The Impact of the Average Crop Revenue Election (ACRE) Program on the Effectiveness of Crop Insurance

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Introduction

After prolonged discussions and negotiations, the Farm, Nutrition and Bioenergy Act of 2007 (also known as 2007 Farm Bill) was finally passed and signed into law in May of 2008. While the provisions of the Act address a wide variety of issues, one of the critical changes from the risk management prospective became introduction of the Average Crop Revenue Election (ACRE) program. The ACRE program is a revenue-based plan designed as an alternative to government support programs such Counter-Cyclical Payments (CCPs) that were introduced in the 2002 Farm Bill.

Generally speaking, CCPs become effective when the average market price for the covered commodity falls below the target national price. A shortcoming of the CCP is that it only addresses price risk and is not based on the crops or acres actually being grown by the farmer each year. The ACRE program is designed to address these problems by keying the payments off the benchmark state yield multiplied by the ACRE guarantee price for a specific commodity.

The payoff of ACRE program depends on realizations of state-level revenues and thus may be related to the payoffs of other risk management instruments available to farmers, such as crop revenue coverage (CRC) and to a lesser extent the actual production history (APH) insurance contracts. Since the decision to switch to ACRE is irreversible, understanding the full effect of ACRE on producer's risk exposure is an important factor in making the decision.

Vedenov and Power analyzed the effect of government support programs on risk-reducing effectiveness of crop insurance instruments under the provisions of 2002 Farm

Bill and the versions of 2007 Farm Bill being discussed at the time. In particular, they investigated the hypothesis that a combination of (free) government price support programs and yield insurance may provide risk reducing benefits comparable to those of revenue insurance for the crop/region combinations characterized by low correlation between prices and yields. They found partial support of this hypothesis for corn production in Texas under the provisions of 2002 Bill and one of the intermediate versions of the 2007 Farm Bill.

However, the ACRE program adopted in the final version of the 2007 Farm Bill turned out to be substantially different from the intermediate alternatives. This paper attempts to address this issue and analyze the effect of the ACRE program on risk-reducing effectiveness of insurance products. To the best of our knowledge this is a first attempt to analyze the effect of ACRE program on the risk management decisions of crop producers. In particular, we compare the risk-reducing effectiveness of two most common insurance contracts — APH and CRC — under the provisions of the 2002 Farm Bill and under ACRE program for representative cotton producer in Texas and corn producer in Illinois. These particular crop/region combinations are selected so as to represent situations of low and high price-yield correlations, respectively.

The rest of the paper is organized as follows. The next section discusses related literature and presents a formal decision model of a representative farmer followed by a section outlining stochastic simulation methodology and data. The results are presented and discussed next. The last section concludes.

Analytical Model

The model used for the present analysis is similar to that of Vedenov and Power. In particular, we consider a representative farmer who grows a single crop (cotton in Texas or corn in Illinois), receives payments from any government programs she is eligible for, and may purchase either a yield or a revenue insurance contract. The analysis includes the direct, counter-cyclical, and loan-deficiency payments (DP, CCP, and LDP, respectively) as well as yield and revenue insurance contracts (APH and CRC). The brief descriptions of the programs and their payoffs are summarized in Appendix A.

Average Crop Revenue Election

The ACRE program is triggered by the state-level revenue dropping below a guaranteed level which is defined as a product of the benchmark yield and an ACRE guarantee price. The benchmark state yield, y_{ACRE}, is determined as the Olympic average[1] of the actual state yields for the previous five years and the ACRE guaranteed price, y_{ACRE}, is the simple average of the national marketing year price for the previous two years. Switching to ACRE is an irreversible decision for the duration of the Farm Bill. Furthermore, producers who choose to elect the ACRE program must forgo the CCP payments and accept a 20 percent reduction in direct payments and a 30 percent reduction in marketing assistance loan rates.

