Using Prospect Theory to Explain Anomalous Crop Insurance Coverage Choice

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Abstract

Farmers' decisions about how much crop insurance to buy are not generally consistent with either expected profit or utility maximization. They do not pick coverage levels that maximize expected subsidy nor do they demand full insurance coverage. In addition, the absolute size of farmer-paid premium seems to influence the type of insurance product farmers buy. Understanding demand drivers for crop insurance has taken on new importance because of the expanded role Congress has designated for crop insurance as a key part of Federal farm policy. By modeling financial outcomes as gains and losses, prospect theory offers an appropriate framework to better understand farmers' purchase decisions. Because insured events are best modeled as continuous random variables, cumulative prospect theory is used to find a theoretical foundation that can explain farmers' anomalous decisions. The role of the reference point that defines outcomes as either a gain or a loss, the degree of loss aversion, and the probability weighting function are explored under typical distributions of price, yield, and revenue for a corn producer. Choice of reference points that are consistent with farmers using crop insurance to manage risk are not consistent with observed purchase decisions. Choosing the reference point to make crop insurance akin to a stand alone investment generates optimal choices that are consistent with observed decisions and with the way that insurance agents sell the product.

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A missing market justification for subsidizing the provision of crop insurance seems plausible because of findings that the systemic nature of claims leads to an inability to pool losses, which leads to underprovision of crop insurance (Miranda and Glauber 1997). The argument is that private insurers would not supply enough crop insurance to meet the private demand for insurance by farmers. The standard assumption that farmers are risk averse expected utility maximizers creates an automatic demand for crop insurance because risk averters will demand full insurance if insurance is actuarially fair (Arrow 1974). If risk aversion is the motivation for farmers purchasing insurance, and if premiums are set at actuarially fair levels then we should see farmers buying 85% coverage, which is the highest coverage for farm-level crop insurance allowed. According to USDA's Risk Management Agency's summary of business reports, aggregating across corn, soybeans, wheat and cotton in 2013, only 12% of insured acres were insured at the 85% coverage level; 20% were insured at 80%; 28% were insured at 75%; 21% at 70% and 18% were insured at the 65% coverage level or lower. It is clear that farmers are not demanding more insurance than they can purchase.

One explanation for a lack of demand for full coverage is that premiums are loaded. Risk averters will demand less than full coverage with loaded premiums (Pashigian, Schkade, and Menefee, 1966). But the evidence is overwhelming that crop insurance premiums are subsidized, not loaded. The level of premium subsidy can be calculated either by the nominal premium subsidy rate that varies by the coverage level a farmer selects or by the extent to which historical indemnities paid to producers have exceeded premiums paid by producers. The nominal subsidy rate varies from 38% at the 85% coverage level available to 67% at the 50% coverage level. Figure 1 provides data that shows indemnities paid to farmers have exceeded indemnities in every year since 2001. The implied average annual premium subsidy over this time period is 50%.

The large dispersion in insurance coverage across producers suggests that farmers generally do not buy the level of coverage that maximizes per-acre subsidies. To demonstrate this better requires a lower level of aggregation. In Jasper County, Iowa, Risk Management Agency summary of business data shows that per-acre premium subsidies in 2013 for soybean farmers who purchased Revenue Protection, ranged from a low of $7.07 per acre at the 65% coverage level to a high of $19.13 per acre at the 85% coverage level. The 80% subsidy was $17.32 per acre. But less than 25% of soybean acreage was insured at the 85% coverage level. A total of 64% was insured at either 80% or 75%.

If farmers do not maximize expected utility or expected profit, what do they maximize? The answer to this question has policy implications because understanding why farmers buy crop insurance is needed to determine the impact of participation if subsidy levels are changed. One possibility is that farmer preferences for crop insurance can be captured by prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992). The key features of prospect theory is the reference point that distinguishes gains from losses, the degree of loss aversion, and the weighting function.

Eckles and Wise (2013) show that how insurance is framed by choice of the reference point in prospect theory can change the value of insurance and the level of the insurance deductible chosen. When crop insurance is used to manage risk from farming it seems natural to use a reference point that calculates gains and losses accounting for market income, the premium paid for insurance, and any indemnity received. A reference point that accomplishes this is initial wealth. If net income from farming, including the cost of insurance and any insurance indemnity received, is positive then final wealth will exceed initial wealth and a gain is felt. As will be demonstrated, this natural view of how crop insurance should be framed does not generate optimal coverage levels that are consistent with farmers' observed choices. Treating crop insurance as a risk management strategy under prospect theory generates insurance demand that is consistent with expected utility theory. That is, farmers will buy full insurance if it is actuarially fair.

An alternative reference point is motivated by Brown et al. (2008) who argue that consumers view insurance as an investment and judge its value on the basis of insurance gains or losses in isolation from the effects of insurance on overall income or consumption. This way of viewing crop insurance treats it not as a risk management tool but rather as a simple investment or lottery. A loss occurs when the premium paid is greater than the indemnity. A gain occurs when the indemnity exceeds the premium paid. This view of crop insurance is consistent with educational material at a prominent educational website (farmdoc) that shows the historical pattern of gains and losses from buying crop insurance. Furthermore, some agents use the historical record of payouts and premiums to sell crop insurance on the basis of the odds that indemnities will exceed premium paid.

This paper makes two contributions. First, it demonstrates a practical way to implement prospect theory to evaluate choices involving the types of risks and models often used by agricultural economists. Second, it shows that modeling crop insurance as an investment leads to simulated optimal coverage levels that are consistent with how much crop insurance actually buy. The results are consistent with earlier findings (Just, Calvin and Smith (1999); Goodwin (1993)) that crop insurance is viewed by producers as a form of income support rather than as a risk management tool.

