Forward Contracts and Crop Insurance:
Should Premiums Be Adjusted For Risk Management Practice?

AAEA Annuual Meeting 2002

Jayashree Sil
jsil@are.berkeley.edu
Department of Agricultural & Resource Economics
207 Giannini Hall, University of California,
Berkeley, CA 94720

Forward Contracts and Crop Insurance: Should Premiums be Adjusted for Risk-Management Practice?

Current premium rate-making methodology for the government-sponsored Multiple Peril Crop Insurance (MPCI) program adjusts premium rates for farms engaging in certain cropping practices. These practices are production methods such as irrigation, fallow and double-cropping. Actuarial evidence has shown that such practices can separate farms into distinct risk classes. We suggest that risk-management tool is another category of practice which rate-making entities could consider to set premium rates that accurately reflect risk class. The present analysis shall focus on one risk management tool: cash forward contracts. Making this assessment requires use of the key actuarial concept of loss cost ratio.

The rate adjustment for a particular practice is made using a practice factor. The practice factor is calculated using loss cost ratios. This ratio measures, for a given time period and group of producers, the total indemnity payments made as a fraction of total liability. This ratio helps the insurer predict costs it can expect to incur in the form of indemnity payments.

If loss cost ratios differ in the presence of a particular practice, this gives justification for considering that practice in rate-making. We ask the question: are loss cost ratios lower for producers using forward contracts? Preliminary evidence suggests that indeed the loss cost ratio may be lower in the presence of forward contracts when corn, wheat and soybeans are the insured crops.

The biological basis for yield-enhancing effects of practices like irrigation and double-cropping are well-understood by rate-making entities. Given actuarial evidence for these practices, a practice factor can be appropriately set. We shall give one argument for the economic basis for yield-enhancing effects of cash forward contracts: incentives may lead to relatively high fertilizer use. [1]

---

[1] Note that here we do not present the optimization framework which delivers optimal input use and

First, we discuss how our analysis complements the literature on governement-sponsored crop insurance rate-making. Second, we shall briefly discuss how MPCI rates are set. We elaborate on the key concept of loss-cost-ratio that is used to set base rates and practice factors. Finally, we give some preliminary evidence in the form of descriptive statistics on loss probabilities and mean yields (which we use to make a rough calculation of loss cost ratios), and on fertilizer use. We then offer preliminary conclusions.

I. Selected Literature

Crop Insurance

Following passage of the 1995 Farm Bill, crop insurance has gained premier importance among government farm programs. Government-sponsored crop insurance programs in the United States, as well as in numerous other developed and developing countries, historically, have been plagued by low adoption rates and unsustainable program costs. Low adoption, frequently, is explained by producer preferences for alternative risk management tools: diversification, spreading sales, off-farm income and forward contracts. Excess program cost, frequently, is explained by adverse selection and moral hazard. Adverse selection occurs if premium rates do not accurately reflect risk class of insured parties. And, moral hazard occurs if the insured party does not take due care.

MPCI premium rates periodically undergo rate reviews with the objective of reducing program costs. Several government, academic and private entities have attempted to assess whether and why crop insurance program costs may be excessive. See the work of Josephson, Lord and Mitchell (2000) and Schnapp, Driscoll and Josephson (2000) for descriptions of rate-making, and that of Coble, Knight,

---

optimal forward contract choice. This is elaborated upon in Sil (2001).

Reference	Method	Conclusion on Insured Group
Horowitz and Lichtenberg	Selectivity-bias corrected input	high chemical use
Quiggin et al.	Joint input demand and yield	low yield
Coble et al.	Tobit on indemnity	excess indemnity
	Tobit on loss ratio	high loss ratio
Just et al.	Simulation of loss ratio	high loss ratio

Table 1: Empirical Studies on Crop Insurance

Pope and Williams (1997), Just, Calvin and Quiggin (1999), Horowitz and Lichtenberg (1993) and Quiggin, Karagiannis and Stanton (1993) for empirical analysis (summarized in table 1). A recent analytical model of Stohs (2000)questions the rationale behind increases in crop insurance subsidies, since effects can be to increase overall riskiness of insured producers if insurance gives the incentive to engage in production on low-quality high-risk land.