More formally, the payoff of the ACRE program is defined as

$$ACRE = 0.833 \times \alpha \times \max(0, \min(y_{ACRE} p_{ACRE} - y_{State}\, p_{MYA}, 0.25 y_{ACRE}\, P_{ACRE})) \times \frac{\bar{y}_{farm}}{y_{ACRE}},$$

[1] i.e. the average of values remaining after the highest and lowest observations are dropped

where a is the acreage planted under a crop, y_{State} is the realized state average yield as determined by the National Agricultural Statistical Service (USDA/NASS), p_{MYA} is the realized marketing year average price, and $\overline{y}_{farm}$ is the Olympic average of farm-level yields for the most recent five years (Zulauf, Vitale and Dicks, 2008). In addition, the payoff of the direct payment in Appendix A needs to be multiplied by 0.8, while the payoff of the LDP is replaced by

$$LDP_{ACRE} = a \times y_{farm} \times \max(0.7 \times p_{LDP} - p, 0).$$

Scenario Comparison

In order to evaluate the effect of ACRE on effectiveness of crop insurance contracts we constructed a representative farmer's final wealth under four scenarios reflecting the possible combinations of two insurance contracts — APH and CRC —with 2002 and 2008 Farm Bills. Formally

$$W_{APH,2002} = W_0 + py_{farm} + LDP + DP + CCP + APH - a \times Premium\,(\eta_{APH})$$

$$W_{CRC,2002} = W_0 + py_{farm} + LDP + DP + CCP + CRC - a \times Premium\,(\eta_{CRC})$$

$$W_{APH,ACRE} = W_0 + py_{farm} + 0.8DP + LDP_{ACRE} + ACRE + APH - a \times Premium\,(\eta_{APH})$$

$$W_{CRC,ACRE} = W_0 + py_{farm} + 0.8DP + LDP_{ACRE} + ACRE + CRC - a \times Premium\,(\eta_{CRC})$$

where, W_0 is an initial wealth, a is planted acreage, *Premium* is per-acre insurance premium for a corresponding insurance contract with selected coverage level, and the payments are expanded in Appendix A.

Measuring Risk-Reducing Effectiveness

The four scenarios were compared using the expected utility framework. In particular, the representative farmer was assumed to prefer an alternative that maximized the CRRA power utility function $U(W;\gamma) = \frac{W^{1-\gamma}}{1-\gamma}$. In particular, the expected utility optimization was used to determine the optimal coverage level for each insurance product under the provisions of both Farm Bills.

Data and Simulation Methodology

Following Vedenov and Power, we used the Monte-Carlo simulations combined with the copula approach to simulate the distributions of the net wealth and corresponding expected utilities. The approach is briefly outlined below. A more complete overview of copulas and specific details of simulation methodology can be found in Cherubini, Luciano and Vecchiato; Nelsen; and Vedenov and Power.

For the purposes of the analysis, historical yield data at national, state, county and farm level were used along with data on cash, marketing year average (MYA), and futures prices for cotton and corn. Given the shortness of farm-level data, the primary joint distribution modeled was that of futures prices and county-level data. Frank copula was used to model the dependence structure. The choice of this particular copula is justified by the desire to have clearly defined tail dependence typically observed between yields and prices. The functional form of the Frank copula is

$$C_F(u, v; \alpha) = -\frac{1}{\alpha} ln\left\{1 + \frac{(e^{-\alpha u} - 1)(e^{-\alpha v} - 1)}{e^{-\alpha} - 1}\right\},$$

where α is a parameter that can be estimated from data (Nelsen, 2006).

The copula was combined with kernel density estimate of the marginal distribution of state-level yields y_{state} and log-normal marginal distribution of harvest-time futures prices f_1 and used to generate Monte-Carlo draws of the pairs $(y_1 state, f_1 1)$. As in Vedenov and Power, the local cash prices, p, and the marketing year average prices, p_{MYA} were modeled as linear functions of the harvest-time futures prices f_1. The latter were also used as proxy for the CRC harvest price, p_{Harv}. In particular, we estimated

$$p = b_0 + b_1 f_1 + \varepsilon , \qquad where \ \varepsilon \sim N(0, \sigma^2)$$

$$p_{MYA} = b_0^{MYA} + b_1^{MYA} f_1 + \varepsilon^{MYA} , \qquad where \ \varepsilon^{MYA} \sim N\left(0, \sigma_{MYA}^2\right)$$

The realizations of the county and farm-level yields were then generated from the realizations of the state-level yields using the Frank copula and kernel-density estimates of the corresponding marginal distributions.

Model Parameters

To implement the analysis, data were collected for a number of price and yield variables. Data for cash and market year average prices were collected from NASS for the time period 1969-2007. To approximate cash prices, we used the average prices received by producers in November (cotton) and October (corn). Futures price data were obtained for the time period 1970-2008 from the Chicago Board of Trade (CBOT) in the case of corn and from the Intercontinental Exchange, formerly New York Cotton Exchange, in the case of cotton.

