Influence of the Premium Subsidy on Farmers' Crop Insurance Coverage Decisions

Bruce A. Babcock and Chad E. Hart

Working Paper 05-WP 393
April 2005

Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011-1070
www.card.iastate.edu

Bruce Babcock is a professor of economics at Iowa State University and director of the Center for Agricultural and Rural Development (CARD). Chad Hart is a research scientist at CARD and the U.S. policy and insurance analyst in the Food and Agricultural Policy Research Institute (FAPRI) at Iowa State University.

For questions or comments about the contents of this paper, please contact Bruce Babcock, 578 Heady Hall, Iowa State University, Ames, IA 50011-1070; Ph: 515-294-6785; Fax: 515-294-6336; E-mail: babcock@iastate.edu.

Abstract

The Agricultural Risk Protection Act greatly increased the expected marginal net benefit of farmers buying high-coverage crop insurance policies by coupling premium subsidies to coverage level. This policy change, combined with cross-sectional variations in expected marginal net benefits of high-coverage policies, is used to estimate the role that premium subsidies play in farmers' crop insurance decisions. We use county data for corn, soybeans, and wheat to estimate regression equations that are then used to obtain insight into two policy scenarios. We first estimate that eventual adoption of actuarially fair incremental premiums, combined with current coupled subsidies, would increase farmers' purchase of high-coverage policies by almost 400 percent from 1998 levels across the three crops and two plans of insurance included in the analysis. We then estimate that a return to decoupled subsidies would decrease farmers' high-coverage purchase decisions by an average of 36 percent.

Keywords: Agricultural Risk Protection Act, crop insurance, premium subsidies.

INFLUENCE OF THE PREMIUM SUBSIDY ON FARMERS' CROP INSURANCE COVERAGE DECISIONS

The Agricultural Risk Protection Act (ARPA) of 2000 is the latest in a series of steps by Congress to increase the proportion of U.S. crop risk that is borne by the crop insurance program. To accomplish this, ARPA set up mechanisms to increase the development of new crop insurance products and to induce farmers to buy more insurance. The primary inducement was an end to the rule that largely decoupled crop insurance subsidies from farmers' selected coverage levels. Before ARPA, the Risk Management Agency (RMA) of the U.S. Department of Agriculture (USDA) kept the dollar amount of premium subsidies constant for all coverage levels between 65 and 85 percent, with per acre subsidies dropping for coverage levels below 65 percent. This constant subsidy was accomplished by making the ratio of subsidy rates at different coverage levels inversely proportional to the associated premium rates. In other words, crop insurance subsidies were decoupled from a farmer's choice of coverage over this range.[1]

A cursory examination of the data seems to suggest that the overwhelming farmer response to decoupled subsidies was to minimize the amount they had to spend in order to obtain the maximum fixed premium subsidy. In 1998, of the 75.6 million acres insured at a coverage level of at least 65 percent under the government's Actual Production History (APH) yield insurance program, only 13.6 percent of acres were insured at a coverage level greater than 65 percent.

Standard models of decisions under risk imply that risk-averse farmers will purchase full insurance if their insurance is actuarially fair (expected indemnities equal to premium). That such a small percentage of farmers purchased more insurance than was necessary to obtain the maximum per acre subsidy seems to suggest that their primary motivation for buying insurance was to maximize profits. Using panel data from 1989, Just, Calvin, and Quiggin (1999) come to this exact conclusion. They write: "Surprisingly, risk aversion appears to be a minor part of the incentive to participate" (p. 847).

Given the relatively small size of the crop insurance program in 1989, it seems reasonable to ascertain whether the Just, Calvin, and Quiggin conclusions still hold. After all, the incidence of adverse selection is likely much lower now because participation rates are so much higher. In 2004, 77 percent of corn acres, 89 percent of cotton acres, 78 percent of soybean acres, and 77 percent of wheat acres were insured. The corresponding participation rates in 1989 were 42, 32, 34, and 39 percent.

The contributions we make with this paper are as follows. Using both pre- and post-ARPA county-level data for corn, soybeans, and wheat, we estimate how farmers' coverage level decisions are influenced by the degree to which the incremental cost of higher coverage levels is subsidized. We use actual average insurance premiums charged and simulate expected indemnities to calculate the percent subsidy. We test whether the influence of the subsidy on coverage level decisions varies by crop and insurance plan. We then use regression equations to predict what coverage levels would be purchased under two scenarios. The first scenario applies ARPA subsidies to the actuarially fair incremental costs to estimate where crop insurance coverage levels are likely to settle once a new set of premium rates are fully implemented by USDA. We compare this set of estimates to average coverage levels in 2004 for validation of the regression equations. The second scenario is when per acre subsidies are decoupled from coverage levels and premiums are set so that the incremental costs of insurance coverage above the 65 percent level are set at actuarially fair levels. The analysis begins with a presentation of the incremental benefits and costs of crop insurance.

Incremental Net Benefits of Crop Insurance Coverage

Most U.S. crop farmers choose the amount of insurance to purchase by choosing a percentage of an estimate of their expected yield for the APH program or expected revenue for revenue insurance coverage. For most crops, coverage is available in 5 percent increments from 50 to 85 percent. Throughout the 1990s, three to four times as many acres were insured at the 65 percent level as were insured at higher coverage levels. Very few acres were insured at less than the 65 percent level until eligibility for commodity program payments was made contingent on participation in the crop insurance program in 1995. (See, for example, Figure 1 in Babcock, Hart, and Hayes 2004.)

One of the policy objectives of ARPA was to induce farmers to buy more insurance coverage in which one measure of "more insurance" is the proportion of acres insured at some level greater than 65 percent. This measure is the one that we adopt. Of course, a more exact measure could be obtained by specifying the proportion of farmers who purchase at each coverage level. But this would require reporting on the results from a multinomial choice model that would give little additional insight into the policy issues addressed here.

The key factor in determining whether a farmer chooses to purchase more than the 65 percent coverage level is whether the benefits of higher coverage exceed the costs of higher coverage. Of course, costs and benefits will vary according to the exact coverage level chosen, but given that premium costs and expected insurance indemnities at different coverage levels are highly correlated, good indicators of incremental costs and benefits for higher coverage levels are those that occur at a single coverage level. For this analysis, we select the 75 percent coverage level for our measure of incremental costs and benefits.