Implementation of Cumulative Prospect Theory Using Monte Carlo Simulation

To run simulations using cumulative prospect theory requires specification of a value function, a probability weighting function, and a cumulative distribution function. The value function used here is taken directly from Tversky and Kahneman (1992):

$$v(x) = \begin{Bmatrix} x^{\alpha} \text{ if } x \geq 0 \\ -\lambda(-x)^{\alpha} \text{ if } x < 0 \end{Bmatrix} \quad (1)$$

where x is a monetary gain or loss, λ determines the degree of loss aversion, and α determines the curvature of the value function for gains and losses. The decision weight $\pi(p)$ given to each value of x depends on the probability p of that value occurring. The overall value of an uncertain prospect that can take on N values is the weighted average of the value of each outcome with weights given by the decision weights:

$$V = \sum_{i=1}^{N} v(x_i)\pi(p_i).$$

Tversky and Kahneman (1992) propose a cumulative probability modification of their original theory. This modification ranks the gains from lowest gain to highest gain and the losses from lowest loss to highest loss. The decision weight for any gain x_i depends on the probability of achieving a gain larger than x_i and the probability of achieving a gain that is at least as large as x_i. If probability weights equal probabilities then the decision weight just equals the difference in cumulative probabilities, which, by definition, is equal to the probability of x_i occurring. But decision weights do not, in general, equal probabilities. Tversky and Kahneman (1992) propose a probability weighting function designed to allow for underweighting of moderate and high probabilities and overweighting of low probabilities:

$$w^{+}(p)=\frac{p^{\gamma}}{(p^{\gamma}+(1-p)^{\gamma})^{1/\gamma}};\ w^{-}(p)=\frac{p^{\delta}}{(p^{\delta}+(1-p)^{\delta})^{1/\delta}} \tag{2}$$

If there are n possible gains, then the decision weight for any gain i is:

$$\pi_i^{+}=w^{+}(p_i+...+p_n)-w^{+}(p_{i+1}+...+p_n);\pi_n^{+}=w^{+}(p_n) \tag{3}$$

If there are m possible losses, then the decision weight for any loss i is:

$$\pi_i^{-}=w^{i}(p_m+...+p_i)-w^{i}(p_m+...+p_{i-1});\pi_m^{i}=w^{-}(p_m) \tag{4}$$

The decision weight of any outcome under this formulation equals the incremental value of the weighting function at each possible outcome. This formulation suggests a way to implement cumulative prospect theory numerically when there is no closed form solution for the distribution of outcomes.

Let $F(r)$ be the cumulative distribution function of revenue that will be insured by crop insurance. Let x_i be a random draw from F(r), N be the total number of draws, and r^{ref} be the reference value of revenue such that all values less than r^{ref} are losses and all values greater than r^{ref} are gains. Let N^{+} be the number of gains and N^{-} be the number of losses. Now order the gains from smallest to largest gain, and order the losses from smallest to largest lost. By definition the probability of any of the N draws is $1/N$. Thus the probability that a gain will be greater than the smallest possible gain is given by $\frac{N^{+}-1}{N}$. The probability of a gain equal to or greater than the smallest gain is given by

$\frac{N^+}{N}$. Therefore, following (3) the decision weight for the smallest gain is $w^+(\frac{N^+}{N}) - w^+(\frac{N^+ - 1}{N})$. Similarly, the decision weight assigned to the second to smallest gain is $w^+(\frac{N^+ - 1}{N}) - w^+(\frac{N^+ - 2}{N})$. The decision weight given to the largest gain would be $w^+(\frac{1}{N})$.

For losses, the decision weight for the smallest loss using equation (4) is $w^-(\frac{N^-}{N}) - w^-(\frac{N^- - 1}{N})$. The decision weight for the second-to-smallest loss is $w^-(\frac{N^- - 1}{N}) - w^-(\frac{N^- - 2}{N})$, and the decision weight for the largest loss is $w^-(\frac{1}{N})$. Using draws from a distribution with no closed form solution is a standard way of calculating probabilities. Extending this use of Monte Carlo methods to implementation of cumulative prospect theory replaces equal weighting of all outcomes with unequal weights determined by the difference in the weighting function between two adjacent outcomes, which approximates the derivative of the weighting function. If the parameter in the probability weighting functions for gains and losses are both equal to one, then this procedure reduces to equal weighting used by Monte Carlo methods. If, in addition, the loss aversion parameter and the value function parameter both equal one, then this procedure simply calculates expected value of the outcome. Thus by varying the parameters of the value function, one can isolate the effects of loss aversion from risk seeking and risk averse behavior. By varying the parameters of the probability weighting function, one can determine the effects of using decision weights instead of probabilities.

Modeling the Distribution of Corn Revenue in Iowa

Numerical implementation of cumulative prospect theory to explore valuation of crop insurance requires specification of the cumulative distribution function of the risk. In the simulations that follow this distribution is obtained by taking correlated draws from a representative yield distribution and a representative price distribution following Babcock and Hennessy (1996). Harvest price is assumed to be log-normally distributed with a mean of $3.72 per bushel and a volatility of 20%. Yield is assumed to be beta-distributed with a mean of 170 bushels per acre, a maximum yield of 242 bushels per acre, a minimum of 17 bushels per acre, and a standard deviation of 38.22. This parameterization of the yield distribution is calibrated to an average corn farmer in Hamilton County, Iowa. The distribution generates expected indemnities that are consistent with current crop insurance rates for yield-only insurance. The correlation between price and yield is set at -0.5. The resulting cumulative distribution function of revenue has no analytical function form. Random draws from the distribution are used to show the form of the distribution in figure 2. This distribution was constructed by calculating 5,000 revenue draws from 5,000 correlated yield and price draws. The draws are ranked from low to high and a weight of 1/5000 is assigned to each of the draws to form the distribution.