The Risk Management Agency (RMA) provides guidelines to determine the planting-time futures price f_0 and the CRC base price P_{CRC}. For cotton, we use the average of the futures price during the period 1/15 to 2/15, while for corn we use the average of the futures price in February. Moreover, we approximated both the harvest-time futures price f_1 and the CRC harvest price P_{Harv} using the average futures price in November for both cotton and corn.

The parameters of the normal distribution in the harvest-time futures price equation were obtained from the sample mean and standard deviation of the data series for $d \ln f$. Indeed, test results showed that we could not reject the null of normality for $d \ln f$ at the 90% confidence level. We then ran a regression of cash and market year prices on $d \ln f$ to estimate the model parameters.

To compare the risk-reducing effectiveness of APH and CRC insurance combined with government payments under ACRE and under the previous 2002 Farm Bill (DP, LDP, CCP) , we considered three regions, namely: irrigated and non-irrigated cotton production in Texas and corn production in Illinois. Irrigated cotton production is expected to stabilize yields, which are then less correlated with national prices than in the case of no irrigation. Illinois is the largest corn-growing state in the country. Yields in Illinois tend to be highly correlated with national prices.

We considered representative farms located in Hockley County, Texas, for irrigated cotton and Hale County, Texas, for non-irrigated cotton, and Piatt County, Illinois, for corn. These counties were selected because they are representative for their states. Each farm was assumed to consist of 100 acres, all of which were treated as base acres for the purposes of government payments. Initial wealth (W_0) was set to $50,000 for all three regions.

Yield data at the county, state and national levels were collected from the National Agricultural Statistical Service (NASS) for the time period 1969-2007, while farm-level yield data were obtained from Texas AgriLife Research for Hale County, Texas (87 observations), Hockley County, Texas (18 observations) and Piatt County, Illinois, (545 observations). Then, we converted farm-level data into multiplicative shocks on the corresponding country yields. We fitted a log-linear trend to county, state and national yield series, and converted all observations to multiplicative shocks on the trend. The base trend year is 2007 because it is the most recent year for which all data are available.

Tables 2 and 3 summarize the descriptive statistics of the historical data used in the analysis. If we consider the correlation between detrended county yields and futures prices (in log-differences), we see that it is high for Piatt County, Illinois, low for the no-irrigated region of Hale County, Texas, and very low for the irrigated region of Hockley County, Texas.

The Risk Management Agency (RMA) and Farm Service Agency (FSA) websites (RMA; FSA) provide information to determine the parameters of the government payments and insurance programs in the base year 2007. These are summarized in Table 4. To simplify, we used the 1998-2001 averages to set the DP and CCP yields. Details on the ACRE programs were obtained from Zulauf and applied to the base year. We set APH price election to 100%. The RMA premium calculator was used to determine the actual APH and CRC premiums across levels of coverage and for specific counties in 2006.

The reference risky payoff *x* was defined as net wealth free of government support. We considered risk premiums of 0%, i.e., risk neutrality, 5% and 10%. Table 1 summarizes information about the coefficient of risk aversion γ that corresponds to each risk premium level. The coefficient of risk aversion, for a given risk premium, is highest for Hockley County, TX, where cotton production is irrigated. It is 9.45 for a 5% risk premium and 33.24 for a 10% risk premium. Risk aversion is lower for Piatt County, IL, and lowest for Hale County, TX.

Results

This section discusses results obtained for the certainty-equivalent wealth based on various levels of coverage. For the parameters of both the 2002 Farm Bill and the ACRE program, we consider APH and CRC contracts together with government payments. The results, presented in table 5, show that to achieve the greatest possible reduction in risk, the highest available coverage level should be selected. Indeed, the expected utility of wealth for a producer is for the most part increasing in the level of coverage. Note that the producer, assuming risk-neutrality, nonetheless selects more coverage than the minimum level, particularly in Hockley County, TX, and in Piatt County, IL. This is because the insurance premiums are not actuarially fair. Figures 1, 2 and 3 show, for Hale and Hockley County, TX, and Piatt County, IL, respectively, the certainty-equivalent wealth across insurance contract coverage levels for the case of a 10% risk premium.