The empirical studies have been concerned about the effect of the insurance purchase decision on yield and input use. Horowitz and Lichtenberg (1993) find that fertilizer and pesticide use actually tend to be higher for those who insure. The selectivity bias-corrected input equation is specified with a dummy variable for insurance purchase. They interpret the coefficient on this dummy variable as a measure of moral hazard, since it would have to capture effects not taken account of by the selectivity-bias term. Quiggin et al. (1993) jointly estimate yield and input demand equations under the assumption of a Cobb-Douglas production function. Their specification uses a dummy variable to capture effects of insurance. They find that yields are lower for insured producers and that the result is moderately significant, and that input use is less for insured producers, but that the result is not significant. Coble et al. (1997) find that indemnity payments and loss ratios are excessive for the group of insured producers, particularly in years of very poor yield outcomes; they claim this to be evidence of moral hazard. Just et al. (1999) find that loss ratios are significantly higher for the group of insured producers. This, together with their finding that this group is characterized by different risk characteristics, leads them to conclude that the insurance program is characterized by adverse selection. A main conclusion of their analysis is that it is important to consider farm-specific characteristics in rate-making in order to make insurance purchases worthwhile for those low risk producers currently uninsured. The aim is to lower the overall risk in the pool of insured producers. This, then, provides our point of departure from the current literature.

In this study we wish to examine one type of observable heterogeneity (namely, forward contract use) that may be meaningfully used to differentiate premiums and thus to induce producers with low risk characteristics to purchase insurance. The data set used here offers a unique opportunity to complement this body of literature on crop insurance. Excess losses arise from faulty rate-making. Below, we explain why we require an analysis of loss-cost-ratios and of moments of conditional yield distributions.

II. Rate-Making

Rate-making for MPCI requires information on a producer's yield history, insurance experience of the county, surrounding counties and state, as well as producer-specific cropping practices (Josephson et al. 2000). A key concept is the loss-cost ratio (LCR).

Loss Cost Ratio

First, we need to define liability and value of production. Indemnity equals liability minus value of production, when this difference is positive. The premium charged a producer equals Liability x Rate x Adjustment factor. Rate is the base rate. A practice factor is a type of adjustment factor. The rate is determined with a formula that makes modifications to the county-level LCR. LCR is indemnity divided by liability. Liability can be expressed as:

$$A \cdot \beta \cdot \mu \cdot p_G$$

where A is acres planted, β is the coverage level (a percentage), μ is expected yield as determined by a producer's historical yield experience (called Actual Production History) and p_G is the price guarantee. Value of production can be expressed as:

$$A \cdot y \cdot p_G$$

where y is actual yield. Indemnities are paid out to a producer only when $y < \beta\mu$, so that the county LCR uses indemnity and liability summed over all producers within a county. Let $E(y|y < \beta\mu)$ be the mean yield in the left tail of the yield distribution, the average yield among those experiencing losses. Then, the LCR may be expressed as:

$$P[y < \beta\mu] \cdot (1 - \frac{E[y|y < \beta\mu]}{\beta\mu}). \tag{1}$$

Further elaboration is found in the appendix. Finally, then, from the above we see how LCR depends on $E[y|y < \beta\mu]$, the mean μ and the loss probability $\Pr[y < \beta\mu]$. All else equal, an increase in the loss probability causes an increase in the LCR. Likewise an increase in β or μ cause a fall in the LCR.

Practice Factor

A practice factor is calculated as practice-specific LCR divided by a combined LCR, which is the LCR regardless of practice (Josephson et al. (2000), Schnapp (2001)). The practice factor will have an effect on the premium if it differs from 1; this happens if the LCR in the presence of the practice differs from the LCR without the practice and if there is a sufficiently large proportion of producers using that practice. Again, the question of interest is: does evidence indicate that LCR in the presence of forward contract may be lower than the LCR in the absence of forward contract? This requires the calculation of loss probabilities and tail area expected values in presence and absence of forward contract. Next, we briefly state how we may analytically assess how LCR varies with forward contract use.

