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The Effect of Crop Insurance Premium Subsidies on Soybean Producers' Risk Management Portfolios

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Abstract

We examine how reducing subsidies for federal crop insurance affects the risk management portfolios of US soybean producers. We apply the portfolio optimization approach of Das and Statman (2013) to model how producers risk management portfolios change as subsidies for federal crop insurance premiums change, and examine how the changes to the risk management portfolios impact farmers on-farm income and exposure to downside risk. We optimize farmers risk management portfolio by adjusting the budget shares dedicated to each of four risk management tools: returns on production, forward contracting, savings, and crop insurance.

1 Introduction

This paper examines the impact of crop insurance premium subsidies on the risk management strategies producers use to manage their on-farm income. Crop insurance premiums are offered to farmers at subsidized rates in order to encourage them to proactively purchase federally-backed crop insurance and thus reduce the need for ad-hoc disaster assistance. However, the level of subsidies to offer has been a subject of debate in Congress leading up to the Agricultural Act of 2014, also known as the 2014 Farm Bill, as well as during the 2016 federal budget negotiations.

In recent years, crop insurance has become the second largest agriculture support program in the US. Currently, 80 percent of cropland is covered by some form of federal crop insurance. The most popular form of crop insurance, Revenue Protection, accounts for approximately 70 percent of all crop insurance policies. Revenue Protection insures revenue losses caused by unexpected low yields or low prices¹. Subsidy levels decrease as the to insurance coverage level increases. The largest subsidies are offered for the largest revenue losses, and taper off for smaller revenue losses from insured revenue levels.

The current subsidies rates were set in 2000 under the Agricultural Risk Protection Act (ARPA) of 2000, at a time when revenue insurance uptake levels were lower. Table (1) shows premium subsidy levels for buy-up coverage on Basic units before and after ARPA². At current subsidy rates, farmers have to pay roughly one-third of the total cost of insuring large revenue losses. At most, farmers have to pay 62% of the premium cost for insuring losses below 15% of expected revenue. The key policy question is to understand how farmers would shift their production and risk management decisions in responses to changes in these subsidy rates.

¹Payments from Revenue Protection are based on the higher of the projected price and harvest price.

²Realized revenues of less than 50% of insured revenue are covered through a separate catastrophic coverage policy. Catastrophic coverage is offered for only a nominal administrative fee.

Table 1: Subsidies rates for crop insurance premiums before and after the Agricultural Risk Protection Act of 2000 for Basic units (O’Donoghue, 2014)

Coverage Level (%)	50	55	60	65	70	75	80	85
Pre-ARPA subsidy	55	46	38	32	32	24	17	13
Post-ARPA subsidy	67	64	64	59	59	55	48	38

Since the early 1990’s agricultural economists have been investigating the demand for crop insurance, both exploring the patterns for purchases and possible behavioral reasons for their choices. Under the assumption that the premiums calculated by the federal government are actuarially fair, the standard expected utility model, suggest that risk averse farmers should purchase crop insurance. There is evidence that subsidy rates influence farmers’ insurance purchase decisions. Goodwin (1993) first explored the effect of loss-risk on the demand elasticity and found evidence of adverse selection. He found that producers with greater loss-risk have a more inelastic demand for crop insurance, while producers who have a small loss-risk have an more elastic demand for crop insurance.

However, very few farmers purchase crop insurance at the full actuarially fair premium. Recent work by O’Donoghue (2014) uses panel data collected by the Economic Research Service and concludes that changes in subsidies significantly affect the coverage level selected by farmers (i.e. percent of expected revenue or yield that the farmer chooses to guarantee under the crop insurance policy).

While the empirical support for price sensitivity is well established, the literature has had less success in establishing the behavioral foundations for insurance demand. Studies on different producer populations and at different points in time have not always estimated parameters consistent with risk aversion (Moschini and Hennessy, 2001). These studies were also not always designed to differentiate the effect of risk preferences from the effect of technology, physical constraints, or financial asymmetries (Just and Pope, 2003). Babcock (2015) looks at the demand for crop insurance through the lens of cumulative prospect theory³. Under cumulative prospect theory, individuals tends to overweight the probability of extreme events and underweight “average” events. Babcock’s analysis shows that individuals tend to treat crop insurance payments as a lottery and from decouple the realized crop revenue.

The contradiction between insurance demand and risk aversion has also received much attention in the finance literature. In 1948, Friedman and Savage observed

³Cumulative prospect theory was first developed by Kahneman and Tversky (1979) and later extended the theory (Tversky and Kahneman, (1992)).

that individuals who purchase insurance may purchase lottery tickets as well, i.e. an individual can show both risk averse and risk seeking behavior (Friedman and Savage, 1948). This paradox has caused problems for mean-variance portfolio theory (Markowitz, 1952). Mean-variance portfolio theory maximizes the mean return of the portfolio, while minimizing the variance of the total return. The main criticism of this popular method is that mean-variance portfolio theory does not solve Friedman and Savage’s puzzle. Shefrin and Statman (2000) offered a theoretical solution to this issue with the development of behavioral portfolio theory, which satisfies the Friedman - Savage puzzle by allowing agents to optimize over a combination of secure and risky assets. Das and Statman (2013) extended Shefrin and Statman’s model to include portfolios with complex derivatives. Das and Statman’s application is especially useful for agricultural risk management because returns from federal crop insurance and forward contracting are both derivatives of a producer’s crop revenue.