The parameters of the 2002 Farm Bill appear to generate greater certainty-equivalent wealth than does the ACRE program, at least in the case of the Hale and Hockley Counties, TX. This may be explained by difference in price-yield correlations. Indeed, our results show that contracts are more effective under the 2002 Farm Bill for both Texas counties, but are less effective for Piatt County, IL. Lastly, for the case of a risk-averse producer, CRC insurance appears to be a more efficient instrument to manage risk than APH insurance in all counties studied. One explanation for this finding is that the CRC base price is allowed to increase during the period between planting and harvest, while APH contract prices, established by the FCIC, are fixed during this period.

Conclusion

The purpose of this paper is to compare the impact on the effectiveness of crop insurance of the new ACRE government support program with the previous, 2002 Farm Bill program. Four cases are considered: APH vs. CRC insurance and ACRE program vs. the 2002 Farm Bill programs. Three representative geographical regions are considered: cotton in Hale County (non-irrigated) and Hockley County (irrigated), TX, and corn in Piatt County, IL. Our findings suggest that under both the 2002 Farm Bill provisions and the ACRE program parameters, CRC insurance is more effective than is APH insurance. The effectiveness of insurance under the ACRE program appears to be more variable across the studied counties than is the effectiveness of insurance under the 2002 Farm Bill.

Appendix A. Description and Payoffs of Government Support Programs and Insurance Contracts

The following provides a brief overview of the government payments and insurance contracts used in the paper. More details and most up-to-date information can be found on the websites of Farm Service Agency (www.fsa.usda.gov) and Risk Management Agency (www.rma.usda.gov) of USDA.

Direct Payments (DP)

Direct payment is a fixed amount paid to the farmers according to the formula

$$DP = 0.85 a_{base} \times y_{DP} \times p_{DP}$$

where p_{DP} is the direct payment rate, y_{DP} is the base yield, and a_{base} is base acres.

Loan Deficiency Payments (LDP)

LDP is equivalent to a marketing assistance loan and is essentially a free put option on crop price. The payment is calculated as

$$LDP = a \times y_{farm} \times \max(p_{LDP} - p, 0),$$

where a is planted acreage, y_{farm} is realized yield, P is the commodity price, and p_{LDP} is the marketing loan rate.

Counter-Cyclical Payments (CCP)

CCPs were authorized by the 2002 Farm Bill and provide income support whenever the market price falls below a predetermined target price adjusted for direct payment rate. Formally,

$$CCP = 0.85 \times a_{base} \times y_{CCP} \times \max(p_{CCP} - p_{DP} - \max(p_{MYA}, p_{LDP}), 0),$$

where y_{CCP} is the CCP base yield, p_{CCP} is the CCP target price, p_{MYA} is the marketing year average price, and the remaining variables are as defined above.

Actual Production History Insurance (APH)

APH is a basic yield protection insurance that pays off whenever the realized yield drops below a selected coverage level. Formally,

$$APH(\eta_{APH}) = a \times p_{APH} \times \max(\eta_{APH} \times y_{APH} - y_{farm}, 0),$$

where y_{farm} is the realized farm-level yield, η_{APH} is the coverage level expressed as percent of the historical average yield y_{APH}, *a* is the planted acreage, and p_{APH} is the APH price.

Crop Revenue Coverage (CRC)

CRC guarantees a certain level of revenue defined as a portion of the product of the APH yield and a pre-set price so that

$$CRC(\eta_{CRC}) = a \times \max(\eta_{CRC} \times y_{APH} \times \max(p_{CRC}, p_{Harv}) - y_{farm} \times p, 0),$$

where η_{CRC} is the coverage level, *p* is the realized price, p_{CRC} is the CRC price, p_{Harv} is the harvest time price, and the rest of the variables are the same as in APH.

Table 1: Risk Aversion Coefficients

Risk Premium θ	Risk Aversion Coefficient γ		
	Hale County, TX	**Hockley County, TX**	**Piatt County, IL**
0%	0	0	0
5%	2.164	9.449	2.835
10%	4.459	33.244	5.465

Table 2: Summary of County, State, and National Yield and Price Data for Cotton and Corn for the 2008 Crop Year

	Cotton				Corn		
	Hale	**Hockley**	**Texas**	**U.S**	**Piatt**	**Illinois**	**U.S**
2007 planted acreage, thousand acres	205.4	256	4900	10535	162	13200	93600
Based yield of DP and CCP	676.57 (pound/ac)	649.164 (pound/ac)			153.005 (bu/ac)		
APH yield	930.56	722.156			171.145		
Correlation between detrended yields and log-difference in futures prices	0.256	-0.089	-0.064	-0.118	-0.42	-0.48	-0.51
ACRE benchmark state yield (Olympic average of the actual state yields for previous 5 years)			801.9732 (pound/ac)			169.477 (bu/ac)	
ACRE guarantee price (simple average of the national market price for the previous 2 years)			0.518 ($/pound)			3.56 ($/bu)	