In order to know whether premiums should be adjusted, we need to know the sign of $\frac{\partial LCR}{\partial \alpha}$, where α is the share of total crop that is sold under forward contract. But, this derivative may be re-written as the product of two other derivatives, the analyses of which are more feasible: $\frac{\partial LCR}{\partial x} \cdot \frac{\partial x*}{\partial \alpha}$. The first derivative does not involve the optimization decision of the producer (his utility function, prices, contract terms, scale of operation or other income); it is entirely dependent on the properties of the yield distribution and level of insurance coverage, as will be seen below. The second derivative depends on many more interactions; it is analagous to a Marginal Rate of Substitution, since both input level and forward contract share are endogenous in the producer's optimization problem.

Sign of $\frac{\partial LCR}{\partial x*}$

Yield y is expressed $f(x) = h(x) + g(x)\epsilon$, where x is input and ϵ is a mean 0 disturbance. The function represents risk-increasing input if $g'(x) > 0$ and risk-decreasing input if $g'(x) < 0$. The expected value of y is $h(x)$ and the variance is $g(x)^2\sigma^2$, where σ^2 is the variance of ϵ. $g(x)\sigma$ is therefore the standard deviation of yield. We shall see that the sign of $\frac{\partial LCR}{\partial x*}$ depends critically upon $\frac{d\frac{h(x)}{g(x)}}{dx}$. This is the derivative of the ratio of the mean to standard deviation with respect to input use. The sign depends upon the sign of the difference:

$$h'(x) \cdot g(x) - h(x) \cdot g'(x).$$

We see that when $g'(x) < 0$, in the risk-decreasing case, this expression is always positive. Otherwise, when $g'(x) > 0$ the expression may be positive or negative. In this latter case, when it is positive, we call it weakly risk-increasing and when it is negative, strongly risk-increasing.

Now we shall assess the sign of the derivative $\frac{\partial LCR}{\partial x*}$. First, let us examine the expression for LCR, for the form of yield function chosen here.

$$P[h(x)+g(x)\epsilon < \beta\mu] - P[h(x)+g(x)\epsilon < \beta\mu] \cdot \frac{E[h(x)+g(x)\epsilon | h(x)+g(x)\epsilon < \beta\mu]}{\beta\mu}.$$

First note that the event $I[y < \beta\mu]$=$I[h(x) + g(x)\epsilon < \beta h(x)]$ which indicates a loss state (with yield below trigger level) can be expressed $I[\epsilon < \frac{h(x)}{g(x)}(\beta - 1)]$. Let $\epsilon* = \frac{h(x)}{g(x)}(\beta - 1)$. Then, taking $f(\epsilon)$ to be the continuous density of ϵ, LCR may be expressed:

$$\int_{-\infty}^{\epsilon*} f(\epsilon)d\epsilon - \frac{h(x)}{\beta h(x)} - \frac{1}{\beta}[\frac{g(x)}{h(x)}] \cdot [\int_{-\infty}^{\epsilon*} \epsilon f(\epsilon)d\epsilon]$$

Then, taking the derivative of this expression with respect to x and using Leibnitz rule, we see that the derivative is:

$$\frac{1}{\beta}(h'g - hg') \cdot [\frac{(\beta-1)^2}{g^2} f(\epsilon*) - \frac{(\beta-1)^2}{g^2} f(\epsilon*) + \frac{\int_{-\infty}^{\epsilon*} \epsilon f(\epsilon)d\epsilon}{h^2}]$$

This reduces to:

$$\frac{1}{\beta}(\frac{h'g-hg'}{h^2})\cdot[\int_{-\infty}^{\epsilon*}\epsilon f(\epsilon)d\epsilon]$$

We know that $0<\beta<1$ so that $\frac{1}{\beta}>0$ and $\beta-1<0$. Finally $\int_{-\infty}^{\epsilon*}\epsilon f(\epsilon)d\epsilon<0$. ϵ has mean 0, so that ϵ values in loss states are negative (they are all less than $\epsilon*$). Hence, their density-weighted sum is negative; the integral is unambiguously negative. Hence the sign of the derivative $\frac{dLCR}{dx}$ depends on the sign of $h'g-hg'$. For the risk-decreasing and weakly risk-increasing cases, $h'g-hg'>0$, so that $\frac{dLCR}{dx}<0$ For the risk-increasing case,$h'g-hg'<0$, so that $\frac{dLCR}{dx}>0$ Re-interpreting this latter case, we can say, LCR increases with input use when the elasticity of mean (with respect to input use) is less than elasticity of the standard deviation (with respect to input use).