For now, we abstract from any risk benefits that crop insurance might provide to a farmer and focus on expected profits from the program. We hypothesize that if expected profits at the 75 percent coverage level are greater than expected profits at the 65 percent coverage level, then a farmer will choose the 75 percent coverage level. Of course, this is a sufficient condition for any risk-averse farmer to move to 75 percent coverage as well because we are giving zero weight to any risk benefits from insurance.

Assuming that output prices, expected yields, and production costs are independent of the insurance coverage level, the change in expected profits is given by the difference in expected indemnities (I) and producer-paid premiums (PP) at the 75 and 65 percent coverage levels:

$$\Delta\pi = \mathrm{E}(I_{75}) - \mathrm{E}(I_{65}) - (PP_{75} - PP_{65}) = \Delta I - \Delta PP. \qquad (1)$$

If premiums are actuarially fair and unsubsidized, then $\Delta\pi = 0$. But premiums are subsidized and Babcock, Hart, and Hayes (2004) demonstrated that even if 65 percent premiums are actuarially fair, 75 percent premiums are too high for most farmers. Thus we need to account for both subsidies and actuarial fairness in determining $\Delta\pi$.

Incremental Costs of Crop Insurance Coverage

To estimate ΔPP in equation (1) requires an accounting of the actual subsidies and premiums charged. ARPA changed the subsidy structure but not the premium structure, so we need to estimate ΔPP both before and after ARPA. Denoting 65 and 75 percent premium rates (premium divided by liability) as rate65 and rate75, the premium subsidy rates at 65 and 75 percent as psub65 and psub75, a farmer's APH yield as Y, and the insurance price as p, the change in the producer premium for the APH plan of insurance is

$$\Delta PP = (1 - psub75)*rate75*p*0.75*Y - (1 - psub65)*rate65*p*0.65*Y. \qquad (2)$$

Both before and after ARPA, 75 percent premium rates (dollars of premium per dollar of liability) for the APH program for corn, soybeans, and wheat equal the 65 percent premiums multiplied by the constant 1.538. Therefore,

$$\Delta PP = p*Y*rate65*(1.538*0.75*(1- psub75) - 0.65*(1 - psub65)), \qquad (3)$$

which under pre-ARPA conditions equals approximately $0.5*p*Y*rate65$. After ARPA, premium subsidy rates were increased from 41.7 to 59 percent for 65 percent coverage and from 23.5 to 55 percent for 75 percent coverage. Thus ΔPP^{post} is approximately $0.25*p*Y*rate65$, which demonstrates that ARPA cut the incremental cost of moving to 75 percent coverage in half for all U.S. corn, soybean, and wheat farmers.

The ARPA-induced reduction in incremental cost does not imply that all farmers found that expected profits immediately increased under ARPA when they purchased higher coverage levels. As pointed out in Babcock, Hart, and Hayes, crop insurance premium rates increase too rapidly with coverage level in most regions of the country. For those farmers who faced these high rates, the drop in incremental insurance cost from ARPA simply meant a closer balance between costs and benefits of higher coverage levels, not necessarily an increase in expected profits.

Incremental Benefit of Crop Insurance Coverage

To a risk-neutral producer the incremental benefit of crop insurance coverage is the change in expected indemnities, ΔI, that will be received. Clearly ΔI will be positive because for any given loss, the magnitude of the indemnity will grow as coverage increases and the frequency with which a claim will be made will, in general, be greater.

For actuarially fair premium rates,

$$\Delta I = p^*Y^*(0.75^*rate75 - 0.65^*rate65). \quad (4)$$

Coble, et al. (2002), in an unpublished empirical examination of the actuarial fairness of crop insurance rates, conclude that there is a strongly negative relationship between actuarially fair 65 percent rates and the ratio of actuarially fair 75 to 65 percent rates. Babcock, Hart, and Hayes demonstrate that such a negative relationship must exist if yields are generated by a well-behaved probability distribution. But crop insurance rates for APH and Crop Revenue Coverage (CRC) were, until quite recently, based on constant rate relativities. That is, the premium rate for 75 percent coverage was set equal to a constant factor multiplied by the premium rate for 65 percent coverage. Clearly such an assumption will tend to overestimate ΔI in high-risk areas and perhaps underestimate ΔI in low-risk areas.

Figure 1 shows the relationship between simulated ΔI, expressed as a percent change, and 65 percent premium rates. The simulations assume that yields follow a beta density. The relationship between the change in indemnities and 65 percent base rates illustrated in Figure 1 is quite robust across alternative functional forms for the yield distribution. Thus, we employ the Figure 1 relationship to estimate ΔI.

Data

What we want to estimate is how farmers' coverage level purchase decisions are affected by the net benefits from higher coverage. The independent variable in the relationship is the change in expected profits (expressed as a percentage of the change in expected indemnities) obtained by moving to 75 percent insurance coverage. The dependent variable will be the number of acres insured at a coverage level greater than 65 percent divided by the number of acres insured at 65 percent or higher coverage levels. Throughout this paper, we will refer to crop insurance at or above the 65 percent coverage level as buy-up insurance.

The number of insured acres at each coverage level for all insurance products is available from RMA's *Summary of Business Report* publications. For this analysis, we obtained insured acres for corn, soybeans, and wheat for 1998 and 2002. These two years