In this paper, we apply a behavioral portfolio theory approach to study farmers’ responses to changes in crop insurance subsidies within the context of their portfolio of risk management tools. We construct a simple portfolio model for on-farm income for producers - which includes crop sales, crop insurance, forward contracting, and savings - and solve for the optimal allocation given a farmer’s risk profile, preferences, budget constraint, and insurance subsidy levels. We solve the model for representative soybean producer in three counties with widely different yield risk profiles: Champaign County, IL; Robeson County, NC; and Minnehaha County, SD. Then we conduct sensitivity analysis to examine the crop insurance purchases of farmers under different subsidy levels and budget constraints. We find that the level of revenue risks affects producers’ sensitivity to changes in crop insurance subsidies. Without subsidies, producers across all risk levels prefer to self-insure rather than purchase actuarially fair insurance.

2 Theory

We model farmers’ approach to risk management as if farmers are allocating assets across a portfolio of risk management options. Each risk management option has a profit that depends jointly on realized yields and prices. Farmers allocate their available budget across the available risk management options with the goal of maximizing expected on-farm income while ensuring that the probability of realizing an overall operating loss for the season is within a specified limit.

2.1 Optimization Problem

Following the approach of Das and Statman (2013), we construct the following portfolio optimization problem:

$$V = \max_{\{q_i\}} \int_{u \in U} \left[\sum_{i=1}^n \pi_i(q_i, u) \right] \cdot p(u) du \quad (1)$$

s.t.

$$\sum_{i=1}^n \text{Cost}(q_i) = B, \quad q_i \geq 0 \quad \forall \quad i = 1, 2, \dots, n \quad (2)$$

$$\int_{e \in E} p(e) de \leq \alpha, \quad E = \left[u \mid \sum_{i=1}^n \pi_i(u, q_i) \leq H \right] \quad (3)$$

where u indexes the state of the world, i indexes the available risk management options, q_i is the quantity purchased for risk management option i , and $\pi_i(q_i, u)$ is the profit margin for the risk management option i in each state of the world. Parameters H and α define key behavioral parameters for the model. H is the critical threshold for profit across all risk management options. α is the critical threshold of probability of earning a profit below H . E is the subset of all states of the world U where the total return from all risk management strategies is less than H . B is the total available budget the farmer can devote to all risk management options.

Equation (1) says that farmers choose quantities for each available risk management strategies in order to maximize the expected profit across all states of the world. Equation (2) constraints all quantities to be individually non-negative, and collectively exhaust the available budget. Equation (3) constrains the allocation across all risk management strategies such that the cumulative probability of earning a profit less than H is less than or equal to α . In this set up, farmers can choose to an allocation that allows for the possibility of earning profit less than H in some states of the world E , provided the total probability of those states occurring is less than α .

With this set-up, we are assuming farmers are risk neutral for gambles above the critical threshold H . We could introduce risk aversion by changing the objective function to embed the profit into a concave utility function, such as a power-expo utility function. Loss aversion enters the model as the shadow value on the risk constraint (Equation 3). Farmers who are more loss averse, have smaller values of α , which increases the extent to which the constraint impacts the optimal portfolio allocation.

Because we have assumed risk neutral farmers, the objective function is linear over the feasible set defined by the two constraints. Depending on the parameters of the

budget and risk constraints, it is possible to have a null feasible set. If the cost of producing a crop and purchasing risk management tools is high enough, and the risks faced by the farmer are sufficiently large, then the farmer may not be able to afford to purchase enough risk management in enough possible states of the world to ensure that his probability of earning profit less than H is below α . In that case, the farmer would optimally choose not to produce that crop (i.e. exit the market).

We consider two models with different sets of risk management options. In the first model, we allow for three risk management options: savings, forward contracting, and insurance. This model treats on-farm production decisions as fixed, such as if farmers' decide input and management decisions following some sort of best practice guidance. With production decisions fixed, farmers' ex-ante risk profiles are determined outside the model. The risk management decision is then to allocate their residual budget between savings, forward contracting, and insurance in order to mitigate risk of an operating loss given this pre-determined risk profile.

In the second model, we include on-farm production decisions as a fourth risk management option with the model. This assumes farmers factor risk considerations into their production choices. By comparing optimal portfolio allocations in model 1 and model 2, we can estimate the impact of changes in insurance subsidy rates on production choices such as fertilizer and pesticide application levels, labor inputs, and irrigation.

2.2 Calculation of Profit for Each Risk Management Option

To operationalize our models, we calculate the distribution of profit margins for each risk management option: savings, forward contracting, and insurance.