Implementation of Cumulative Prospect Theory

A key feature of prospect theory is the reference point that distinguishes between gains and losses and the degree of loss aversion. A loss aversion coefficient of 2.25, which was the median coefficient found in a series of experiments conducted by Tversky and Kahneman (1992) means that a person values avoiding a loss 2.25 times as much as obtaining the same magnitude of gain. Suppose a representative farmer has an initial wealth level of w_0. Revenue from farming is r, and the cost of production is c. Final wealth will be $w_f = w_0 + r - c$. If $r - c > 0$ then the farmer's final wealth is greater than initial wealth and a gain is felt. If $r - c < 0$, then the farmer feels a loss. Thus it seems natural to set the reference revenue level as the amount of revenue needed by a grower to cover their cash production costs using prospect theory.

When cash costs are above available insurance guarantees then insurance indemnities will be paid but the farmer will still feel a loss. When cash costs are below available insurance guarantees, as they arguably are when market prices are high, then indemnities could be paid even when market revenue is sufficient to cover cash costs and no loss would be felt even without insurance. To capture these two situations we could vary expected market price or we could vary cash costs. Varying the expected market price would represent how the crop insurance program works in different years in the same region. Varying cash costs would represent how crop insurance works in a given year across regions with different cash costs. Below we vary cash costs to illustrate how the relationship between insurance guarantees and cash costs affect the value of crop insurance.

High cash costs relative to expected market prices and insurance guarantees are represented by a break-even reference point of \$600. Low cash costs are represented by a reference point of \$400. Mean revenue is \$618.23. The annual per-acre value of farming for this representative producer is found by first transforming 5,000 revenue draws from the figure 2 revenue distribution into 5,000 losses and gains. Losses and gains are calculated by subtracting the reference point from each revenue draw. The probability of a loss is the number of losses divided by 5,000. The expected gain is the simple average of all gains and losses. Total value is calculated by summing the total value of gains and the total value of losses. The total value of losses is determined by calculating the value of each loss by equation (1), multiplying this value by the decision weight calculated by equations (3) and (4), and then summing over all losses. The total value of gains is calculated similarly.

Certainty equivalent returns is the certain amount of money that makes a decision maker indifferent between taking the money and taking the risk of a gain or loss. The risk premium equals the expected gain minus certainty equivalent returns. Figure 3 shows how certainty equivalent returns are calculated when the total value of the risk is positive and negative. When total value equals V_1, certainty equivalent returns equals CER_1 in figure 3. It is calculated using the value function defined over gain because the total value is a gain. When total value equals V_2, certainty equivalent returns equals CER_2 using the value function defined over losses.

Table 1 shows the impact of the reference point, loss aversion, curvature of the value function, and the probability weighting function parameters on certainty equivalent returns and the risk premium. When the probability of a loss is small, as it is when the reference point is $400, the impact of loss aversion, as measured by the risk premium of $3.47, is small. Increasing the reference point to $600 increases the risk premium to $35.32. The higher reference point also makes total value go negative, which is reflected by negative certainty equivalent returns.

Adding curvature to the value function has two effects. The first is that for any given level of total value, adding curvature makes certainty equivalent returns more positive (less negative) when total value is positive (negative) simply by adding more concavity (convexity) to the value function. But curvature also affects total value. Large gains and losses have less impact on total value when curvature is increased so adding curvature reduces total value when it is positive and increases total value when it is negative. The two effects work together to reduce the risk premium when total value is negative. The two effects work opposite each other when total value is positive. In table 1, the risk premium increases from $3.47 to $10.98 when curvature is added.

Figure 4 shows how the probability weighting functions work for both gains and losses when the reference point is $600. The values of the parameters are set equal to those used by Tversky and Kahneman (1992) reported in table 1. As shown the probability weighting functions undervalue small probabilities and overvalue moderate probabilities. But recall that decision weights are determined by the slope of these functions, not by their level. Using the $600 reference point figure 5 shows how the decision weights for gains change as cumulative probability increases compared to using marginal probabilities directly. The probability weighting functions result in large overweighting of small probability events and underweighting of almost all other events. Subadditivity is evident with these weighting functions also. The sum of decision weights shown in Figure 5 is 0.43. The cumulative probability is 0.536. Adding the probability weighting function increases the risk premium from $10.98 to $47.03 when the reference point is $400. The risk premium is changed a small amount when the reference point is $600. The substantial increase when the reference point is $400 largely reflects subadditivity because the drop in total value reflects the lower average decision weight. This lower total value translates into lower certainty equivalent returns which in turns implies a higher risk premium.

This preliminary discussion of how cumulative prospect theory can be implemented using Monte Carlo draws from a revenue distribution reveals the importance of the reference point, the value function, and the probability weighting function in determining total value and the resulting risk premium. The large effect that the reference point and subadditivity can have in determining the risk premium shows the importance of determining the value of insurance holding constant the reference point and the probability weighting function.