III. An Empirical Assessment

Evidence in favor of the alternative hypothesis answers our question in the affirmative. The Null Hypothesis is that there is no difference in LCR between those who use forward contracts and those who do not, or that those with forward contracts exhibit higher LCR. If there is no difference, it means that it would make no difference to adjust premiums for the practice. If the difference is positive, the practice induces higher risk. One explanation for the latter might be that the income guarantee offered by a forward contract frees up resources for other activities, like off-farm employment. Less labor is used on farm and this may have deleterious consequences for yield distributions. However, evidence in favor of the alternative hypothesis might be explained by the fact that the obligation to deliver under forward contract induces high input use ($\frac{\partial x*}{\partial\alpha}$) We now make a preliminary empirical assessment using descriptive statistics.

Data

Farm-level data are from the 1996 Agricultural Resources Management Survey (ARMS). Soil Quality Data are from the USDA's Natural Resource Conservation Service, Map Unit Interpretation Records (MUIR) data base. 1996 commodity and fertilizer prices are from USDA's Agricultural Prices Summary for 1997. Precipitation data are from the National Climatic Data Center's 1996 Cooperative Summary of the Day data base. Grain elevator location capacity data are from the Burlington-Northern Santa-Fe (BNSF) Elevator Directory.

All ARMS data are at the individual farm-operator level. We limit our analysis to the group classified as cash grain farms. These operations obtain at least 50% of income from grain sales. We divide this group into four mutually exclusive groups: producers without insurance or forward contracts, producers with only insurance, producers with only forward contract and producers with both forward contract and insurance. A producer is considered to have a forward contract if he has at least one for either corn or wheat or soybeans. He may of course have multiple contracts for one or more commodities. The major grain commodities produced by these farms are corn, wheat and soybeans. 28% produce both corn and soybeans, 22% produce all three and 20% produce only wheat. The majority of cash grain farms (62%) produce some corn.

Commodity spot prices are taken as state-level cash price in the month of peak harvest for the particular crop and state. Fertilizer prices are available by fertilizer region, which overlap but do not coincide with the new ERS agro-climatic regions. Fertilizer may be applied in the pre-planting season, during planting season or during the growing season (USDA 1994). And, fertilizer uptake is influenced by soil moisture and quality. Many measures of soil quality exist. We use the measure called soil orgainic matter in the MUIR data base. Both soil quality and precipitation data are at the county-level. Planting and harvesting dates are known for 1996 (USDA 1997). Mean values of selected variables are presented in the appendix.

Presumably, access to grain elevators influences use of forward contracts as well. We use elevator location and capacity to allocate capacity to each county. This is done using GIS software. First the elevator locations are geo-referenced. The longitude and latitude coordinates are given in the BNSF directory. Then, we create a Voronoi tesselation with these points. What this does is create polygons around each elevator, such that every point in an elevator-polygon is closer to that elevator than any other. We then overlay county boundaries on the elevator polygons. Using elevator polygon areas which intersect with county areas, we are able to allocate elevator capacity to each county. This allocated capacity measures the access to elevators for farms in a county.

IV. Preliminary Results and Conclusions

Here we present estimates of $E[y|y < \beta\mu]$, μ and $Pr(y < \beta\mu)$ used to make a rough calculation of LCR. We give the estimates separately for corn, wheat and soybean yields because crop insurance is purchased for a particular crop and premiums are set separately for each crop a farmer insures. Crop Insurance actuarial tables for the Base Rate are derived by first converting lost cost ratios to a common coverage level β of 65% (Josephson et al. 2000). That is why we present the estimated LCRs for $\beta = 0.65$.