Savings. We calculate the profit margin for savings as $\pi_s(q_{save}, u) = q_{save} \cdot (1 + \rho)$, where ρ is the risk-free return rate. Savings has the same profit in all states of the world, and the total cost of savings is simply $Cost(q_{save}) = q_{save}$.

Sales. We calculate the profit margin for forward contracting as:

$$\pi_{forw}(q_f, u) = \begin{cases} q_f \cdot P_f - [q_f - Y_{actual}(u)] \cdot P_m(u) - Cost[\bar{Y}(T)] & \text{if } q_f > Y_{actual}(u) \\ q_f \cdot P_f + [Y_{actual}(u) - q_f] \cdot P_m(u) - Cost[\bar{Y}(T)] & \text{if } q_f \leq Y_{actual}(u) \end{cases} \quad (4)$$

where q_f is the quantity forward contracted, P_f is the forward contract price, $P_m(u)$ is the spot market price, $Y_{actual}(u)$ is the harvested quantity, and $\bar{Y}(T)$ is the expected yield given the farm production plan T . Forward contract quantities and prices do not depend on the realized state of nature, u , but market prices and actual yields do. Similarly, costs of planting are incurred for a given production plan before the state of nature is revealed. $Cost[\bar{Y}(T)]$ is calculated as the total cost of production for plan T with associated expected yield $\bar{Y}(T)$. Production costs are independent of realized state of the world, but depend on on-farm decisions made, T . In model 1, we treat T as given, which specifies the probability distribution of u and determines $\bar{Y}(T)$. In model 2, we allow farmers to choose T endogenously within the model.

Profit from forward contracting is a piece-wise function that depends on how the quantity forward contracted compares to realized yields at harvest time. In the case of a bad yield where $q_f > Y_{actual}(u)$, the farmer has to purchase the shortfall from the spot market. In the case of a good harvest, the farmer has additional output to sell on the spot market in excess of his forward contracted amount. If $q_f = 0$, then all production is sold on the spot market and the profit is simply the net return to production.

Insurance. We restrict our analysis to revenue-based crop insurance, and assume insurance covers the full acreage planted. Farmers choose a coverage rate q_{ins} , where 100% corresponds to full insurance and 0% means no insurance is purchased. Insurance provides a payment to farmers whenever the actual revenue is below a specified percent of expected revenue:

$$Payment(q_{ins}, u) = \max[0, q_{ins} \cdot \bar{Y}(T) \cdot \max[P_{ins}, P_m(u)] - Y_{actual}(u) \cdot P_m(u)] \quad (5)$$

The right-hand side of Equation (5) takes the larger of 0 and the difference between the insured revenue level and actual revenue. Actual revenue depends on the revealed state of the world. Insured revenue also depends on the state of the world because of the second maximum operation. $\max[P_{ins}, P_m(u)]$ allows for expected revenue to be based on whichever is larger: a pre-set price, P_{ins} , or the actual market price.

The profit margin for insurance is:

$$\pi_{ins}(q_{ins}, u) = Payment(q_{ins}, u) - (1 - s)Cost(q_{ins}) \quad (6)$$

where s is a government subsidy on the cost of insurance, and $(1 - s)Cost(q_{ins})$ is the premium paid by farmers for insurance.

3 Methodology

We construct a stochastic programming problem to compute the optimal portfolio allocation of a representative farmer for a given county. We use Monte Carlo sampling and a Sample-Average Approximation (SAA) Method to construct distributions of yield risk and price risk for the representative farmer based on historical yield and price data. Then we draw a large sample of yields and prices from these distributions, and use these values to solve the programming program described in Equations (1) - (3) for the optimal portfolio allocations across the available risk management strategies. We take advantage of the discrete nature of insurance coverage and forward contracting to simplify the computational complexity of searching for optimal portfolio allocations.

3.1 Parameters Used in Model 1

To parameterize the model, we follow these procedures:

Distribution of prices. We assume prices are uncorrelated with yields and follow a log-normal distribution. We use the projected price and variance estimate provided by RMA to parameterize the price distribution used for our analysis.

Distribution of yields. To generate a distribution for county average yields, we use 40 years of county average yields for each county, detrend the data using a loess regression, and then fit a kernel density function to the detrended data. To generate a distribution for a representative farmer's idiosyncratic risk, we follow the methodology of Coble and Dismukes (2008). We pick a candidate standard deviation of idiosyncratic risk for the representative farmer and compare the implied expected premium rate for the candidate standard deviation to the actual average effective premium rate published by RMA for the given county. Then we conduct a grid search over a range of candidate standard deviations to find an optimal candidate standard deviation that minimizes the difference between implied expected premium rate and actual average effective premium rate.

The distribution of yield risk for a representative farmer is then the sum of systematic and idiosyncratic risk. We assume idiosyncratic risk is normally distributed with mean zero and standard deviation equal to the optimal candidate standard deviation from the Coble and Dismukes procedure. Systematic risk is modeled as the kernel density function generated from the detrended county average yields. We draw from each of these distributions 10,000 times, adding the draw of county and idiosyncratic yields each time, to create the yield distribution used for our analysis.