Value of Crop Insurance

Insurance is valued under expected utility maximization because it is typically assumed that the utility function is concave in wealth. Full insurance is demanded when the insurance premium is set at actuarially fair levels. Partial insurance is optimal under expected utility when an insurance load is applied. Consumer demand for low deductible insurance with loaded premiums has long been known to exceed levels predicted by expected utility (Pashigan, et al 1966). Rabin (2000) demonstrates that support for a globally concave utility function is weak, which led to efforts by Koszegi and Rabin (2006, 2007, 2009) to explain this anomalous demand with prospect theory preferences. This series of papers imposed linear utility, which runs counter to the Kahneman and Tversky's (1978) finding that people are risk averse in gains and risk seeking in losses. Eckles and Wise (2013) relax this linearity assumption and focus on the reference point to explain the demand for low deductible policies. They show that when insurance preferences are modeled using prospect theory then full insurance is demanded if premiums are actuarially fair. However, their paper does not incorporate probability weighting functions that are used to determined decisions weights under cumulative prospect theory. The purpose of the Eckles and Wise (2013) paper is to show that prospect theory preferences induce demand for low deductible insurance even if premiums contain a load. The purpose of this study is to see if prospect theory can explain less-than-full insurance when premiums are subsidized.

Preference ranking over insurance alternatives is given by simulated certainty equivalent returns holding constant the degree of loss aversion, the curvature of the value function, the probability weighting function parameters, and the reference point. If certainty equivalent returns at a given deductible is higher than certainty equivalent returns without crop insurance, then crop insurance will be purchased. The coverage level (value of the deductible) that maximizes certainty equivalent returns will be assumed to be optimal.

The most widely-used form of crop insurance in the United States is called Revenue Protection. This product establishes an initial revenue guarantee before a crop is planted that equals up to 85% of the product of expected price and expected yield. If the price at harvest moves higher than this expected price then the guarantee is revised by replacing expected price with harvest price the calculation. A more straightforward product is called Revenue Protection – Harvest Price Exclusion, which does not allow revision of the guarantee. An insurance indemnity is paid if the product of harvested yield and harvest-time price is less than the final revenue guarantee. The amount of the indemnity is the difference between the guarantee and harvest revenue.

To begin, the value of crop insurance with actuarially fair premiums at different deductibles levels is simulated using the same parameter values and cash costs in table 1. Total value without insurance is simulated by setting the coverage level equal to zero.

The crop insurance premium is included as an optional cost of doing business. When an indemnity I occurs, it is added to revenue. We initially set $I = \max(r_g - r, 0)$ where $r_g = \alpha E(P)E(Y) = \alpha \cdot 3.72 \cdot 170$, where $E(P)$ is expected price, $E(Y)$ is expected yield, market revenue at harvest is r and α is the coverage level. Market revenue at harvest is the product of actual yield and actual price at harvest. This indemnity formula is consistent with RP-HPE (Revenue Protection with the Harvest Price Exclusion), a revenue insurance product sold throughout the United States because the insurance guarantee does not increase if the price at harvest is greater than expected price. With production costs of c final wealth is greater than initial wealth with insurance when $r + I - c - p > 0$, or when $r + I - p > c$. Thus c defines the reference level of revenue, assuming that net revenue from insurance is added to revenue from farming when determining if there is a gain or loss. If no indemnity is received a loss will be felt if $r - p < c$. If the insurance guarantee is less than c, then whenever an indemnity is paid, a loss will be felt. If the insurance guarantee is greater than c, then even when an indemnity is paid, a gain may be felt.

Table 2 presents the first set of results modeling crop insurance for the two reference points for coverage levels varying from 65% to 85%. Also included are a hypothetical 100% coverage level and the results under no insurance. Crop insurance with the low cash cost of $400 per acre eliminates all losses. With the $600 reference level the probability of a loss actually increases as coverage increases because paying the premium can turn a gain into a loss and the insurance guarantee minus the premium is always below 600. Increasing the probability of a loss should decrease value because of loss aversion. But the table 2 results show that benefit of reducing the severity of losses with insurance outweighs the greater frequency of a loss and certainty equivalent returns increase with coverage level with the 600 reference point. It is not surprising that certainty equivalent returns increase with coverage level with the 400 reference point because the 65% coverage level eliminates any chance of a loss, which means that loss aversion no longer affects value. Only the concave value function and the probability weighting function determine total value and both tend to favor insurance. The last two columns of Table 2 show the value of insurance, which is calculate as the difference between certainty equivalent returns with insurance and without insurance. As shown, the value of insurance is less with the 600 reference point than the 400 reference point. This suggests that when insurance increases the chances of a loss, then it has less value then when it allows a producer to lock in a gain. Because the value of insurance increases with coverage level, treating crop insurance as a risk management tool does not generate predictions that are consistent with the observatins that most farmers do not choose to buy the maximum amount of coverage available.

Crop Insurance as an Investment

Suppose that producers treat crop insurance as an investment activity separate from their production activities. Such a treatment is analogous to economic modelers ignoring other household activities when modeling farming decisions. Further suppose that a producer with prospect theory preferences can choose to buy actuarially fair crop insurance at different coverage levels. The gain or loss in this situation is simply the indemnity payment less the insurance premium. A loss is felt if the investment does not pay off, which occurs when the indemnity payment is less than the premium paid. Defining gains and losses in this manner runs counter to the notion that farmers suffer a loss when they receive a crop insurance payment. But, as shown above, defining gains and losses from crop insurance as a risk management device does not generate coverage level choices consistent with observed choices.

Table 3 presents summary results from the same set of indemnity calculations used to generate the table 2 results. The second column shows the simulated actuarially fair premium for each coverage level. Certainty equivalent returns in the third column assumes that the column two premium is paid. Returns in the fourth column assume that the premiums are subsidized following the premium subsidy percentages published by the USDA's Risk Management Agency. The amount of the subsidy is shown in the rightmost column. The probability of a loss is shown for both subsidized and unsubsidized premiums. As shown, premium subsidies reduce the probability that a loss will be felt by only a small amount.