Estimated Practice Factors are presented in the last row of the table. This is calculated by taking the LCR for the group with insurance and forward contracts and dividing by the LCR for the insured group as a whole. So, for instance, for Corn, the Practice Factor is 0.79. This says that Premiums for corn for producers using a forward contract may meaningfully be set to levels that are about 20%

below (that is, about 0.8 times) that of the group of producers not using the contract. The magnitude is similar for Wheat and it is about 40% for soybeans. We did this calculation to derive Practice Factors using the LCR for group of producers with forward contracts (both with and without insurance) and the LCR for all producers. The resulting ratios were 0.55 for Corn, 0.78 for Wheat and 0.71 for Soybeans.

[2]

Conclusions

We have found some evidence in favor of our alternative hypothesis for the case of corn, wheat and soybeans. Premium rates for thsese crops therefore may be fruitfully adjusted downwards from 20% to 40% for producers using forward contracts.. From the summary statistics on labor we see that labor use in the pre-harvest months for corn and soybeans is lower for those using forward contracts (since $0.09 < 0.11$) [3]. This holds true for Wheat as well ($0.10 < 0.12$). And, we find that fertilizer applications at the whole farm level are in fact higher in the presence of forward contract (since $30 > 23.9$). See table 3.

In order to further understand the meaning of the magnitudes of Practice Factors, we show selected premium rates from the 1996 actuarial tables for corn and soybean insurance for Barnes County, North Dakota and Aitken county, Minnesota. See table 4. These examples are useful for at least two reasons. First, they permit us to get some notion of excess costs that might be incurred from faulty rate-making. And, second, we can get some notion of how close a factor can be to

---

[2] Fertilizer is the largest single component of variable costs for corn and wheat (USDA 1999). The survey collects information on farm total expenditure on fertilizer and soil conditioners; the variable used is this expenditure divided by total operated acres used for crop production.

[3] The survey asks for weekly hours of operator, spouse, partner (if a family corporation) and unpaid labor, for each of 4 quarters. The second quarter months (April- June), roughly, are the pre-harvest months for wheat. And, the third quarter months (July-September), roughly, are the pre-harvest months for corn and soybeans. It is input use pre-harvest which can give a measure of "care" taken.

Contract	Corn Yield	Wheat Yield	Soybean Yield
$\hat{Pr}(y < \beta\mu)$			
No Insurance or Forward Contract	0.17	0.25	0.12
Only Insurance	0.14	0.25	0.11
Only Forward Contract	0.05	0.19	0.08
Both Insurance and Forward Contract	0.09	0.17	0.07
Insured (with & without Forward)	0.12	0.21	0.09
$\hat{\mu}$			
No Insurance or Forward Contract	109	40	35
Only Insurance	120	37	37
Only Forward Contract	129	48	37
Both Insurance and Forward Contract	128	45	38
Insured (with & without Forward)	124	41	37.5
$\hat{E}[y \mid y < \beta\mu]$			
No Insurance or Forward Contract	47	18	17
Only Insurance	52	15	17
Only Forward Contract	68	21	18
Both Insurance and Forward Contract	55	21	20
Insured (with & without Forward)	53.5	18	18.5
LCR			
No Insurance or Forward Contract	0.06	0.08	0.03
Only Insurance	0.05	0.09	0.03
Only Forward Contract	0.01	0.06	0.02
Both Insurance and Forward Contract	0.03	0.05	0.01
Insured (with & without Forward)	0.04	0.07	0.02
Practice Factor	0.79	0.71	0.61

Table 2: Estimated Loss Cost Ratios (Coverage Level $\beta = 0.65$)

Contract	Fertilizer $\hat{x}^*_{im}$	April-June Labor	July-Sept Labor
No Insurance or Forward Contract	27.9	0.34	0.24
Only Insurance	23.9	0.12	0.11
Only Forward Contract	35.2	0.13	0.11
Both Insurance and Forward Contract	30.0	0.10	0.09

Table 3: Fertilizer ($)and Family Labor (Hrs/Wk) Per Operated Acre

1 and yet be considered by rate-making authorities to be worthy of consideration in differentiating premiums.[4]

In the case of North Dakota, for instance, we see that the implied practice factor for Irrigated Corn is 0.56 $(\frac{0.099}{0.175})$ and for Irrigated soybeans is 0.85 $(\frac{0.087}{0.102})$, for the medium yield risk class. That is, a producer insuring soybean crop with irrigation gets a base premium rate that is 15% lower than a producer insuring soybean crop with no irrigation. For Minnesota, actuarial evidence has informed rate-makers that irrigation practices do not differentiate producers into separate risk classes for the case of corn, but does for the case of soybeans. Note that the magnitudes of these implied practice factors are similar to those obtained in our preliminary analysis.