Table 3: Summary of **Parameters of Cash and MYA Price Regression** for Cotton and Corn

	Parameters of Cash and MYA Price Regression			
	Texas		**Illinois**	
	Cash	**MYA**	**Cash**	**MYA**
b_0	0.027(0.403)	0.07(0.077)	0.15(0.237)	0.205(0.283)
b_1	0.822(0.000)	0.741(0.000)	0.86(0.000)	0.905(0.000)
$\sigma_{residual}$	0.0313	0.0379	0.129	0.1957
R^2	0.912	0.851	0.918	0.851

Table 4: Parameters of Government Payments and Insurance Contracts for Cotton and Corn in 2008

	Cotton (Hale and Hockley county in Texas) (unit : $/pound)	**Corn (Piatt county in Illinois) (unit : $/bushel)**
DP rate, P_{DP}	0.0667	0.28
Target Price for CCPs, P_{CCP}	0.724	2.63
Marketing Loan Rate, P_{LDP}	0.52	2.07
APH established price, P_{APH}	0.66	3.75
CRC base price, P_{CRC}	0.77	5.4

Table 5.: Risk-Reducing Effectiveness of APH vs. CRC Insurance under the Provisions of the 2002 Farm Bill and the ACRE program

		Maximum Achievable CE Wealth $ Thousands			Coverage Level Required		
		Hale County, TX	Hockley County, TX	Piatt County, Il	Hale County, TX	Hockley County, TX	Piatt County, Il
2002 Farm Bill	**Risk Premium**						
APH	0%	$101.7	$92.8	$107.7	75%	85%	85%
	5%	$100.9	$92.4	$106.0	75%	85%	85%
	10%	$100.3	$90.8	$104.5	75%	85%	85%
CRC	0%	$115.7	$100.9	$128.8	80%	85%	85%
	5%	$115.0	$100.2	$128.7	80%	85%	85%
	10%	$114.4	$98.5	$128.6	80%	85%	85%
ACRE Program	**Risk Premium**						
APH	0%	$92.7	$85.3	$106.8	75%	85%	85%
	5%	$91.8	$84.9	$105.1	75%	85%	85%
	10%	$91.1	$83.4	$103.6	75%	85%	85%
CRC	0%	$106.7	$93.4	$128.0	80%	85%	85%
	5%	$106.4	$93.2	$127.9	80%	85%	85%
	10%	$106.0	$92.9	$127.8	80%	85%	85%