Treating crop insurance as an investment rather than a risk management tool leads to sharply different coverage level rankings. When the premium is not subsidized, the coverage level that maximizes value is the 60%. When the premium is subsidized, 70% coverage maximizes value. The variation in certainty equivalent returns seem small across coverage levels, particularly with the unsubsidized insurance, but at the low coverage levels, the value of this investment relative to the premium paid is large. At the 60% coverage level, the premium paid is $1.84 per acre. This investment cost generates certainty equivalent returns, which represents the total value of the net indemnity received, of $1.28. A negative value for certainty equivalent returns indicates that the producer would not make the investment. With unsubsidized insurance, negative returns begin at 75% coverage and increase as coverage increases.

When premiums are subsidized, there is no coverage level that generates negative value. Thus, from an investment perspective, prospect theory predicts that crop insurance generates positive value to farmers when premiums are subsidized. This result demonstrates that the prospect theory framework as implemented here leads to common sense findings as well as more nuanced findings. The rankings reported in Table 3 are largely consistent with the actual choices of most producers regarding coverage level. That is, the coverage level that generates the highest certainty equivalent returns with premium subsidies is 70%. The reduction in value moving to 75% is small. The reduction in value moving to 80% or 65% is somewhat larger but not dramatically smaller.

To further investigate the ability of prospect theory to generate predictions that are consistent with observed crop insurance choices needs to account for the fact that most producers who have the choice buy Revenue Protection. Under this type of insurance $I = \max[\alpha \max(P, E(\mathrm{P}))\,\mathrm{E(Y)} - \mathrm{r}, 0]$. Approximately 90% of 2013 corn acres insured under farm-level crop insurance of the type considered here was insured with RP. Only 1.2% was insured with RP-HPE.

Table 4 presents simulation results for RP. Both out-of-pocket expenses and premium subsidies increase with RP because of the feature that allows the insurance guarantee to increase. If RP premiums were not subsidized the model predicts that this representative producer would choose the 60% coverage level, which is the same result as in Table 3. Of course whether producers would actually buy unsubsidized crop insurance would depend on the premium load to cover other costs not considered here. When premiums are subsidized the coverage level that maximizes subsidy, 85%, is not the coverage level that maximizes certainty equivalent returns. Certainty equivalent returns for available coverage levels are at their highest at 75% coverage with the 80% coverage level returns almost as high. Again these simulation results lead to the conclusion that modeling crop insurance coverage level decisions as an investment using prospect theory preferences predicts coverage level decisions that are more consistent with observed choices than competing models.

Policy Implications

The question of whether there is any economic basis for the extensive government involvement in providing US producers with crop insurance hinges in part on the value that crop insurance provides farmers. If farmers value crop insurance as their primary means of managing risk, as industry and Congressional supporters claim, then government provision of insurance may be justified if the private sector cannot provide the level or type of insurance needed by farmers. This would be a classic missing market justification for government intervention. Evidence needed to support this justification is that farmers buy crop insurance to manage risk. Empirical evidence (Just, Calvin, and Quiggin (1999)) indicates that farmers buy crop insurance more for the opportunity to increase income rather than to manage risk. If this were finding were strictly true and farmers were profit maximizers then we should see farmers choosing the level of coverage that maximizes expected subsidy. But Du, Feng and Hennessy (2014) demonstrate that farmers maximize neither expected utility nor expected profits.

Here I show that the use of prospect theory to value crop insurance as an investment rather than a risk management tool results in predicted choices about the level of coverage that are consistent with observed choices and not consistent with either expected utility or profit maximization. Thus the best explanation for why farmers buy crop insurance is that it is appealing as a risky investment. The implication of this finding is that there is little economic justification for public provision of crop insurance in terms of meeting unmet demand for risk management tools. Given the large number of private opportunities for investment that exist, it makes little economic sense to provide an investment opportunity for farmers that only exists because it is subsidized.

Of course the crop insurance program does not exist solely on the basis that it improves social welfare. Even though there is growing agreement among economists (Wright 2014) that crop insurance is mainly a means of supporting farm incomes, two political realities likely mean that the program will continue to exist for some time. First, history shows that Congress needs to act when a crop disaster strikes politically important regions of the country. It is possible that having farmers purchase crop insurance before any disaster strikes forestalls an ex post response by Congress that could do more economic harm than is done by supporting the program. Second, the widespread support the crop insurance program garners from farmers, crop insurance agents and companies and the reinsurance industry means that it is a public program that serves the political needs of elected officials. Given these political realities perhaps the growing realization that there is no real public benefit provided by crop insurance will lead to reform of the program that lowers its cost to taxpayers without significantly lowering the political benefits that it generates to its supporters.