In order to get some notion of the magnitude of errors involved when rates are not adjusted to accurately reflect practice risk class, let us consider an example. Suppose a producer in Barnes county, North Dakota wishes to insure his soybean crop. Suppose, too, that he belongs to the medium yield risk class and wants an insurance contract with total liability for the insurer of $100,000. The table shows that the base premium rate for a producer using irrigation is 0.087 and that for a

---

[4] So as not to clutter discussion, we omit any reference to additional adjustment factors in these examples.

	Irrigated	Non-Irrigated	Implied Practice Factor	Irrigated	Non-Irrigated	Implied Practice Factor
	N. Dakota			**Minnesota**		
Yield Risk Class	(1)	(2)	(1) ÷ (2)	(3)	(4)	(3) ÷ (4)
	Corn					
High	0.199	0.414	0.48	0.330	0.330	1.00
Medium	0.099	0.175	0.56	0.132	0.132	1.00
Low	0.074	0.116	0.64	0.094	0.094	1.00
	Soybeans					
High	0.220	0.261	0.84	0.233	0.285	0.82
Medium	0.087	0.102	0.85	0.089	0.107	0.83
Low	0.054	0.062	0.87	0.053	0.063	0.84

Table 4: Selected Premium Base Rates and Practice Factors: N. Dakota and Minnesota

producer not using irrigation is 0.102. When insurance is actuarily fair, premiums are set equal to expected indemnities. So, here expected indemnity costs for the insurer, calculated as rate x liability, would be $8,700 with irrigation and $10,200 without irrigation. If use of the practice was un-accounted for in setting the premium, the producer might be charged the more favorable 0.087 or some average, say 0.095. Such faulty rate-making could result in excess costs in the amount of $700 (10,200 - 9,500) to $1,500 (10,200 - 8,700).

Our assessments using simple descriptive statistics are preliminary and the analysis must be refined further to get a more complete and accurate assesment.

References

Coble, Keith, Thomas Knight, Rulon D. Pope, and Jeffrey Williams, "An Expected Indemnity Approach to the Measurement of Moral Hazard in Crop Insurance," *American Journal of Agricultural Economics*, February 1997.

Horowitz, John and Erik Lichtenberg, "Insurance, Moral Hazard and Chemical Use in Agriculture," *American Journal of Agricultural Economics*, November 1993.

Josephson, Gary, Richard B. Lord, and Charles Mitchell, "Actuarial Documentation of Multiple Peril Crop Insurance Ratemaking Procedures," *Milliman and Robertson Inc.*, August 2000.

Just, Richard, Linda Calvin, and John Quiggin, "Adverse Selection in Crop Insurance: Actuarial and Asymmetric Information Incentives," *American Journal of Agricultural Economics*, November 1999.

Quiggin, John, Giannis Karagiannis, and Julie Stanton, "Crop Insurance and Crop Production: Empirical Analysis of Moral Hazard and Adverse Selection," *Australian Journal of Agricultural Economics*, 1993.

Schnapp, Frank F., "Personal Communication," *National Crop Insurance Services*, 2001.

____ **, James Driscoll, and Gary Josephson**, "Ratemaking Considerations for Multiple Peril Crop Insurance," *Milliman and Robertson Inc*, 2000.

Sil, Jayashree, "Forward Contracts and Crop Insurance: Should Premiums be Adjusted For Risk Management Practice?," *Dissertation Research Prospectus*, July 2001.

Stohs, Stephen, "Risky Business: the Unintended Consequences of Federal MPCI Subsidies," *mimeo*, 2000.

USDA, *Agricultural Resources and Environmental Indicators*, 1994.