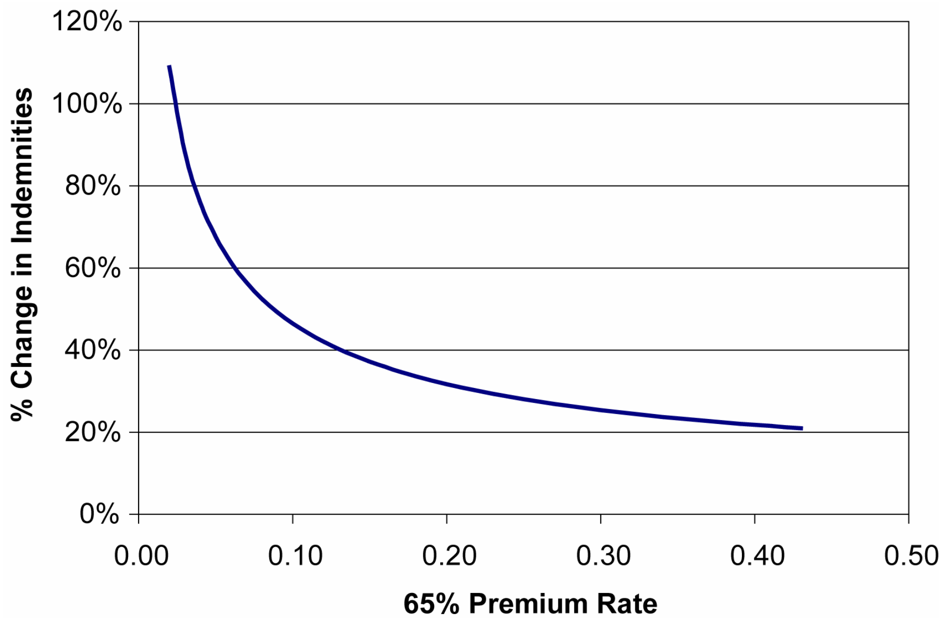

FIGURE 1. Increase in expected indemnities from moving to 75 from 65 percent coverage

were selected for a number of reasons. ARPA was passed in June of 2000. Its subsidy provisions went into effect immediately, but farmers had already made their decisions about which coverage level to purchase so there would be little or no impact from ARPA in 2000. We could have selected crop year 2001 data but experience with crop insurance provisions suggests that it takes time for the industry to learn about significant changes in policy. Insurance agents must be notified and trained, quoting software must be adjusted, and then farmers must be made aware of the impacts of change. Hence, the 2002 data should more fully reflect awareness of the ARPA policy changes and subsequent changes in coverage levels.

We could also extend the analysis to 2003 and 2004 crop year data, but then we would not have a ceteris paribus change in subsidy levels. Beginning with the 2003 crop year, RMA began to implement a new set of premium rates and surcharges at higher coverage levels. Thus we would have to account for the confounding effects of these changes.

We chose not to use 1999 data because a special 25 percent premium reduction program was implemented late in the crop insurance sign-up period. This program reduced producer-paid premiums by an additional 25 percent. Undoubtedly some proportion of agents and their farmer clients were aware of this program, but many were not. Thus, assuming that all farmers made their 1999 coverage level decisions with full information would be incorrect. The 25 percent premium reduction program was also in place in 1998, but it was announced after farmers had made their crop insurance decisions. Thus, we can assume that 1998 decisions reflect their prior knowledge about premium and subsidy rates.

Table 1 provides a summary of the acreage data for the two crop insurance programs with premium rates that were based on constant rate relativities in 1998 and 2002. As is readily apparent, the proportion of acres insured above 65 percent under the APH plan of insurance relative to all acres insured with buy-up insurance increased dramatically over this period. Of course, one would expect this type of response because of the 50 percent drop in the cost of incremental coverage. Also apparent is that there was a dramatic shift in acreage to CRC between 1998 and 2002. Part of this switch occurred because CRC was more widely known and available in 2002 than in 1998. But part of the reason is likely due to the change in CRC subsidies because of ARPA.

Before ARPA, CRC premium subsidies were limited to the per acre amounts available under APH. After ARPA, the same subsidy rates were applied to the full CRC premium. Because CRC premiums are proportionate to the 65 percent premium rates for APH and

TABLE 1. Share of acres insured at different coverage levels

	APH		**CRC**	
	1998	**2002**	**1998**	**2002**
Corn				
< 65%	18,315,168	10,023,815	606,167	1,299,162
65%	16,968,857	4,743,560	7,359,291	4,308,534
> 65%	3,236,315	4,147,485	2,784,919	15,707,193
Share > 65%*	16%	47%	27%	78%
Soybeans				
< 65%	19,196,259	12,894,083	512,576	493,708
65%	13,139,644	6,731,213	6,361,680	1,787,981
> 65%	2,633,019	15,036,483	2,223,009	7,757,582
Share > 65%*	17%	69%	26%	81%
Wheat				
< 65%	16,080,981	6,489,865	396,641	1,353,613
65%	21,398,984	5,368,095	4,210,962	5,456,146
> 65%	1,917,366	4,592,073	310,259	11,859,205
Share > 65%*	8%	46%	7%	68%

Source: Summary of Business Report from RMA: http://www3.rma.usda.gov/apps/sob/.
*Acreage at greater than 65% divided by acreage at or greater than 65%.

because CRC uses the same APH rate relativities, ARPA decreased the incremental cost of moving from 65 to 75 percent CRC coverage by the same 50 percent proportion as the decline in APH. However, because CRC premiums are greater than APH premiums, the per acre amount of subsidy available under CRC is now greater. This increased amount of subsidy may explain part of the large movement of business toward CRC.

The summary statistics in Table 1 suggest that we are likely to find that the decline in the incremental cost in moving to higher coverage levels due to ARPA resulted in an increase in the proportion of acres insured at higher coverage levels under APH and CRC. However, we do not rely solely on the change in subsidies under ARPA to estimate how coverage level decisions are affected by expected profits. We also exploit the tremendous cross-section variation in expected profits from higher coverage levels.

As shown in Figure 1, the percent change in expected indemnities as one moves from 65 to 75 percent coverage depends on the degree of risk, as represented by the 65 percent premium (expected indemnity). But the percent change in the premium charged for 75 percent coverage under APH and CRC is a constant, as can be easily verified by the expressions for ΔPP^{pre} and ΔPP^{post} given earlier. This means that the percent change in expected profits obtained from 75 percent coverage is greatest for low-risk farmers and is lowest for high-risk farmers.

Figures 2 and 3 illustrate the tremendous variation in riskiness of corn and soybean production in the United States. Wheat shows a similar range. Therefore, we have the ability to use cross-sectional variation as well as two years of time variation in expected profits to estimate the role that the pursuit of expected profits plays in determining coverage levels.

As previously discussed, our estimates of the change in expected profits depend on knowledge of the degree of yield risk. With both APH and CRC in 1998 and 2002, increases in yield risk result in proportionately lower benefits and proportionately constant costs. Thus, the proportionate change in expected profits from moving to 75 percent coverage is inversely related to yield risk.