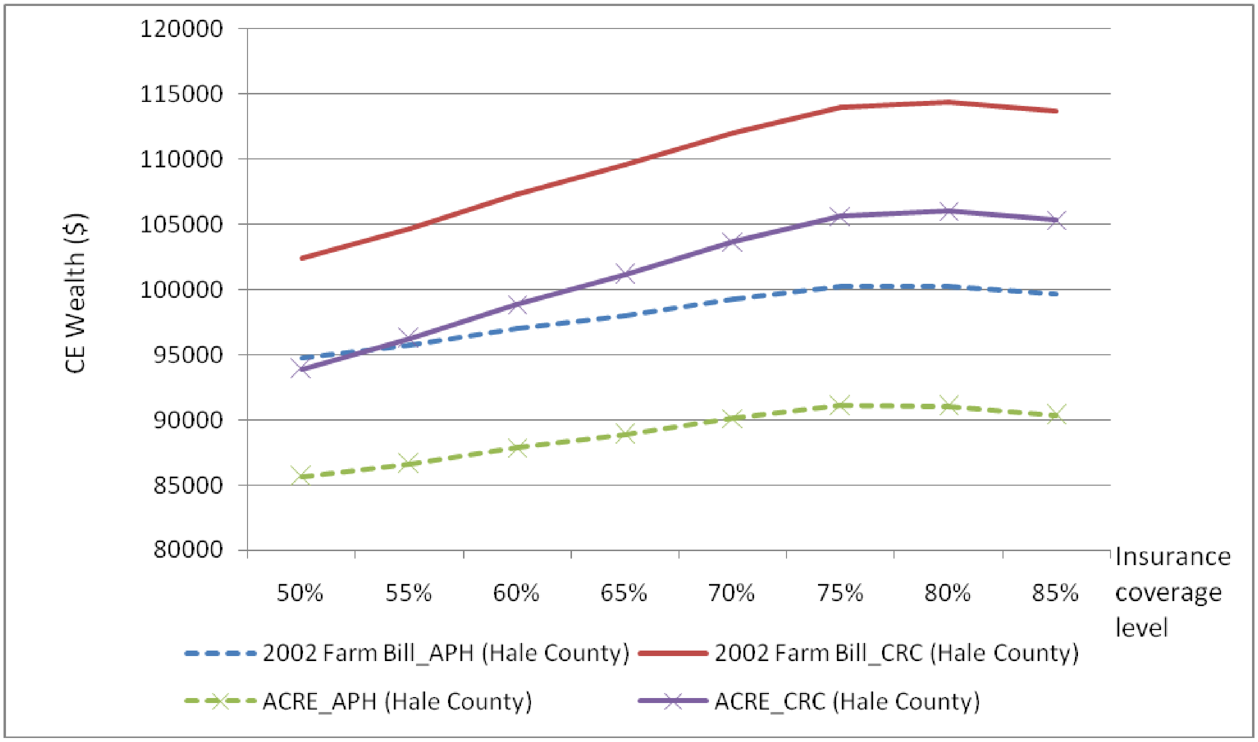

Figure 1: Risk-Reducing Effectiveness of APH versus CRC under the Provisions of the 2002 Farm Bill and the ACRE program in 2008, Hale County, TX.