Behavioral parameters. We assume the threshold value for farmers is zero eco-

conomic profit, $H = 0$. For α we explore a large range of possible value to determine the impact of α on diversification.

3.2 Parameters Used in Model 2

In order to incorporate on-farm production decisions as a risk management strategy, we need to construct an empirical distribution of yield risk based on observed county average yields, individual farm yields, and farm inputs. Using data from the Agricultural Resource Management Survey, we estimate the following regression model:

$$\ln(Y_j) = \beta_0 + \beta_1 \cdot \ln(\bar{Y}_{county}) + \sum_i \alpha_i \cdot \ln(x_i) + \epsilon_j \quad (7)$$

where j is the set of all sampled farmers, i is the set of all inputs x_i , Y_j is observed ex-post yields, and ϵ_j is the residual error term. We use the estimated α_i parameters in our model where production decisions are determined endogenously. ϵ_j provides a measure of yield risk. The empirical application of this model is not included at this time.

4 Data

We model the risk management allocation for a representative soybean producer in three different US counties. To generate the yield risk distribution for a representative farmer in each location, we use NASS county yield data for soybean production from 1975-2014. County base premium rates for different coverage levels are taken from RMA published figures. We use RMA's published daily prices and price volatility to generate the price risk distribution.

Subsidy rates and farmer premiums come from RMA. RMA offers insurance coverage levels from 50% - 85% in 5% increments. Forward contract prices are calculated as the project price plus a transaction cost. Following Etienne et al (2016), we set the transaction cost at \$0.16 per bushel.

For the empirical application we examine three counties with significant soybean production: Champaign County, IL; Minnehaha County, SD; and Robeson, County. Champaign County harvests over a quarter of a million acres of soybeans every year. This area has low yield risk and high yields for soybeans. Although soybeans are widely produced in Minnehaha County, the yield risk is much higher compared to Champaign County, IL. The coefficient of variation ⁴ for soybean gross revenue risk in Champaign

⁴The coefficient of variation is the standard deviation divided by the mean. For these values, we use the

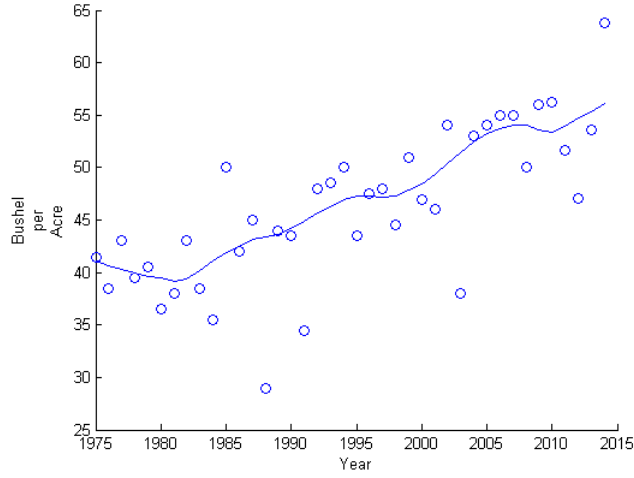


Figure 1: Historical yield and trend for soybeans in Champaign County, IL

County, IL is 0.28, while the coefficient of variation for Minnehaha County is 0.38. Robeson County, NC is the largest soybean producing county on the East Coast of the United States despite the high coefficient of variation (0.65) for soybean revenue.

Figures (1) - (3) show the historical yields for these three counties along with a LOESS regression trend line. The historical yields for these three counties display several differences among their soybean production. Champaign County not only has the highest average yield, but the variance is smaller than the variance of soybean yields of Minnehaha or Robeson Counties. Robeson County has both the lowest average yield and the highest variance among the three counties. Several soybean yield observations for Robeson County were below 15 bushels per acre, which would be considered a catastrophic loss.

In this analysis all counties are faced with the same price distribution, which is shown in Figure 4. This distribution shows the frequency of prices when prices are simulated for 100,000 draws. The price is centered around the 2015 projected price of \$9.73 per bushel. The 2015 RMA volatility factor of 0.16 is used to create variation in the distribution.

simulated yields and prices produced by our analysis.