Clearly there exists variation in yield risk among fields and among farmers within a county. One could use observations on individual farmer decisions about coverage level, modeling it as a 0-1 decision depending on whether a farmer purchased 65 percent

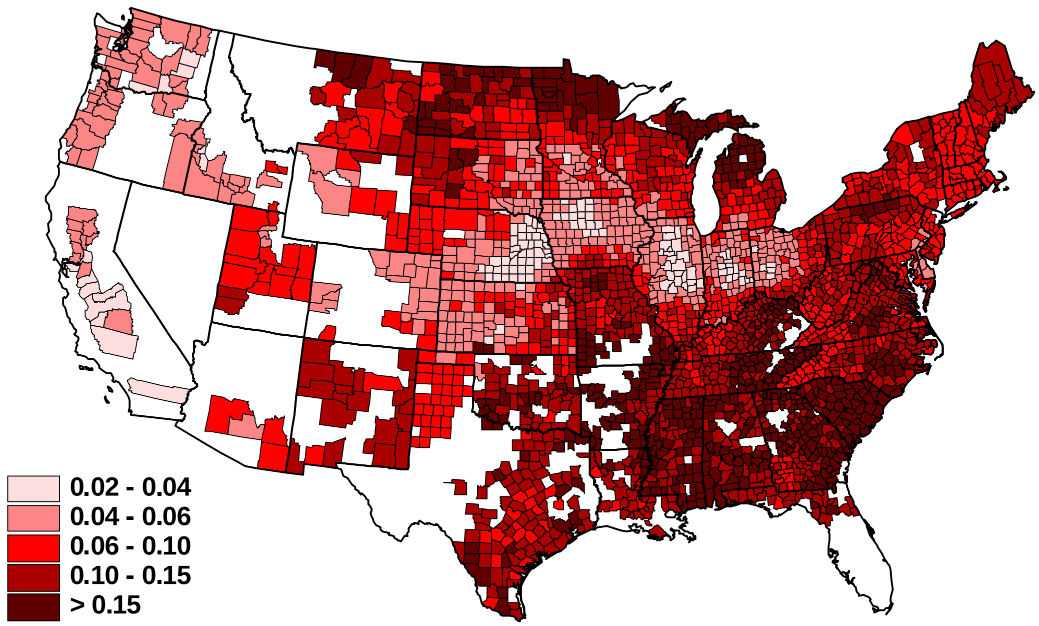

FIGURE 2. APH premium rates of 65 percent for corn for the 2002 crop year

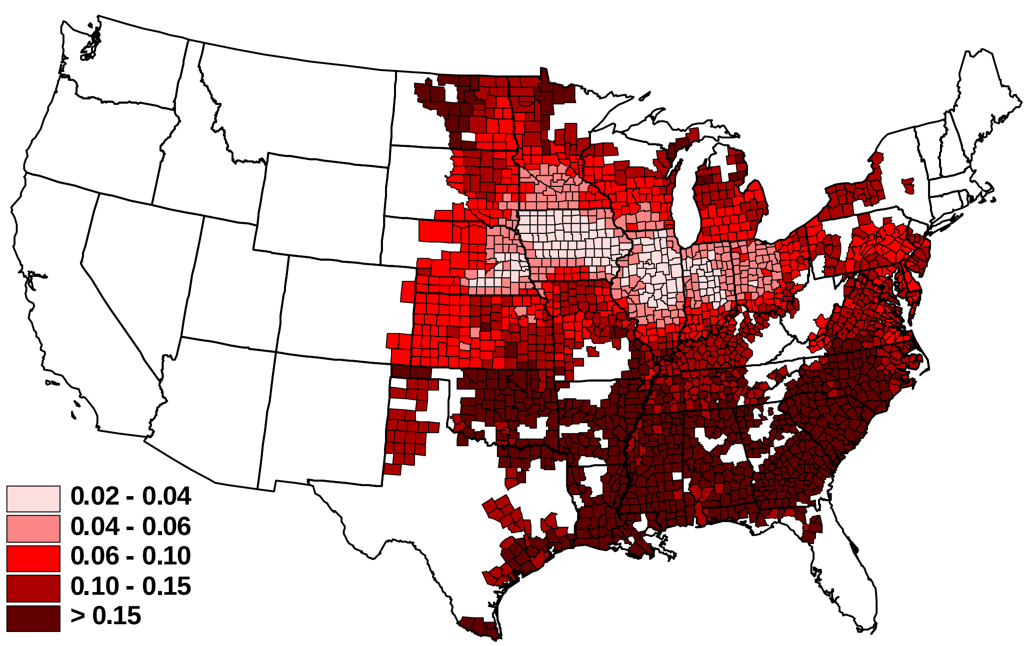

FIGURE 3. APH premium rates of 65 percent for soybeans for the 2002 crop year

coverage or higher coverage. Such an analysis would be complicated by the sheer number of insured farmers. Reducing the number of observations would require a sampling procedure that would result in an adequate data set.

An alternative is to rely on the extensive variation in yield risk across counties, as shown in Figures 2 and 3, and to aggregate individual farmer decisions into a county decision variable. This more aggregate approach models how county average changes in expected profits from higher crop insurance coverage levels influence the average coverage decision in a county. The following procedure was used to estimate the average change in expected yield profits at the county level.

RMA reports total premium and total liability by county, crop, and coverage level. Thus, for each coverage level we can measure the average premium rate for the county by dividing total premium by liability. Our goal is to measure the average yield risk of farmers in a county who purchase coverage of at least 65 percent. We will measure the amount of yield risk by the average 65 percent premium rate charged to those farmers in the county. The data in Table 1 show that a significant amount of acreage is insured at coverage levels greater than 65 percent, so we do not want to restrict our measure to only those who insured at 65 percent. The procedure that we used to measure the average 65 percent rate for those producers who purchased at least 65 percent coverage is best explained with an example.

