309 Soybean row spacing of thirty inches with nine plants per foot
LOW Corn population of 20,000 plants per acre
MED Corn population of 24,000 plants per acre
HIG Corn population of 28,000 plants per acre

Table 5. 65% MPCI Coverage Case Summary of Net Returns and Management Strategy Results by Risk Attitude

Section I. Summary of Net Returns above Specified Costs

	Risk Significance Level*			
Component	Risk Neutral	Slight Risk	Moderate Risk	High Risk
Mean ($)	383,128	381,677	366,853	354,869
Max ($)	455,539	443,674	415,316	394,475
Min ($)	281,114	277,405	282,097	282,469
Std. Dev. ($)	55,364	51,710	40,763	34,504
C.V.(%)	14	14	11	10
% of Profit Max.	100	100	96	93

Section II. Summary of Cropping and Land Management Strategy Results in Acres

		Risk Significance Level*			
Component	Land Type	Risk Neutral	Slight Risk	Mod. Risk	High Risk
a. Cropping Strategy					
Total Soybean acreage		675	675	533	399
Total Corn acreage		675	675	817	951
Total Insured Soybean		338	395	384	311
Total Uninsured Soybean		338	280	149	88
Total Insured Corn acreage		0	0	142	276
Total Uninsured Corn		675	675	675	675
b. Land Management					
Uninsured Soybean	Deep Silty Loam	338	280	149	88
Insured Soybean	Deep Silty Loam	0	58	128	77
Insured Soybean	Medium Silty Loam	338	338	256	234
Uninsured Corn	Loring Silty Loam	338	338	338	338
Uninsured Corn	Sharkey clay	338	338	338	338
Insured Corn	Deep Silty Loam	0	0	60	173
Insured Corn	Medium Silty Loam	0	0	82	103

* Risk Neutral : Z = 50%
Slight Risk : Z = 65%
Moderate Risk : Z = 75%
High Risk : Z = 80%

Table 6. 65% MPCI Coverage Case Summary of Alternative Production Practices by Risk Attitude in Acres.

Crop	Planting Date	Maturity Class	Plant Population*	Land Type	Risk Significance Level Risk Neutral	Slight Risk	Mod. Risk	High Risk
Uninsured Soybean	April 26	MG4	R092	Deep Silty Loam	0.00	0.00	6.40	0.00
Uninsured Soybean	April 26	MG5	R092	Deep Silty Loam	128.00	128.00	128.00	88.36
Uninsured Soybean	May 3	MG3	R092	Deep Silty Loam	0.00	0.00	14.89	0.00
Uninsured Soybean	May 3	MG4	R092	Deep Silty Loam	0.00	0.00	0.00	0.00
Uninsured Soybean	May 3	MG5	R092	Deep Silty Loam	128.00	128.00	0.00	0.00
Uninsured Soybean	May 10	MG5	R092	Deep Silty Loam	81.50	23.70	0.00	0.00
Insured Soybean	June 7	MG5	R092	Med. Silty Loam	81.50	75.10	0.00	0.00
Insured Soybean	June 14	MG5	R092	Med. Silty Loam	128.00	128.00	128.00	0.00
Insured Soybean	June 14	MG5	R194	Med. Silty Loam	0.00	0.00	0.00	106.12
Insured Soybean	June 14	MG5	R306	Med. Silty Loam	0.00	0.00	0.00	0.00
Insured Soybean	June 21	MG3	R092	Med. Silty Loam	0.00	6.40	0.00	0.00
Insured Soybean	June 21	MG5	R092	Deep Silty Loam	0.00	57.80	128.00	76.58
Insured Soybean	June 21	MG5	R092	Med. Silty Loam	128.00	128.00	0.00	0.00
Insured Soybean	June 21	MG5	R093	Med. Silty Loam	0.00	0.00	128.00	0.00
Insured Soybean	June 21	MG5	R196	Med. Silty Loam	0.00	0.00	0.00	128.00
Insured Soybean	June 21	MG5	R306	Med. Silty Loam	0.00	0.00	0.00	0.00
Uninsured Corn	April 26	LATE	HIG	Sharkey Clay	0.00	80.19	27.35	0.00
Uninsured Corn	May 17	LATE	LOW	Loring Silty Loam	0.00	0.00	103.38	103.38
Uninsured Corn	May 24	LATE	LOW	Loring Silty Loam	0.00	0.00	0.00	0.00
Uninsured Corn	May 24	LATE	MED	Loring Silty Loam	0.00	103.38	0.00	0.00
Uninsured Corn	May 24	LATE	MED	Sharkey Clay	0.00	0.00	0.00	39.60
Uninsured Corn	March 29	LATE	HIG	Loring Silty Loam	103.38	0.00	0.00	0.00
Uninsured Corn	March 29	LATE	HIG	Sharkey Clay	103.38	50.55	103.38	91.14
Uninsured Corn	April 5	LATE	LOW	Loring Silty Loam	0.00	0.00	27.35	27.35
Uninsured Corn	April 5	LATE	MED	Loring Silty Loam	0.00	27.35	0.00	0.00
Uninsured Corn	April 5	LATE	MED	Sharkey Clay	0.00	0.00	0.00	0.00