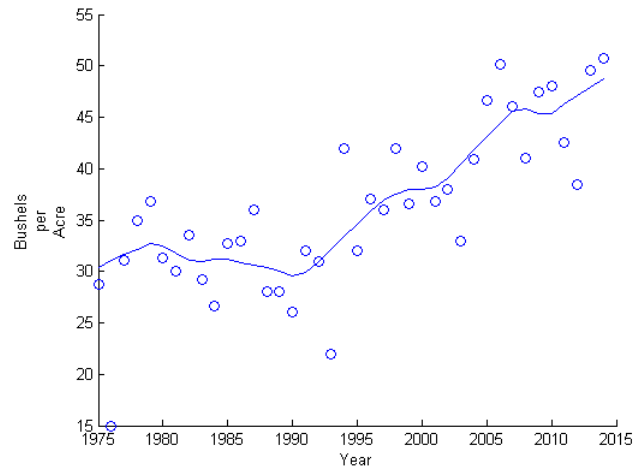


Figure 2: Historical yield and trend for soybeans in Minnehaha County, SD

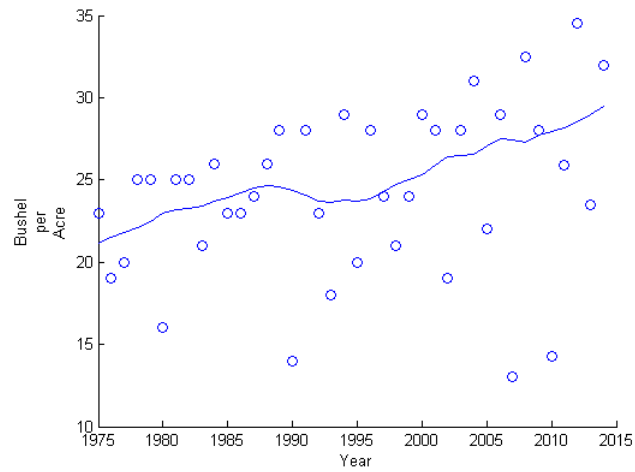


Figure 3: Historical yield and trend for soybeans in Robeson County, NC

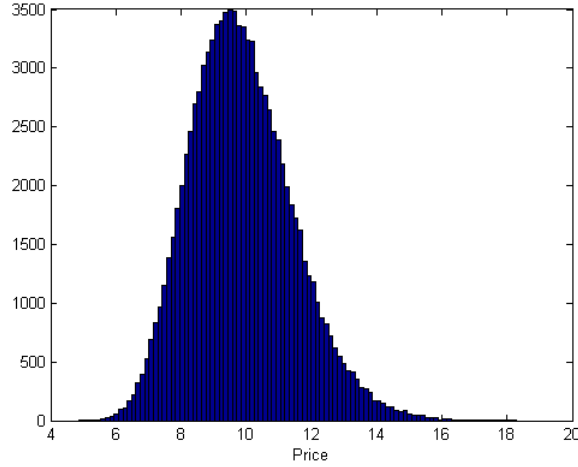


Figure 4: 2015 Soybean Price Frequency

5 Results

5.1 Yield and Price Risk Distributions

Before delving into the risk management strategies for each representative farm of the three counties, we observe the simulated soybean revenue for each representative farm without crop insurance or forward contracting. Each distribution is constructed from 100,000 independent draws of yields and prices that are then multiplied together to generate the 100,000 soybean revenue draws. Figures (5) - (7) illustrate the vast differences in soybean revenue among the representative farms of the three counties.

In Champaign County (Figure 5), average soybean revenue is greater than \$550 per acre, and the probability of complete crop failure is close to zero. The soybean revenue for the representative farm of Minnehaha County (seen in Figure 6) averages slightly less than \$490, and there is a small but noticeable probability mass at \$0 per acre. Finally, Figure (7) shows the representative farm of Robeson County, NC. Robeson County has the lowest average soybean revenue and a large probability mass at \$0 per acre. Over 11% of simulated soybean revenue draws result in failed acreage.

Intuitively, these soybean revenue distributions show that a producer in Robeson County, NC faces a much greater probability of a severe revenue loss compared to a producer in Champaign County, IL or even Minnehaha County, SD. If farmers in all three counties had the same budget constraints, soybean production costs, and tolerance for losses, the farmer living in Champaign would be able to spend less on insurance and forward contracting, and have more available for savings, than the farmers

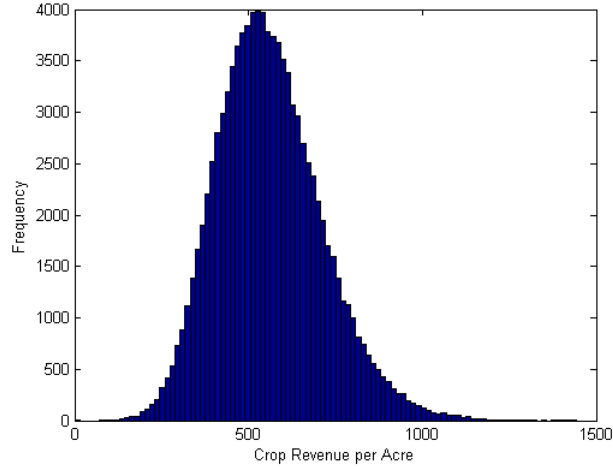


Figure 5: Soybean revenue distribution for the representative farmer of Champaign County, IL

in Minnehaha or Robeson Counties.