Table 2 presents 2002 corn data for Cass County, Illinois, for APH. At each coverage level, the average rate is calculated by dividing total premium by total liability. The average rate at each coverage level is then converted to the corresponding average 65 percent rate by dividing it by the appropriate rate relativity factor. These rate relativity

TABLE 2. Data for Cass County used to calculate average 65 percent premium rates

Coverage Level (%)	Insurance Plan	Insured Acres (acres)	Total Liability ($)	Total Premium ($)	Average Rate	Average 65% Rate
65	APH	2,446	456,555	28,563	0.0626	0.0626
70	APH	113	21,138	1,269	0.0600	0.0494
75	APH	341	75,912	4,590	0.0605	0.0393
80	APH	36	8,525	651	0.0764	0.0391
85	APH	0	0	0	na	na

Source: Summary of Business Report from RMA: http://www3.rma.usda.gov/apps/sob/.

factors are 1.0 for 65 percent coverage, 1.215 for 70 percent coverage, 1.538 for 75 percent coverage, 1.954 for 80 percent coverage, and 2.462 for 85 percent coverage. The result of this multiplication is reported in the last column in Table 2. The average 65 percent rate is then calculated by talking the acreage-weighted average of the results in the last column. In this example, the average rate is 0.0591. This is a bit higher than the 0.052 rate that would be charged a farmer in Cass County in 2002 if the farmer had an APH yield equal to the reference yield of 120 bu/ac.

Given this estimate of the average rate, we can estimate the average expected gain from moving to 75 percent coverage. Using the beta distribution that generated the rates in Table 4 in Babcock, Hart, and Hayes (2004), the actuarially fair 75 percent premium rate is 0.0825.[2] Then, using the earlier expressions for ΔI and ΔPP^{post}, we have ΔI = 0.02346*p*Y and ΔPP^{post} = 0.014927*p*Y. Thus, the change in expected profits is 0.008533*p*Y. We normalize this change in expected profits by dividing through by our estimate of ΔI. The result then represents the change in expected profits as a percent subsidy. In this example, the result is 0.36, or in other words, the change in expected profit amounts to a 36 percent subsidy.

Before moving to a discussion of how we estimate the change in expected profit for CRC, it is instructive to calculate the percent subsidy for Cass County before ARPA. Assuming that the average 65 percent premium rate in 1998 was 0.0591, the change in expected profit is -0.006296*p*Y, which translates into a -27 percent subsidy. That is, Cass County farmers were being asked to pay 27 percent more than the actuarially fair incremental cost for 75 percent coverage in 1998. This switch from a 27 percent tax to a 36 percent subsidy creates a large incentive for the average farmer in Cass County to switch coverage levels.

Calculating the change in expected profits from higher coverage levels with CRC is more difficult than with APH because the CRC rating structure contains three separate components (yield risk, revenue risk, and price risk) and a portion of the change in expected indemnities is due to price variability. However, examination of the relationship between 65 percent APH base premium rates and CRC premium rates at the 65, 75, and 85 percent coverage levels reveals an exact linear relationship, which is shown in Figure 4. Thus we can use the average premium rates for CRC at different coverage levels to

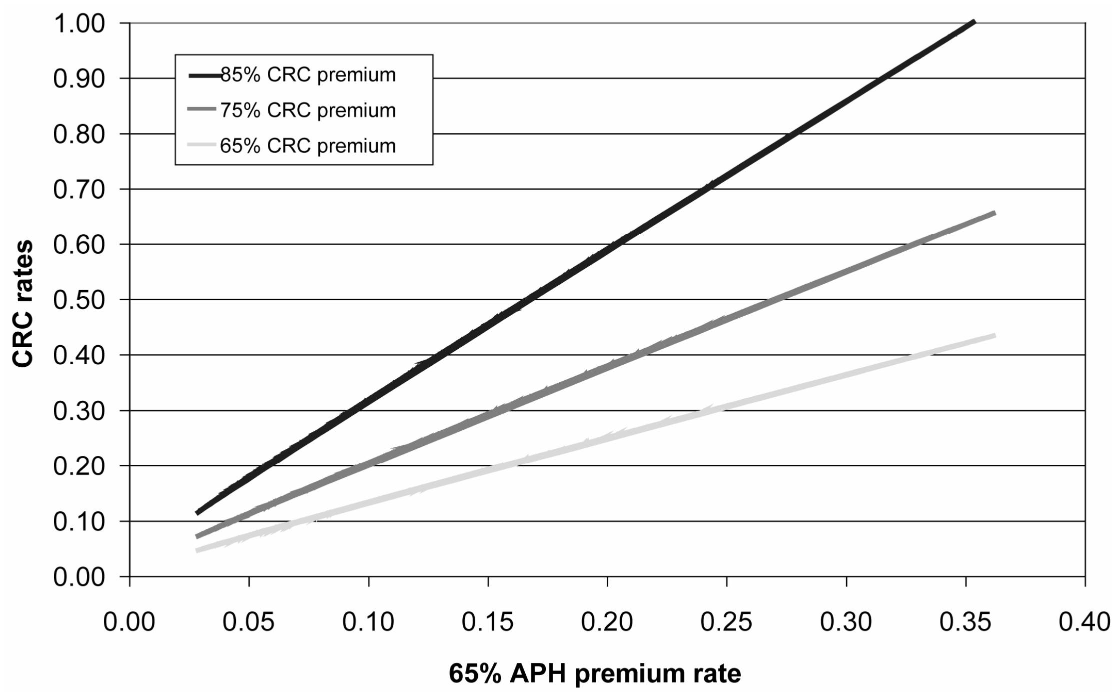

FIGURE 4. Predicting CRC premium rates with 65 percent APH premium rates

reveal the average underlying 65 percent APH premium. This underlying 65 percent APH premium rate can then be used to calculate ΔPP^{pre} and ΔPP^{post}. What remains is how to calculate ΔI for CRC.

Because CRC premiums use the same constant rate relativities that are used to rate APH, we know that they cannot be used to calculate ΔI. What is needed is an independent measure of ΔI that is based on a revenue distribution, much like we used to calculate ΔI for APH.

The rating equations for Revenue Assurance can be used to estimate ΔI for CRC coverage. The coverage provided by Revenue Assurance with the harvest price option is nearly identical to CRC, and the current rating equations are based on Monte Carlo integration of revenue draws as discussed in Babcock and Hennessy 1996. The rating equations were estimated by regressing the results of many Monte Carlo simulations on the level of rating variables that vary across the simulations. The rating variables included are price volatility, APH premium rate, APH yield divided by a county's reference yield, and coverage level. A quadratic functional form is used. Separate rating equations were estimated for different assumed levels of price-yield correlation. But because negative correlation does not significantly affect ΔI for CRC, we take the Revenue Assurance rating equation used for Iowa for corn and use it for all states and crops. Table 3 provides the rating equation coefficients.