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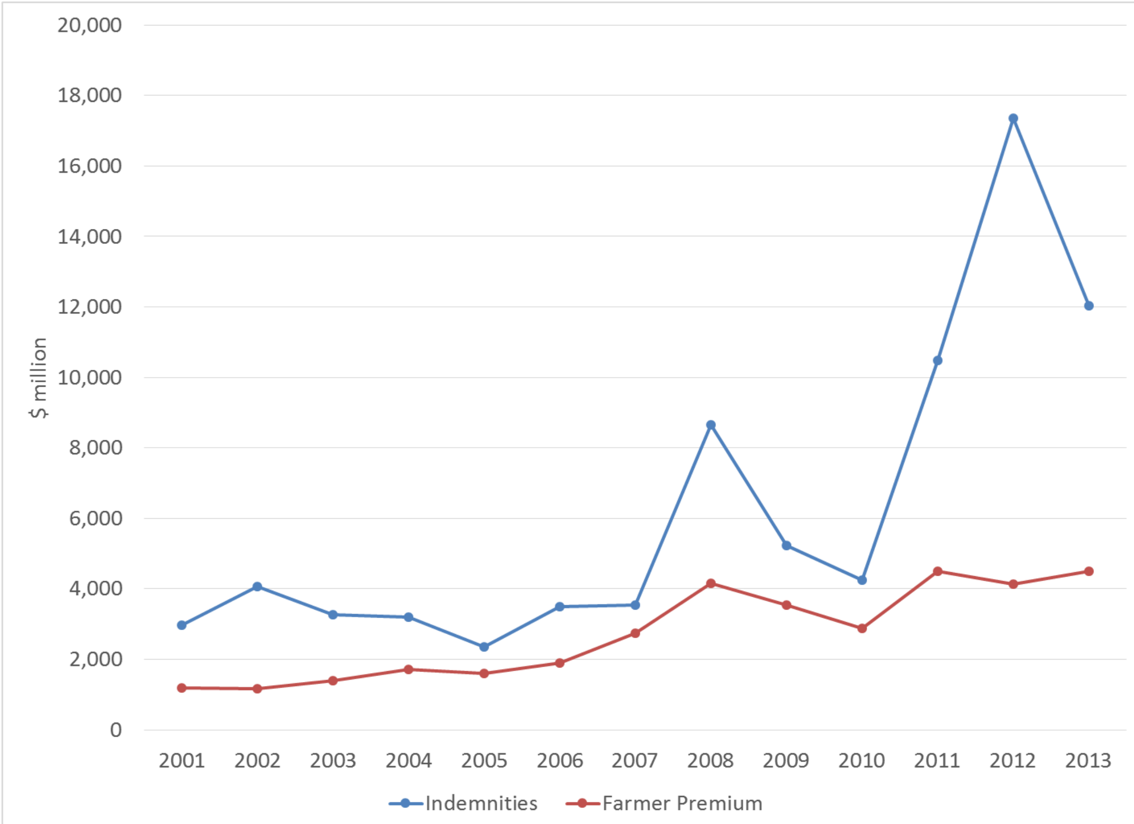