5.2 Role of Loss Aversion

Now that the soybean yields and revenues have been described for each county and representative farmer, we move on to the optimization of the financial risk management portfolios of representative farm. Since each county is located in a different geographic area, the representative farm for each county is faced with different costs of production. For this stage of the analysis, we differentiate between accounting and economic costs. We assume the total economic cost⁵ to be equal to the expected values of soybean revenue of each county as shown in Figures (5) - (7): \$560 per acre for Champaign County, \$485 for Minnehaha County, and \$310 for Robeson County. If economic total cost is greater than expected revenue, then the producer will exit in the long run. If the total economic cost is less than expected revenue, then farming soybeans will increase in entry and raise the rental rate of the land until economic total cost is equal to expected revenue. Although the total economic cost can vary substantially across a country, per acre operating costs for non-irrigated soybeans typically fall between \$175 per acre and \$200 per acre [Needs source].

One large factor in this analysis is the parameter α , which represents the producer's tolerance to losses below a given profit. For some values of α , a solution to the pro-

⁵Economic cost includes both the explicit operating cost and opportunity costs.

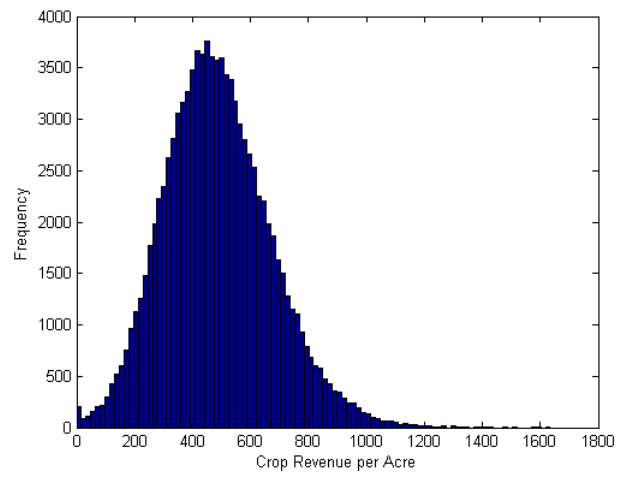


Figure 6: Soybean revenue distribution for the representative farmer of Minnehaha County, SD

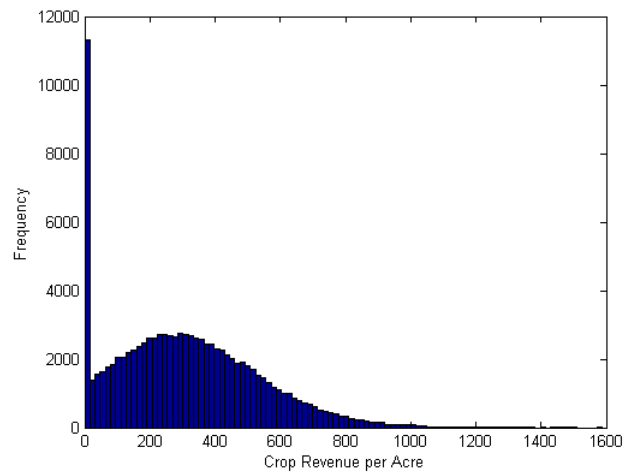


Figure 7: Soybean revenue distribution for the representative farmer of Robeson County, NC

ducer’s portfolio does not exist. In other words, a farmer is unable to diversify his portfolio to eliminate a satisfactory amount of risk because his crop production is too variable. For Champaign County, IL, the representative farmer can have an α that is close to zero (i.e. no loss aversion) when production costs and risk management expenditures are within \$20 of the expected value of production. Budgets need to be decreased in order to increase the impact of loss aversion on the optimal portfolio allocation. To see an impact for $\alpha = 0.2$, we must work with 25% less budget.

At current parameter levels, however, the representative producers of Minnehaha, SD and Robeson, NC must be much more tolerant of the potential for losses than the representative soybean farmer in Champaign County. The representative producer of Minnehaha, SD and the representative producer of Robeson, NC must have an $\alpha = 0.50$ or higher in order to be willing to engage in any soybean production. In other words, the representative farms of Minnehaha, SD and Robeson, NC must be willing to accept a 50 percent chance of realizing an economic loss from growing soybeans *even after applying their optimal risk management strategies*. Note that if we consider only accounting profit⁶ (i.e. opportunity cost not included), then the representative farmer of Minnehaha County, SD is willing to produce soybeans even with low tolerance for losses (α close to zero). However, the representative farmer of Robeson County, NC still has to be willing to accept at least a 30% chance of earning an accounting loss after applying their optimal risk management strategies in order to be willing to produce soybeans.

Large-scale differences in loss aversion across the population of US farmers is possible, but has not heretofore been suggested by the literature. There are a couple explanations of why this variation in α may be an artefact of our model. First, producers in these counties may not have their total economic cost equal to the expected value of soybean sales. Land and capital values reflect the profitability of all crops grown in the county, not just soybean returns. As we continue on with this research and delve deeper into ARMS, this issue may be resolved. Another related hypothesis is that farmers receive additional value from double cropping soybeans in areas with winter wheat or another crop. Therefore, the producers care less about making a profit on the soybeans themselves and more on greater potential yield of the wheat that comes from double cropping with soybeans. Our model does not as yet account for production of multiple crops.