This regression equation is used to estimate the change in expected indemnities under CRC using the equation $\Delta I = p*Y*(0.75*rate75 - 0.65*rate65)$ where *rate*75 and *rate*65 denote premium rates using the Revenue Assurance rating equation. Given these pieces of information, we constructed the average by which higher coverage was subsidized by county for corn, soybeans, and wheat for the 1998 and 2002 crop years.

Table 4 presents the average percent subsidy by crop and year for the sample. Before ARPA, the incremental cost of higher coverage was substantially more than the incremental benefit. That is, farmers received a negative subsidy for increased coverage. This negative subsidy results from per acre premium subsidies being decoupled with respect to coverage level combined with the fixed rate relativity factor. The coupled subsidies under ARPA dramatically lowered the incremental cost of increased coverage, resulting in almost actuarially fair incremental CRC incremental premiums and a net average positive subsidy for producers who purchased higher coverage levels of APH insurance in 2002. Of course, as illustrated in Figures 1 and 2, there is tremendous cross-sectional variation

TABLE 3. Revenue Assurance rating equation used to estimate expected indemnities

Variable	Coefficient
Intercept	-0.096525
APH 65% rate	1.393955
APH 65% rate^2	-0.653385
Coverage	-0.052425
Coverage^2	0.273246
Yield ratio	0.074885
Yield ratio^2	0.001167
Price volatility	-0.312273
Price volatility^2	0.269246
Coverage x APH 65% rate	-0.226561
Yield ratio x APH 65% rate	0.043532
Price volatility x APH 65% rate	0.503837
Coverage x yield ratio	-0.110972
Coverage x price volatility	0.515275
Price volatility x yield ratio	-0.032282

TABLE 4. Average percent subsidy by crop, insurance plan, and year (%)

	1998 (Pre-ARPA)		2002 (Post-ARPA)	
Crop	**CRC**	**APH**	**CRC**	**APH**
Wheat	-85	-72	-7	16
Corn	-61	-66	-1	17
Soybeans	-84	-63	-11	18

in the net subsidy received for buying higher coverage levels, with those farmers in low-rate counties receiving dramatically higher percent subsidies than those in high-rate counties. We next show how we combine this cross-sectional variability with the variability in subsidies brought about by ARPA.

The Model

Under our premise, insurance participation at coverage levels above 65 percent is driven by the percent subsidy producers receive in changing from 65 percent coverage to a higher level of coverage. For our dependent variable, we have chosen the proportion of buy-up insured acres with coverage levels above 65 percent. This ratio is limited to be between 0 and 1. Given this censored data, traditional regression analysis would not be appropriate. The statistical technique used in the analysis should account for this censoring. We have chosen to use a two-limit Tobit procedure for this work. This technique will account for the censoring at both ends of the (0, 1) interval and maintain predictions within the interval.

The model equation is given by

$$
\begin{aligned}
Y_t &= X_t{*}\beta + u_t && \text{if } 0 < X_t{*}\beta + u_t < 1 \\
&= 0 && \text{if } X_t{*}\beta + u_t \leq 0 \\
&= 1 && \text{if } X_t{*}\beta + u_t \geq 1 \quad \text{for } t = 1, 2, \ldots, T
\end{aligned}
\tag{5}
$$

where Y_t is the proportion of buy-up insured acres with coverage levels above 65 percent, X_t is a vector of independent variables, β is a vector of coefficients, and u_t is an error term. The errors are assumed to be independently distributed with a zero mean and a constant variance of σ^2. After examining scatter plots of the data, we decided to utilize a linear and quadratic term for the percent subsidy as part of the vector of independent variables. Given the combination of crops and insurance plans we are examining, we tested whether the regression parameters varied by insurance plan or by crop. Table 5 contains the likelihood ratio test results comparing these various combinations. The likelihood ratio test compares the log-likelihoods of competing models. The test statistic follows a χ^2 distribution with the degrees of freedom equal to the difference in the number of regressors in the model. In all cases, the results from the pooled estimates are rejected. Thus, we estimated independent equations by crop and insurance plan.

Given the results in Table 5, separate regressions are run for each crop-insurance plan combination. The regression equation is

$$\text{(Proportion of Buy-Up Insured Acres with Coverage above 65 percent)}_t \\ = \beta_0 + \beta_1\text{*(Percent Subsidy)}_t + \beta_2\text{*(Percent Subsidy}^2)_t + u_t. \tag{6}$$

The results from the separate regressions are given in Table 6. Only the quadratic terms in the wheat-APH equations are not statistically significant; all other estimates are significant at the 1 percent level. In all cases, the percent subsidy has an increasingly positive impact on the proportion of buy-up insurance beyond 65 percent coverage.

Model Prediction

Given the structure of the model, the prediction mechanism must account for the censoring of the data at zero and one. Following Greene (1990, p. 738), predicted values from a two-limit Tobit model can be computed as

$$\hat{Y} = U + L*\Phi(z_L) - U*\Phi(z_U) + [\Phi(z_U) - \Phi(z_L)]*X*\beta + \sigma*[\varphi(z_L) - \varphi(z_U)] \tag{7}$$

TABLE 5. Likelihood ratio tests

Model	Log-Likelihood	Number of Regressors	Test Value	Degrees of Freedom	Probability
No Pooling	-10,512	18			
Pooling by:					
Insurance Plan	-11,995	9	2,966	9	0.00
Crop	-10,766	6	508	12	0.00

TABLE 6. Tobit regression estimates

Crop	Ins. Plan	β_0	β_1	β_2	σ
Wheat	CRC	0.6530	0.9349	0.0774	0.5306
		(0.0146)	(0.0334)	(0.0058)	(0.0121)
Wheat	APH	0.2637	0.4172	0.0207	0.4363
		(0.0093)	(0.0228)	(0.0191)	(0.0176)
Corn	CRC	0.5953	1.0650	0.2302	0.3677
		(0.0082)	(0.0286)	(0.0200)	(0.0064)
Corn	APH	0.2108	0.5942	0.1676	0.3572
		(0.0070)	(0.0174)	(0.0141)	(0.0056)
Soybeans	CRC	0.7256	0.9188	0.1946	0.3673
		(0.0102)	(0.0270)	(0.0138)	(0.0069)
Soybeans	APH	0.2862	0.6796	0.2087	0.3107
		(0.0065)	(0.0156)	(0.0122)	(0.0050)

Note: Standard errors are reported in parentheses below the estimates.

where $\hat{Y}$ is the predicted value, U is the upper censoring point, L is the lower censoring point, $\Phi(.)$ is the standard normal cumulative distribution function, $z_L = \sigma^{-1}*(L - X*\beta)$, $z_U = \sigma^{-1}*(U - X*\beta)$, and $\varphi(.)$ is the standard normal probability density function. Table 7 contains the average predicted values for the proportion of buy-up insurance coverage above the 65 percent coverage level and the actual values. The model predictions are fairly consistent with the actual results. There can be little doubt that the increased premium subsidies under ARPA helped push producers to choose higher level of insurance coverage.