Crop	Planting Date	Maturity Class	Plant Population *	Land Type	Risk Significance Level			
					Risk Neutral	Slight Risk	Mod. Risk	High Risk
Uninsured Corn	April 5	LATE	HIG	Loring Silty Loam	103.38	0.00	0.00	0.00
Uninsured Corn	April 5	LATE	HIG	Sharkey Clay	103.38	103.38	103.38	103.38
Uninsured Corn	April 12	LATE	LOW	Loring Silty Loam	0.00	0.00	0.00	103.38
Uninsured Corn	April 12	LATE	MED	Loring Silty Loam	0.00	103.38	103.38	0.00
Uninsured Corn	April 12	LATE	MED	Sharkey Clay	0.00	0.00	103.38	103.38
Uninsured Corn	April 12	LATE	HIG	Loring Silty Loam	27.35	0.00	0.00	0.00
Uninsured Corn	April 12	LATE	HIG	Sharkey Clay	103.38	103.38	0.00	0.00
Uninsured Corn	April 19	LATE	LOW	Loring Silty Loam	0.00	0.00	103.38	103.38
Uninsured Corn	April 19	LATE	MED	Loring Silty Loam	103.38	103.38	0.00	0.00
Uninsured Corn	April 19	LATE	HIG	Sharkey Clay	27.35	0.00	0.00	0.00
Insured Corn	M10	EARLY	LOW	Deep Silty Loam	0.00	0.00	0.00	0.00
Insured Corn	M17	EARLY	LOW	Deep Silty Loam	0.00	0.00	60.21	103.38
Insured Corn	M17	EARLY	LOW	Med. Silty Loam	0.00	0.00	81.50	103.38
Insured Corn	M24	EARLY	LOW	Deep Silty Loam	0.00	0.00	0.00	69.18
Insured Corn	M24	EARLY	LOW	Med. Silty Loam	0.00	0.00	0.00	0.00

*R092 Soybean row spacing of nine inches with two plants per foot
R093 Soybean row spacing of nine inches with three plants per foot
R194 Soybean row spacing of nineteen inches with four plants per foot
R196 Soybean row spacing of nineteen inches with six plants per foot
R306 Soybean row spacing of thirty inches with six plants per foot
R309 Soybean row spacing of thirty inches with nine plants per foot
LOW Corn population of 20,000 plants per acre
MED Corn population of 24,000 plants per acre
HIG Corn population of 28,000 plants per acre

Table 7. 75% MPCI Coverage Case Summary of Net Returns and Management Strategy Results by Risk Attitude

Section I. Summary of Net Returns above Specified Costs

	Risk Significance Level*			
Component	Risk Neutral	Slight Risk	Moderate Risk	High Risk
Mean ($)	393,802	391,345	389,036	388,395
Max ($)	425,609	413,747	406,660	405,164
Min ($)	266,647	294,954	305,590	309,323
Std. Dev. ($)	42,599	33,557	30,666	30,238
C.V.(%)	11	9	8	8
% of Profit Max.	100	99	99	99

Section II. Summary of Cropping and Land Management Strategy Results in Acres

		Risk Significance Level*			
Component	Land type	Risk Neutral	Slight Risk	Mod. Risk	High Risk
a. Cropping Strategy					
Total Soybean acreage		259	463	524	568
Total Corn acreage		1091	887	826	782
Total Insured Soybean acreage		128	356	521	568
Total Uninsured Soybean acreage		131	106	3	0
Total Insured Corn acreage		416	340	304	291
Total Uninsured Corn acreage		675	547	522	491
b. Land Management					
Uninsured Soybean	Deep Silty Loam	131	106	3	0
Insured Soybean	Deep Silty Loam	0	0	112	128
Insured Soybean	Medium Silty Loam	128	228	256	256
Insured Soybean	Loring Silty Loam	0	128	153	184
Uninsured Corn	Loring Silty Loam	338	210	185	153
Uninsured Corn	Sharkey clay	338	338	338	338
Insured Corn	Deep Silty Loam	207	231	222	210
Insured Corn	Medium Silty Loam	210	109	82	82

* Risk Neutral : Z = 50%
Slight Risk : Z = 65%
Moderate Risk : Z = 75%
High Risk : Z = 80%

Table 8. 75% MPCI Coverage Case Summary of Alternative Production Practices by Risk Attitude in Acres.