⁶Here we use the estimates from the Economic Research Service cost of production for soybeans.

5.3 Optimal Portfolio Allocations

In Table 2 to Table 4, we examine the optimized risk management portfolio allocations for the representative farms in Champaign County, IL; Minnehaha County, SD; and Robeson County, NC. We also examine how the producers reallocate their budgets under different budget constraints and subsidy levels for crop insurance.

For each representative farmer, we examine the case when the producer has \$15 and \$20 per acre to dedicate to their financial risk management strategies. We look at three subsidy scenarios: no subsidies, subsidy levels equal to those used before the Agricultural Risk Protection Act of 2000 (“Pre-ARPA”), and current subsidy levels after the Agricultural Risk Protection Act of 2000 (“Post-ARPA”). In each scenario, the representative farmer chooses an optimal coverage level of the Revenue Protection (RP) insurance between 50-85 percent in 5 percent increments. If the producer does not select a Revenue Protection policy, then the producer is automatically enrolled in Catastrophic coverage (“CAT”). Unlike RP, CAT does not have a premium⁷. Each table displays the optimal quantity selected as well as the cost of the optimal quantity in parentheses. “Bushels Contracted” is the number of bushels forwarded by the representative farm along with the cost of forwarding in parentheses.

The portfolios of the three representative farms share several common elements. Despite allowing for major differences in the tolerance of loss-risk across representative farmers, all three representative farmers do not purchase Revenue Protection when no premium subsidies are offered. Also farmers are more likely to use forward contracting under the smaller budget constraint, although this result does depend on the subsidy regime. Also for all three representative farmers and under the different budget constraints, the farms purchase a lower coverage level of Revenue Protection under the Pre-ARPA subsidy level. Consistent with our a priori expectations, these tables show that as the premium subsidies increase, the representative farmers are willing to spend more on Revenue Protection.

The representative farms not only vary in the revenue risk, but how they respond to changes in subsidies. Table 2 shows that the change in premium subsidies moving from the Pre-ARPA level to the Post-ARPA level increases the insurance coverage by a 5 percent increment under both the \$15 and \$20 budget for the representative farm of Champaign, IL. The representative farm for Minnehaha County, SD increases RP coverage by 10 percent and 15 percent under the \$15 and \$20 budget constraints, respectively, as the premium subsidy increases from the Pre-ARPA to Post-ARPA

⁷CAT does have an administrative fee that is not included in this analysis because the fee is negligible on a per acre basis.

Table 2: Champaign County, IL

Risk Management Budget: \$15			$\alpha = 0.20$
	Coverage Level	Bushels Contracted	Saved
None	CAT	2 (\$0.32)	14.68
Pre-ARPA	75 (\$9.21)	7 (\$1.12)	4.67
Post-ARPA	80 (\$9.95)	7 (\$1.12)	3.93

Risk Management Budget: \$20			$\alpha \approx 0$
	Coverage Level	Bushels Contracted	Saved
None	CAT	7 (\$1.12)	18.88
Pre-ARPA	80 (\$15.86)	3 (\$0.48)	3.66
Post-ARPA	85 (\$17.40)	4 (\$0.64)	1.96

Table 3: Minnehaha County, SD

Risk Management Budget: \$15			$\alpha = 0.5$
	Coverage Level	Bushels Contracted	Saved
None	CAT	20 (\$3.20)	11.80
Pre-ARPA	55 (\$4.76)	40 (\$6.40)	\$3.84
Post-ARPA	65 (\$6.79)	47 (\$7.52)	\$0.69

Risk Management Budget: \$20			$\alpha = 0.5$
	Coverage Level	Bushels Contracted	Saved
None	CAT	0 (\$0)	20
Pre-ARPA	65 (\$11.22)	47 (\$7.36)	1.42
Post-ARPA	80 (\$18.80)	0 (\$0)	1.20

levels. Finally, for the representative farm of Robeson County, the producer will only purchase Revenue Protection under the \$20 budget constraint with the Post-ARPA subsidy levels.

Table 4: Robeson County, NC

Risk Management Budget: \$15			$\alpha = 0.5$
	Coverage Level	Bushels Contracted	Saved
None	CAT	5.76	9.24
Pre-ARPA	CAT	40 (\$6.40)	8.60
Post-ARPA	CAT	43 (\$6.88)	8.12

Risk Management Budget: \$20			$\alpha = 0.5$
	Coverage Level	Bushels Contracted	Saved
None	CAT	27 (\$4.32)	15.68
Pre-ARPA	CAT	16 (\$2.56)	17.44
Post-ARPA	55 (\$12.64)	43 (\$6.88)	0.48

5.4 Comparison of Actual Insurance Enrollments and Model Predictions

Figure (8) shows the total premiums and farmer-paid premiums from 1998 to 2014. All three counties show a general increase in both total premiums and farmer-paid premiums consistent with increasing enrollment in crop insurance over time. From 1998 to 2000, producers were faced with lower premium subsidies compared to 2001 to 2014. Therefore, for all three counties the difference between total premiums and farmer-paid premiums is smaller between 1998-2000 compared to 2001 to 2014. Since higher premium subsidies are given to lower coverage levels, a larger difference between the total premium and the farmer-paid premium indicates a larger percentage of farmers in the county enrolled in lower coverage levels. Conversely, a smaller difference between the total premium and the farmer-paid premium indicates more farmers elected to purchase higher coverage levels of crop insurance.