TABLE 7. Predicted versus actual values

		Predicted		Actual	
Crop	Insurance Plan	Pre-ARPA (1998)	ARPA (2002)	Pre-ARPA (1998)	ARPA (2002)
		----------------	---------------(%)---------------	----------------	
Wheat	CRC	21.63	56.47	15.85	60.07
Wheat	APH	18.06	38.10	16.50	36.84
Corn	CRC	20.87	58.08	17.82	62.53
Corn	APH	12.75	36.82	9.00	38.54
Soybean	CRC	23.90	61.48	20.49	66.91
Soybean	APH	15.41	44.84	9.93	49.66

Note: Values are simple averages across all counties for which crop insurance data is reported.

To explore the effects of ARPA further, Figures 5 and 6 show how the predicted percent buy-up varies with the percent subsidy for APH and CRC, respectively. Immediately one can see why the hypothesis of constant regression parameters across insurance plans was rejected. For a given percent subsidy, farmers who purchase CRC have a much greater incidence of buying higher coverage levels. For example, a 20 percent subsidy induces approximately 70 percent of CRC acreage to be insured at a coverage level greater than 65 percent but only 35 percent of APH acreage. One explanation for this difference may be that farmers who select CRC are more interested in insuring against price movements. The likelihood that a price movement will trigger an indemnity at the 65 percent coverage level is much lower than the likelihood that farm yields will drop by 35 percent. Also, Figure 4 and 5 show that although we reject constant parameters across crops, there is a great deal of similarity to how the coverage level increases with subsidies across the three crops. As shown, increasing the subsidy from -20 percent to 20 percent increases the percent buy-up from approximately 23 percent to 40 percent for the three crops under APH and from 48 percent to 76 percent for CRC.

We now want to use these regression equations to predict what would happen to the percent buy-up under two scenarios, both involving premium rates that better reflect the incremental indemnities that would occur at higher coverage levels. In the first scenario, producers face actuarially fair underlying premium rates that better reflect incremental costs but still enjoy ARPA-style premium subsidies. This scenario is what the RMA is currently striving to achieve through annual premium rate adjustments. In the second scenario, producers face the correct incremental costs, but they receive no marginal premium subsidies, as would be the case under no subsidies or a lump-sum subsidy.

Table 8 contains the predictions under the two scenarios, along with the actual values for the 2004 crop year. Under the first scenario, most counties would receive an increase in subsidies relative to their 2002 levels because the 2002 incremental premium rates are greater than actuarially fair levels. The regression model predicts that corn CRC buy-up would increase from the actual 62 percent level (see Table 7) to 90 percent. Soybean buy-up under CRC would increase from 67 percent to 92 percent, and wheat CRC would increase from 60 percent to 83 percent. For APH, we predict that corn would increase from its actual 2002 level of 37 percent to 53 percent, soybeans would move from