Figure 1. Farmer premium vs. indemnities paid since 2001

Source: USDA-RMA Summary of business reports

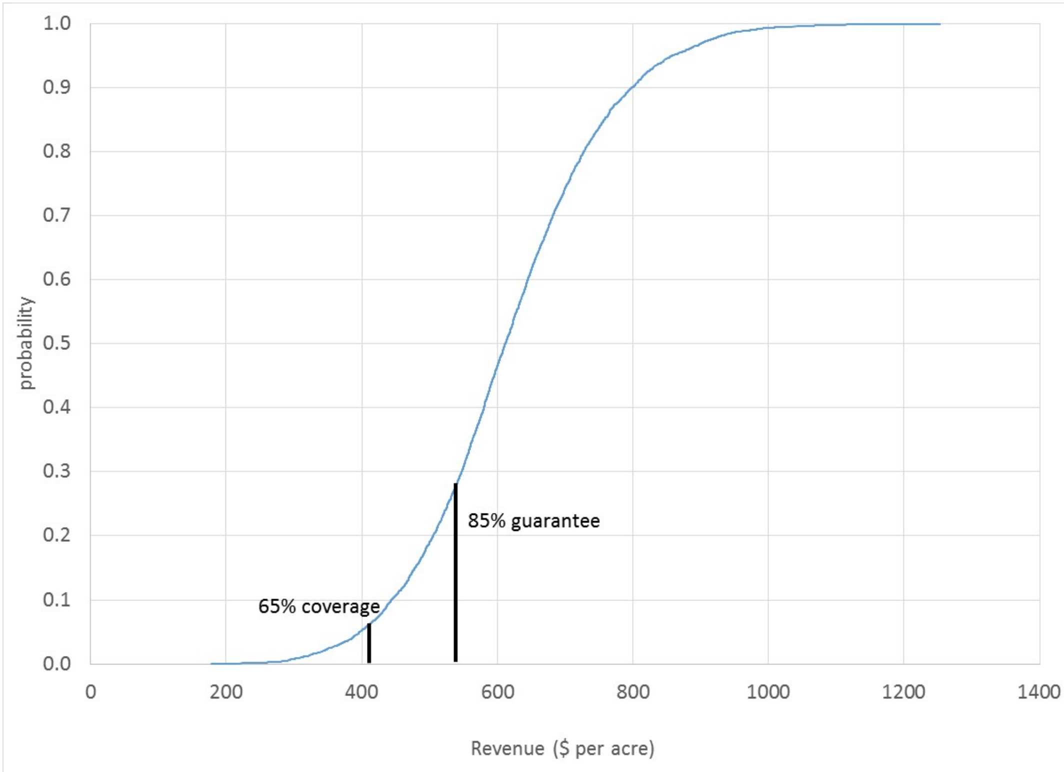

Figure 2. Cumulative distribution of Iowa corn revenue used in simulations

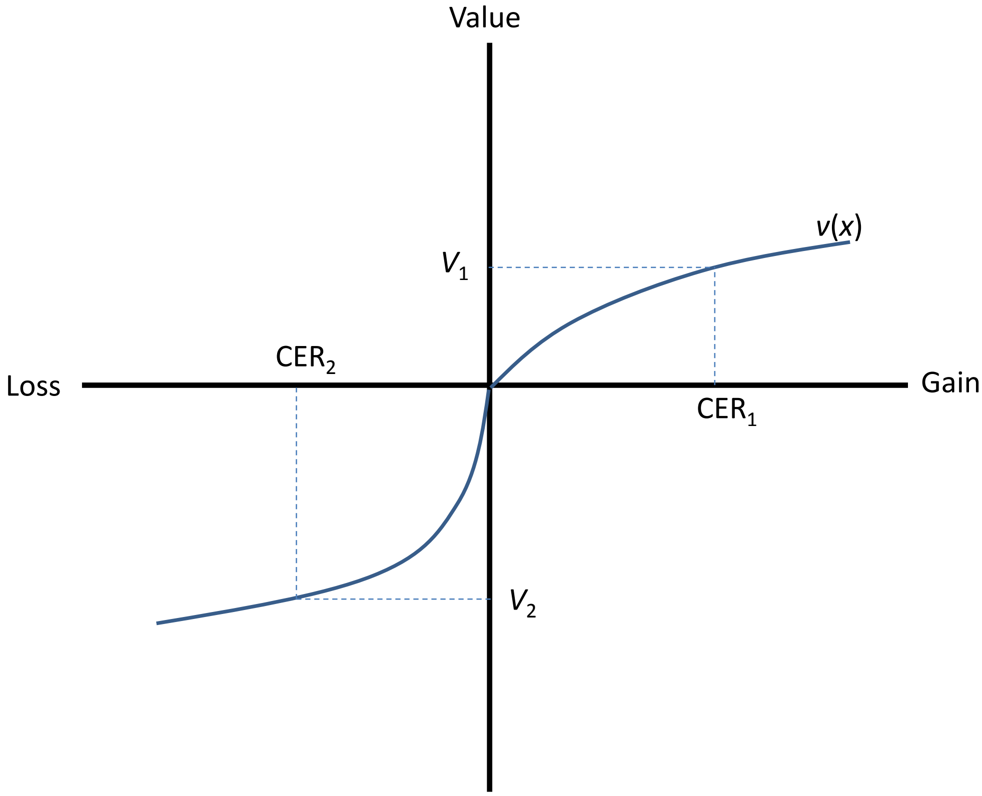

Figure 3. Calculation of certainty equivalent returns in prospect theory

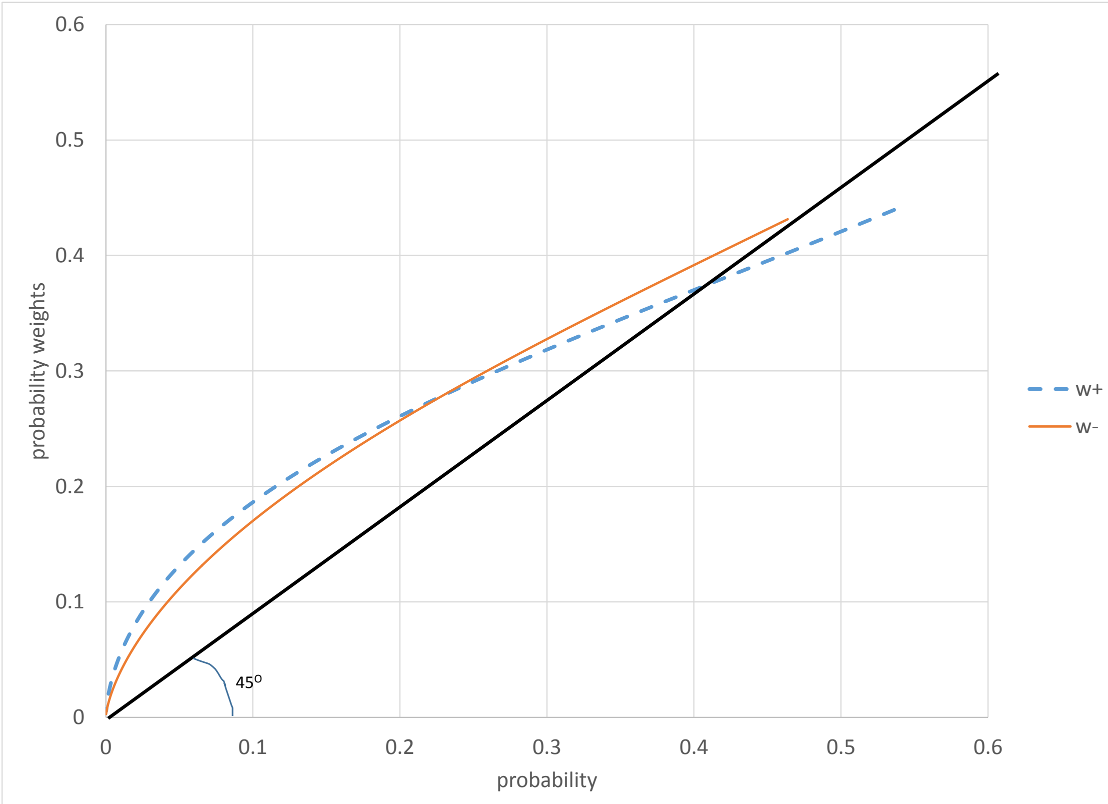

Figure 4. Probability weighting functions

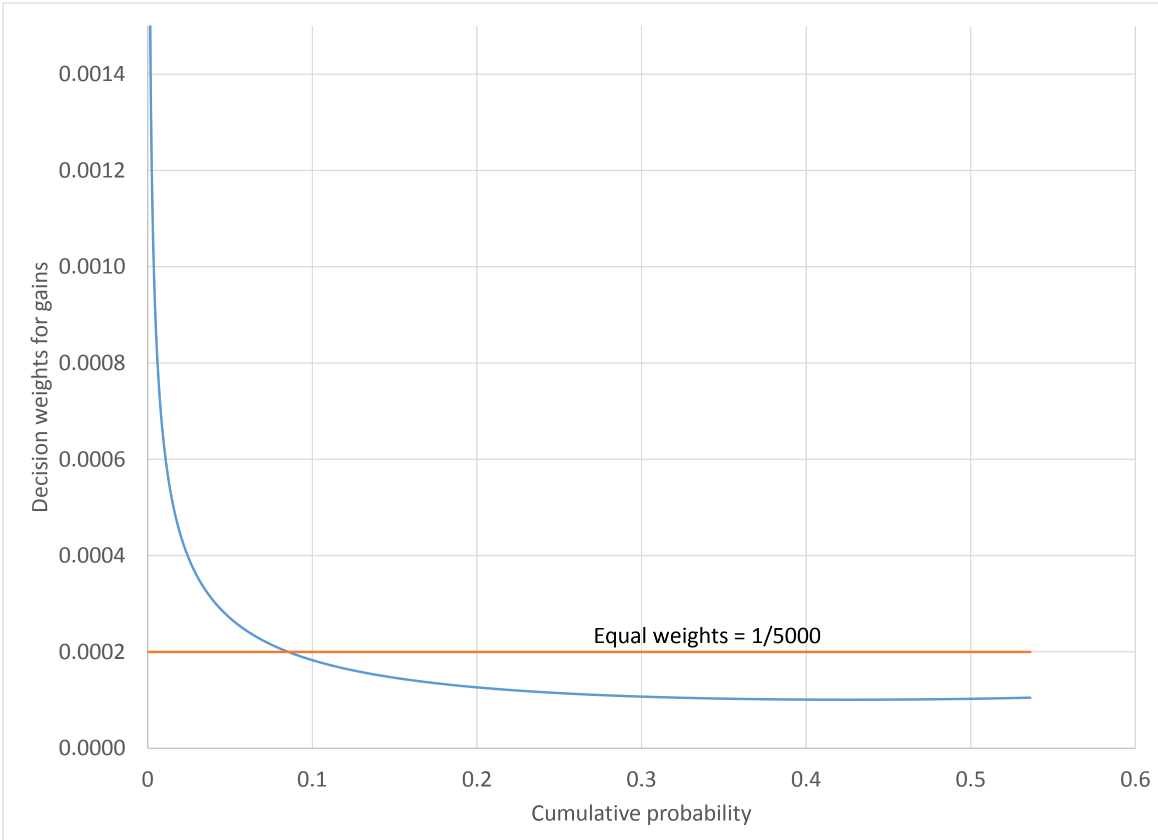

Figure 5. Decision weights vs equal weights

Table 1. Impact of Prospect Theory Parameters on Total Value, Certainty Equivalent Returns and Risk Premia

	Reference Point	
	$600	$400
Probability of a Loss	0.46	0.052
Expected Gain	$18.23	$218.23
Loss Aversion Only[a]		
Total Value	-38.5	214.76
Certainty Equivalent Returns	-$17.10	$214.76
Risk Premium	$35.32	$3.47
Loss Aversion plus Curved Value Function[b]		
Total Value	-22.3	109.27
Certainty Equivalent Returns	-$13.60	$207.25
Risk Premium	$31.81	$10.98
Prospect Theory[c]		
Total Value	-28.2	92.36
Certainty Equivalent Returns	-$17.70	$171.00
Risk Premium	$35.92	$47.03

[a]Loss aversion coefficient $\lambda = 2.25$ from equation (1).

[b]Curvature parameter $\alpha = 0.88$ from equation (1).

[c]Probability weighting parameters $\gamma = 0.61$; $\delta = 0.69$ from equation (2).

Table 2. Value of Insurance under Prospect Theory

	Probability of a loss		Certainty Equivalent Returns		Value of Insurance	