____ , *Usual Planting and Harvesting Dates for U.S Field Crops*, December 1997.

____ , *Agricultural Income and Finance*, September 1999.

Appendix

Loss Cost Ratio

Indemnities are paid out to producer i only when $y^i < \beta\mu$. For simplcity let μ and p_G be the same for all producers. Losses are said to occur when $A^i y^i < A^i \beta\mu$. The A^i cancel and the condition for loss state is $y^i < \beta\mu$. Let $I(y^i < \beta\mu)$ equal 1 if yield falls below the trigger level and 0 otherwise. The LCR is:

$$\frac{\sum I(y^i < \beta\mu) A^i \beta\mu - \sum I(y^i < \beta\mu) A^i y^i}{\sum A^i \beta\mu,}$$

Now, we take the liberty of going from a simple summation to a probability weighted summation. If we take area and yield to be independent, LCR can be re-expressed as:

$$P[y < \beta\mu] \cdot (1 - \frac{E[y|y < \beta\mu)]}{\beta\mu}).$$

To see how this is true, consider an example with discrete support. Let $A^i \in \{A_1, A_2, A_3, A_4\}$ and $y^i \in \{y_1, y_2, y_3\}$. Let the marginal distribution of A_j be $Pr(A_1) = Pr(A_2) = Pr(A_3) = Pr(A_4) = \frac{1}{4}$ and that of y_k be $Pr(y_1) = Pr(y_2) = Pr(y_3) = \frac{1}{3}$. Given independence of y_k and A_j, $Pr(A_j \cdot y_k) = Pr(A_j \cap y_k) = Pr(A_j)Pr(y_k) = \frac{1}{4} \cdot \frac{1}{3}$. Now, for illustration, suppose $y_1 < \beta\mu$ and $y_2 < \beta\mu$. Here, 8 out of 12 producers incur losses, with yield y_1 or y_2, across all 4 acreage levels. The above expression can be derived from collapsing the following expression:

$$\frac{2 \cdot (\sum A_j)\beta\mu - (\sum A_j)(y_1 + y_2)}{3 \cdot (\sum A_j)\beta\mu}$$

where $j \in 1, 2, 3, 4$. This then equals:

$$\frac{\frac{2}{3} - \frac{(\sum A_j)(y_1 + y_2)}{3}}{\beta\mu}$$

where $\frac{2}{3}$ is just $Pr(y < \beta\mu)$. Finally, then, in general, this just equals:

$$P[y < \beta\mu] - P[y < \beta\mu] \cdot \frac{E[y|y < \beta\mu]}{\beta\mu}.$$

Characteristic	No Forward No Insurance	Only Insurance	Only Forward	Forward & Insurance
Number of farms	331	895	119	556
Percent of sample	17	47	6	29
Total Operated Acres	798	1614	1464	1808
Crop Income ($1000)	107	173	234	321
Livestock Income ($1000)	14	23	23	24
Off-farm Income ($1000)	3	5	5	6
Age (years)	54	52	47	48
Crop Insurance Premiums				
Basic Catastrophic	0	1000	0	≈ 1000
Additonal "buy-up"	0	2000	0	4000
Crop Sales ($1000)				
Cash Corn	38	52	50	55
Cash Wheat	14	39	13	22
Cash Soybean	30	37	42	47
Contract Corn	0	0	32	66
Contract Wheat	0	0	29	22
Contract Soybean	0	0	43	56
Crop Prices ($ per Bushel)				
Cash Corn	2.98	2.99	2.92	2.98
Cash Wheat	4.72	4.87	4.61	4.80
Cash Soybean	7.00	6.99	7.02	7.03
Contract Corn			3.23	3.19
Contract Wheat			4.44	4.47
Contract Soybean			7.18	7.19
Government Income ($100)	117	219	209	320
CCC	12	40	21	63
Deficiency Payment	3	3	15	0.5
Fair Act Payments	94	149	160	240
Indemnity Payments	7	41	5	31
Debt and Assets ($1000)				
Assets (Buildings & Equipment)	154	244	304	344
Debt	70	142	131	212

Table 5: Selected Mean Characteristics of Sample Farms