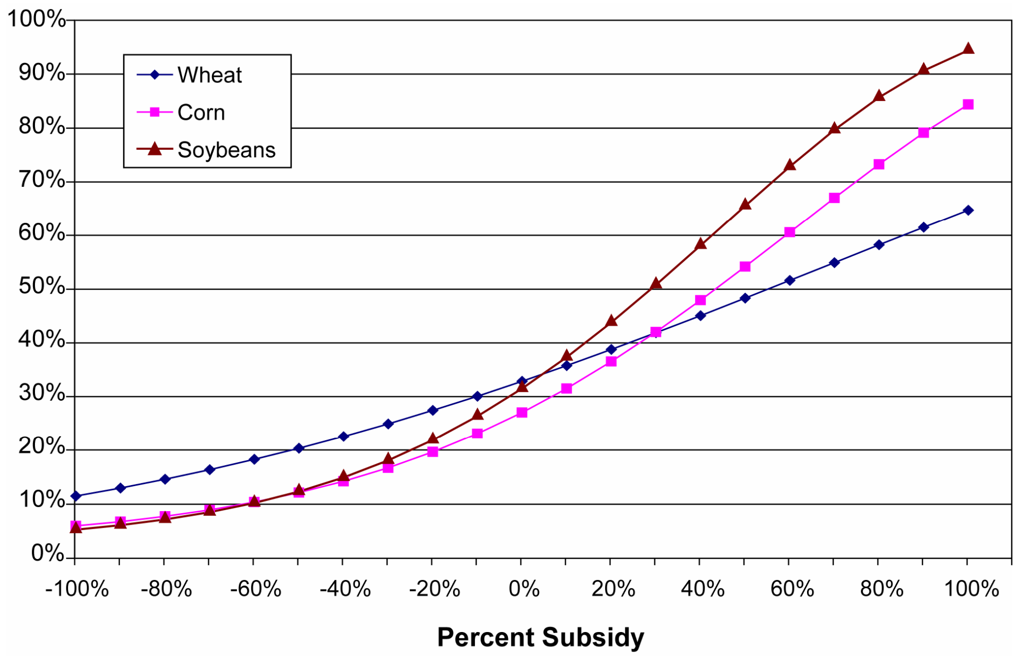

FIGURE 5. Predicted percent buy-up for APH

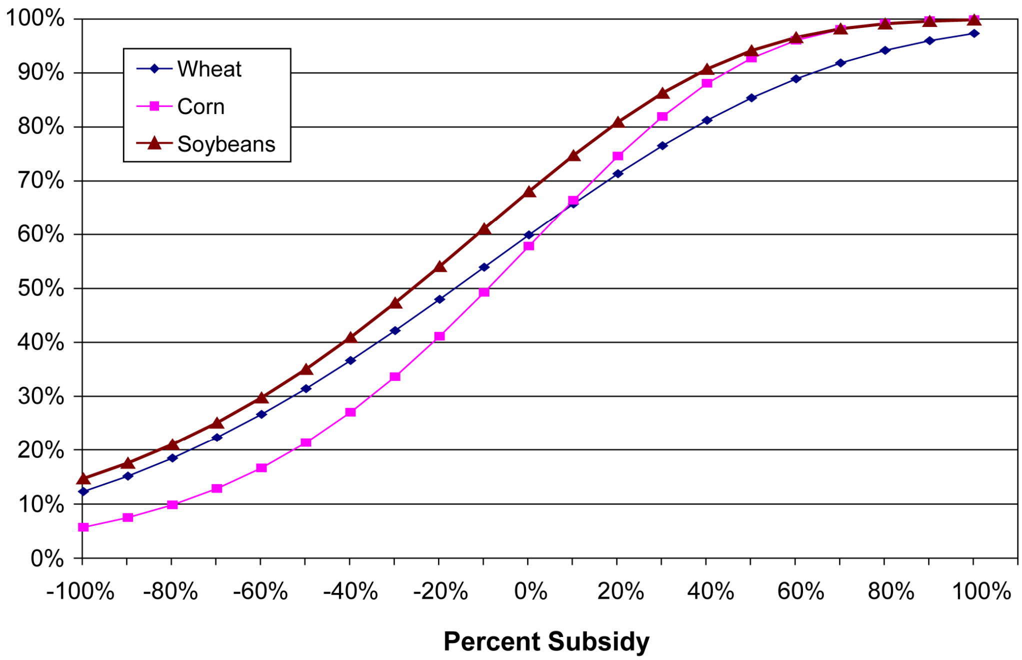

FIGURE 6. Predicted percent buy-up for CRC

TABLE 8. Predicted values from scenarios and 2004 actual values

Crop	Insurance Plan	Predicted: Correct Rates, ARPA Subsidies	Predicted: Correct Rates, No Subsidies	Actual 2004
		-----------------------------%---------------------------		
Wheat	CRC	82.89	59.90	69.04
Wheat	APH	47.14	32.85	47.82
Corn	CRC	90.30	57.82	84.81
Corn	APH	51.94	27.03	52.90
Soybean	CRC	91.96	68.05	82.21
Soybean	APH	62.98	31.51	55.75

Note: Values are simple averages across all counties for which crop insurance data is reported.

50 percent to 63 percent, and wheat would move from 60 percent to 69 percent. As Congress and the RMA look to spur continued use of insurance at higher coverage levels, these results suggest that the premium rate adjustments that RMA is currently implementing may be a productive place to start. The effects of these changes made in 2003 and 2004 are reflected in the 2004 results in Table 8. As shown, percent buy-up in 2004 is greater than the level in 2002 for both CRC and APH for all crops.

The second scenario removes the marginal premium subsidies. Under this scenario, the profit-maximizing reason for increasing coverage level is removed, as the incremental percent subsidy is zero. Risk-averse producers would still purchase higher coverage levels, whereas risk-neutral producers would be indifferent. The results show that the predicted proportion of buy-up insurance acres with coverage above 65 percent would fall dramatically below 2004 actual levels. Approximately 60 percent of CRC acres would be insured at greater than 65 percent and only 30 percent of acres insured under APH would be insured at levels above 65 percent. This suggests that the profit-maximizing reason for purchasing crop insurance is rather strong, possibly driving up to nearly half of the participation at the higher coverage levels.

Policy Implications and Conclusions

The results of this analysis suggest that by subsidizing higher coverage levels, Congress was successful in achieving its policy objectives of inducing farmers to buy crop insurance coverage at greater than the 65 percent coverage level. The acres of corn, soybeans, and wheat insured at more than 65 percent coverage relative to acres insured at

65 percent and greater coverage levels more than doubled because of ARPA. As we show, the primary effect of the increased premium subsidies was to neutralize the large disincentive that producers in most counties faced when choosing whether to buy higher coverage levels. This disincentive was that the incremental cost of the additional coverage far exceeded the incremental benefits. The ARPA subsidies more closely balanced incremental costs and subsidies in most counties and farmers responded accordingly.

One could argue that Congress needed to pass the subsidies to correct this disincentive. But RMA is currently correcting this disincentive through adjustments in its rating procedures. We estimate that insurance buy-up will increase substantially over 2004 levels once RMA fully implements its adjustments if the ARPA subsidies are left in place. Of course, one justification for the ARPA subsidies will disappear after the rate adjustments are done. We estimate that buy-up acreage would decrease significantly if Congress moved back to decoupled subsidies.

Endnotes

1. It would not be accurate to claim that the entire crop insurance program was decoupled because farmers had to participate in the program and they had to buy at least 65 percent coverage to obtain the fixed amount of premium subsidy.

2. This 75 percent premium rate is a reasonable estimate of an actuarially fair rate if the 65 percent premium rate is actuarially fair and if marginal moral hazard is insignificant.

References

Babcock, B.A., C.E. Hart, and D.J. Hayes. 2004. "Actuarial Fairness of Crop Insurance Rates with Constant Rate Relativities." *American Journal of Agricultural Economics* 86: 563-75.

Babcock, B.A., and D. Hennessy. 1996. "Input Demand Under Yield and Revenue Insurance." *American Journal of Agricultural Economics* 78: 416-27.

Coble, K., B. Goodwin, A. Ker, and T. Knight. 2002. "Rate Review Analysis: Report for External Review." Unpublished report written for the Risk Management Agency, U.S. Department of Agriculture. December.

Greene, W.H. 1990. *Econometric Analysis*. New York: Macmillian Publishing.

Just, E.R, L. Calvin, and J. Quiggin. 1999. "Adverse Selection in Crop Insurance: Actuarial and Asymmetric Information Incentives." *American Journal of Agricultural Economics* 81: 834-49.

Risk Management Agency (RMA). Various. *Summary of Business Report.* U.S. Department of Agriculture. www.rma.usda.gov/FTP/Reports/Summary_of_Business/sumbtxt.zip (accessed April 2005).