Crop	Planting Date	Maturity Class	Plant Population *	Land Type	Risk Significance Level			
					Risk Neutral	Slight Risk	Mod. Risk	High Risk
Uninsured Soybean	April 26	MG5	R092	Deep Silty Loam	128.00	106.46	3.01	0.00
Uninsured Soybean	May 3	MG5	R092	Deep Silty Loam	2.73	0.00	0.00	0.00
Insured Soybean	June 14	MG5	R092	Med. Silty Loam	0.00	100.11	128.00	128.00
Insured Soybean	June 14	MG5	R092	Loring Silty	0.00	0.00	24.63	56.04
Insured Soybean	June 14	MG5	R194	Med. Silty Loam	0.00	0.00	0.00	0.00
Insured Soybean	June 21	MG5	R092	Deep Silty Loam	0.00	0.00	112.27	128.00
Insured Soybean	June 21	MG5	R092	Med. Silty Loam	128.00	128.00	128.00	128.00
Insured Soybean	June 21	MG5	R092	Loring Silty	0.00	128.00	128.00	128.00
Uninsured Corn	April 26	LATE	HIG	Sharkey Clay	0.00	27.35	0.00	0.00
Uninsured Corn	May 10	LATE	HIG	Sharkey Clay	0.00	0.00	0.00	4.30
Uninsured Corn	May 17	LATE	LOW	Loring Silty	0.00	0.00	0.00	4.73
Uninsured Corn	May 17	LATE	MED	Loring Silty	0.00	0.00	0.00	0.00
Uninsured Corn	May 24	LATE	MED	Loring Silty	0.00	103.38	103.38	103.38
Uninsured Corn	May 24	LATE	HIG	Sharkey Clay	0.00	0.00	27.35	23.05
Uninsured Corn	March 29	LATE	HIG	Loring Silty	103.38	0.00	0.00	0.00
Uninsured Corn	March 29	LATE	HIG	Sharkey Clay	103.38	103.38	103.38	103.38
Uninsured Corn	April 5	LATE	HIG	Loring Silty	103.38	0.00	0.00	0.00
Uninsured Corn	April 5	LATE	HIG	Sharkey Clay	103.38	103.38	103.38	103.38
Uninsured Corn	April 12	LATE	MED	Loring Silty	0.00	34.76	81.48	45.34
Uninsured Corn	April 12	LATE	MED	Sharkey Clay	0.00	0.00	0.00	0.00
Uninsured Corn	April 12	LATE	HIG	Loring Silty	27.35	0.00	0.00	0.00
Uninsured Corn	April 12	LATE	HIG	Sharkey Clay	103.38	103.38	103.38	103.38
Uninsured Corn	April 19	LATE	MED	Loring Silty	103.38	71.36	0.00	0.00
Uninsured Corn	April 19	LATE	HIG	Sharkey Clay	27.35	0.00	0.00	0.00
Insured Corn	May 10	EARLY	LOW	Deep Silty Loam	0.00	24.27	15.45	2.73
Insured Corn	May 10	EARLY	LOW	Med. Silty Loam	2.73	0.00	0.00	0.00

Crop	Planting Date	Maturity Class	Plant Population *	Land Type	Risk Significance Level			
					Risk Neutral	Slight Risk	Mod. Risk	High Risk
Insured Corn	May 17	EARLY	LOW	Deep Silty Loam	103.38	103.38	103.38	103.38
Insured Corn	May 17	EARLY	LOW	Med. Silty Loam	103.38	103.38	81.50	81.50
Insured Corn	May 24	EARLY	LOW	Deep Silty Loam	103.38	103.38	103.38	103.38
Insured Corn	May 24	EARLY	LOW	Med. Silty Loam	103.38	6.01	0.00	0.00

*R092 Soybean row spacing of nine inches with two plants per foot
R093 Soybean row spacing of nine inches with three plants per foot
R194 Soybean row spacing of nineteen inches with four plants per foot
R196 Soybean row spacing of nineteen inches with six plants per foot
R306 Soybean row spacing of thirty inches with six plants per foot
R309 Soybean row spacing of thirty inches with nine plants per foot
LOW Corn population of 20,000 plants per acre
MED Corn population of 24,000 plants per acre
HIG Corn population of 28,000 plants per acre