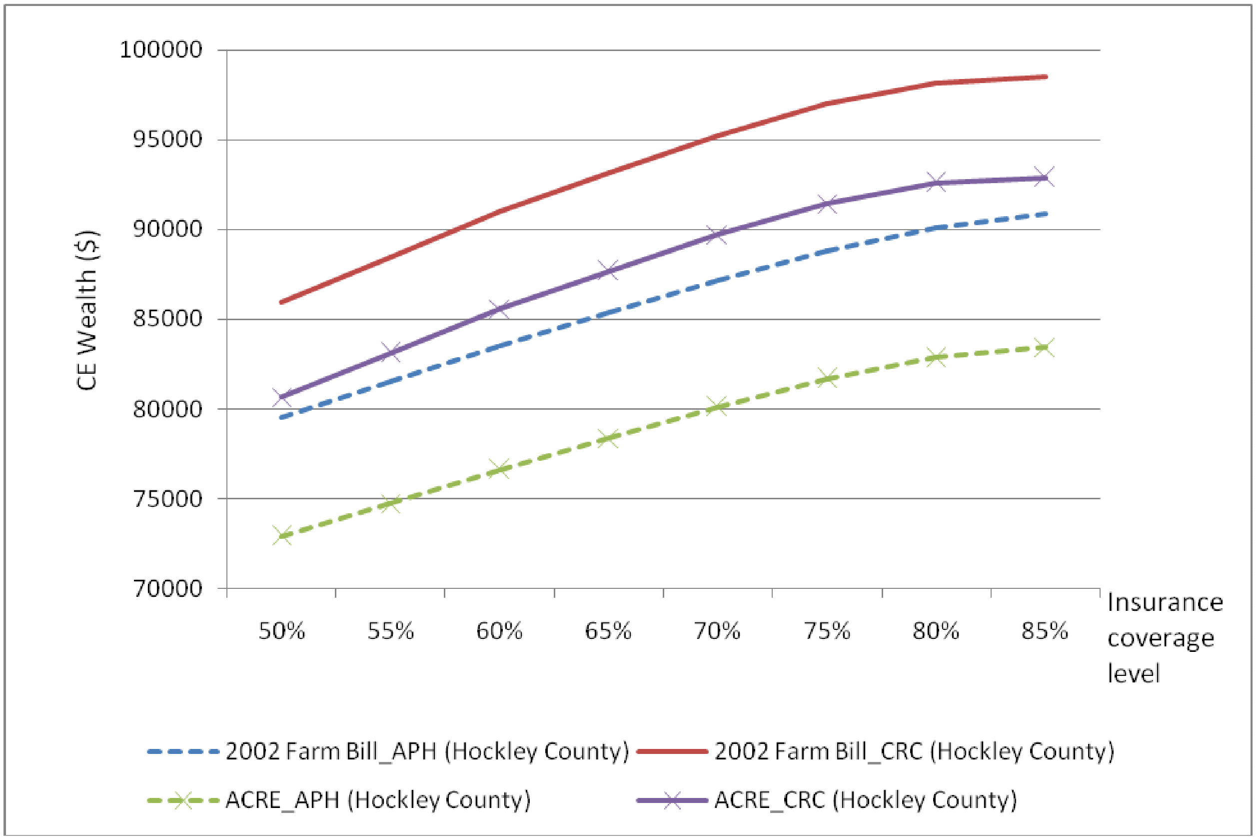

Figure 2: Risk-Reducing Effectiveness of APH versus CRC under the Provisions of the 2002 Farm Bill and the ACRE program in 2008, Hockley County, TX.

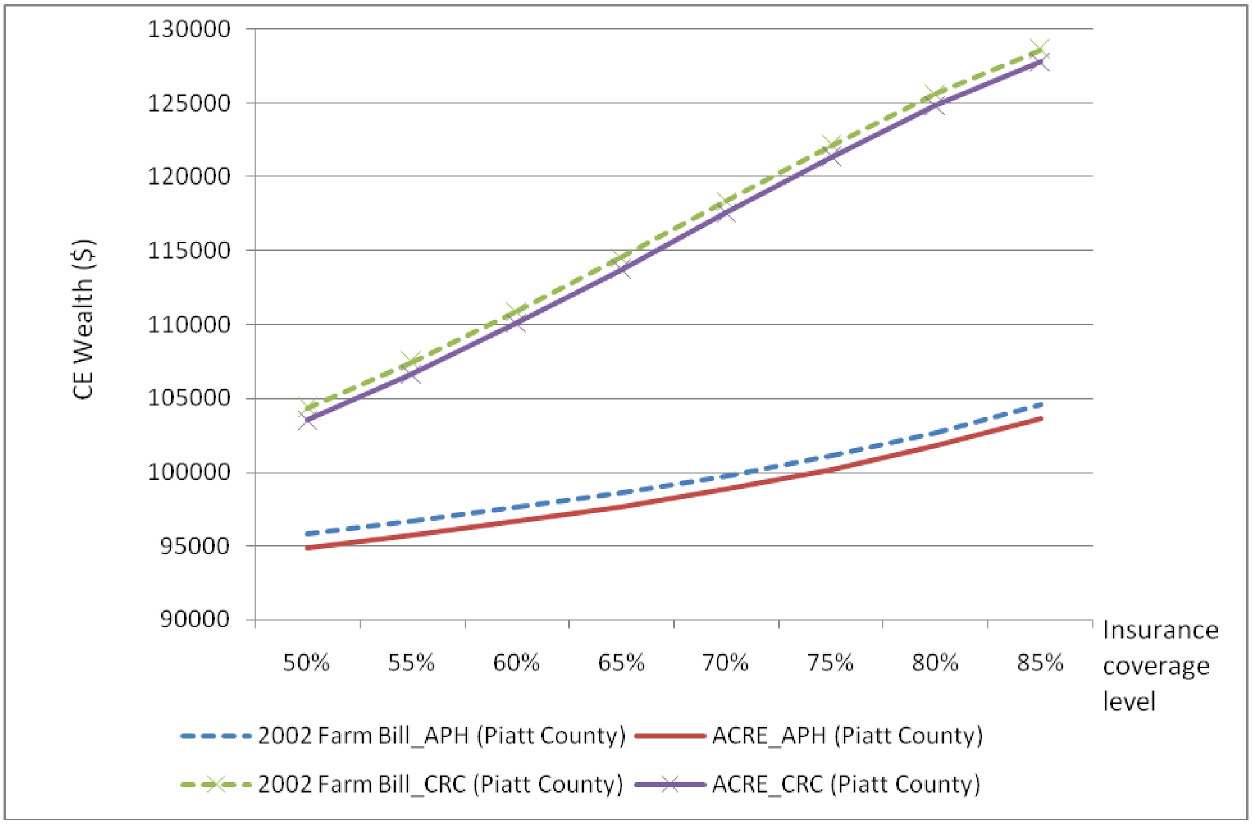

Figure 3: Risk-Reducing Effectiveness of APH versus CRC under the Provisions of the 2002 Farm Bill and the ACRE program in 2008, Piatt County, IL.

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