Robeson County, NC has the greatest difference between total premium and farmer-paid indicating that soybean farmers in Robeson County tend to enroll in lower coverage levels. Farmers in Champaign County tend to enroll in higher levels of crop insurance coverage. The soybean farmers' crop insurance choices of Minnehaha County, SD more closely resemble the choices made by Champaign County, IL soybean farmers compared to those in Robeson County, NC. However, the farmers' in Minnehaha County tend to enroll in coverage levels lower than farmers in Champaign County but higher coverage levels than Robeson County, NC. Overall, the current crop insurance choices for these counties resemble the outcome of the portfolio optimizations in our model.

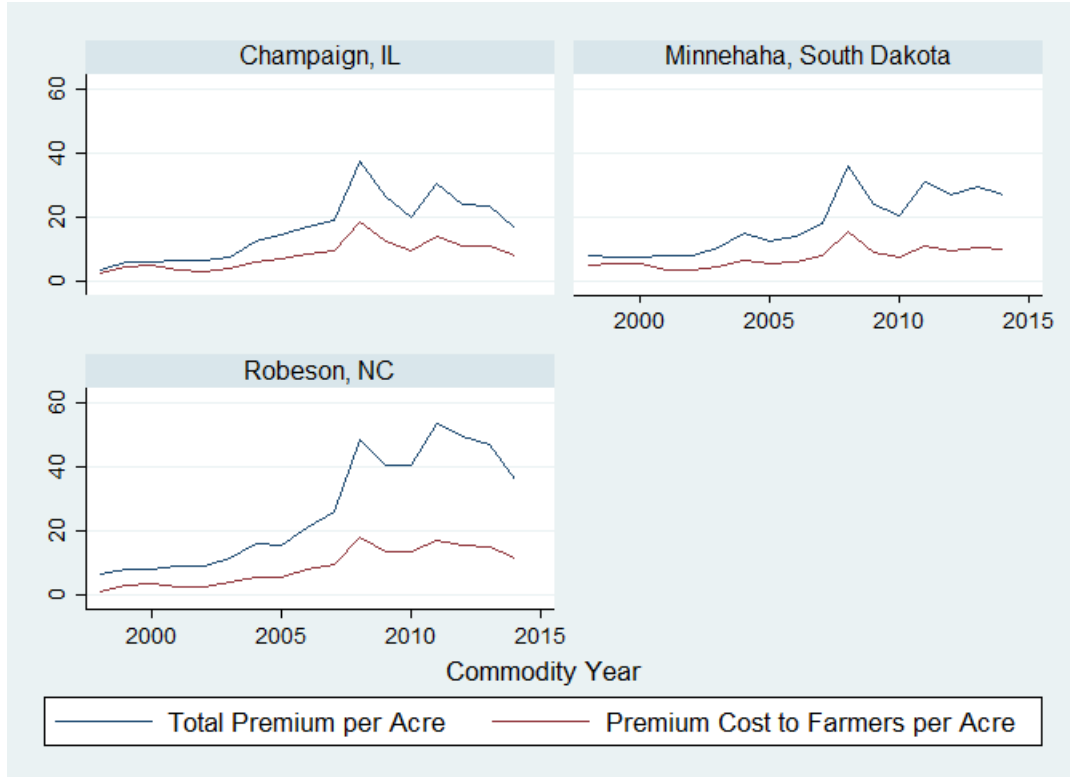


Figure 8: Insurance premiums 1998-2014 for selected counties

6 Conclusion

We examine how reducing subsidies for federal crop insurance affects the risk management portfolios of US soybean producers. We apply the portfolio optimization approach of Das and Statman (2013) to model how producers' risk management portfolios change as subsidies for federal crop insurance premiums change, and examine how the changes to the risk management portfolios impact farmers' on-farm income and exposure to downside risk. We optimize farmers' risk management portfolio by adjusting the budget shares dedicated to each of four risk management tools: returns on production, forward contracting, savings, and crop insurance.

From this analysis, we find that the level of revenue risk affects the producers sensitivity to changes in the subsidy levels. In the event of no subsidies, producers across all risk levels prefer to self-insure rather than purchase actuarially fair insurance, a result which is consistent with the historical relationship between enrollment in federal crop insurance and premium subsidies. This paper has novel contributions to the methodology for simulating demand for crop insurance. Both the methodology and

results are likely to be of interest for researchers and policy makers concerned with agricultural risk management.

Our subsequent analysis will include an empirical application with our second model that incorporates production inputs. This will allow modeling financial risk management decision to be made jointly with other input decisions.

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