	Reference Revenue Level					
Coverage	600	400	600	400	600	400
0%	0.46	0.052	92.36	171.20		
65%	0.478	0	97.40	181.81	5.04	10.61
70%	0.482	0	101.10	189.73	8.74	18.53
75%	0.494	0	104.71	197.45	12.35	26.25
80%	0.510	0	108.21	204.97	15.85	33.77
85%	0.530	0	111.50	211.97	19.14	40.77
100%	0.647	0	117.90	225.94	25.54	54.74

Source: Calculated

Table 3. Simulated Returns Treating Crop Insurance as an Investment

Insurance Coverage	Fair Premium	Certainty Equivalent Returns		Probability of a Loss		Amount of Subsidy
		Unsubsidized	Subsidized	Unsubsidized	Subsidized	
		$ per acre				$ per acre
50%	0.40	0.77	0.51	0.99	0.99	0.27
55%	0.92	1.09	2.49	0.98	0.98	0.59
60%	1.84	1.28	3.91	0.96	0.96	1.18
65%	3.73	1.25	5.30	0.94	0.94	1.99
70%	5.83	0.81	7.72	0.91	0.91	3.44
75%	9.56	-0.02	7.25	0.88	0.87	5.26
80%	14.96	-0.63	5.83	0.83	0.81	7.18
85%	23.34	-1.69	2.48	0.78	0.76	8.53

Table 4. Simulated Returns from Revenue Protection

		Certainty Equivalent Returns		Probability of a Loss		
Insurance Coverage	Fair Premium	Unsubsidized	Subsidized	Unsubsidized	Subsidized	Amount of Subsidy
		$ per acre				$ per acre
50%	1.43	1.82	3.74	0.98	0.98	0.96
55%	2.72	1.96	6.76	0.96	0.96	1.74
60%	4.83	2.10	8.48	0.94	0.94	3.09
65%	8.01	1.61	10.49	0.90	0.90	4.75
70%	12.43	0.60	13.30	0.87	0.87	7.53
75%	18.48	-0.26	15.04	0.83	0.82	10.16
80%	26.65	-1.14	14.94	0.79	0.78	12.79
85%	37.64	-2.47	11.67	0.74	0.72	14.30