Risk-Reducing Effectiveness of Revenue versus Yield Insurance in the Presence of Government Payments

Dmitry V. Vedenov and Gabriel J. Power

Government farm support programs such as Loan Deficiency Payments (LDP) and Counter-Cyclical Payments (CCP) have payoff structures that effectively make them costless price insurance instruments. A combination of these payments with yield insurance may provide a viable alternative to revenue insurance. This paper finds that, contrary to expectations, the revenue product analyzed is uniformly superior to yield insurance under both current (2002) and proposed (2008) Farm Bill structures of government payments. Given minor adjustments, however, yield insurance combined with government payments can provide more effective risk management than revenue insurance in production areas with low yield–price correlation.

Key Words: copulas, crop insurance, farm bill, government payments

JEL Classifications: Q14, Q18

Government support of crop producers in the United States is a time-honored tradition dating back to the 1930s (Kramer 1983). Over the years, the support programs have been updated through a series of legislative acts commonly known as farm bills. Most recently, the Farm Security and Rural Investment Act of 2002 modified some of the provisions of the farm payment program and introduced counter-cyclical farm income support. For the duration of the 2002 Farm Bill (2002–2007), eligible crop producers were receiving (fixed) direct payments (DPs) as well as loan deficiency payments (LDPs) and counter-cyclical payments (CCPs), which provided protection against low commodity prices.

As the 2002 Farm Bill neared its expiration, proposals for the new Farm Bill have been discussed in the Congress for most of 2007. By December 31, 2007, both chambers of the Congress passed their own versions of the Farm, Nutrition and Bioenergy Act of 2007, which were still being discussed in a conference committee as of May 1, 2008. Several programs from the previous farm bills, in particular yield and revenue insurance as well as LDPs, will be continued in the new bill under the Producer Income Protection Title. From the risk management perspective, the most significant changes introduced in the legislation are the revenue-based Counter-Cyclical Payments (RCCPs) in the House version and Average Crop Revenue (ACR) program in the Senate version. Additional minor changes include a lower ceiling on received DPs and the end of the $75,000 limit on LDPs.

The RCCP proposal gives the producers a one-time option to select into a revenue-based

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CCP program for the entire duration of the new Farm Bill (2008–2012) instead of the price-based CCP made available in the 2002 Farm Bill (Shurley and Smith). The current CCP program remains the default choice for producers who fail to signal their intentions. The primary difference between the CCP and RCCP programs is that whereas CCPs are determined by the target and seasonal (actual) market prices, RCCPs are triggered when a defined measure of the national average revenue for a given crop drops below a predetermined target revenue for that crop.

The Senate version of the bill gives producers the option to select the ACR program as a replacement for both DPs and CCPs. ACR consists of two parts: a fixed component (essentially a revised DP) and a revenue component (a replacement of CCP). The fixed component is a fixed per acre payment rate applied to 85% of base acres.[1] The revenue component of ACR is a payment made when the state-level average revenue, based on the harvest price, is less than the ACR program guarantee revenue. ACR is therefore similar to RCCP in that it replaces the current price-based CCP program with a revenue-based payment program.

In addition to the government payment programs, crop producers have access to government-subsidized insurance products administered by the Risk Management Agency (RMA). The most popular among those are Multiple-Peril Crop Insurance (MPCI) and Crop Revenue Coverage (CRC) programs. MPCI—also referred to as actual production history (APH) or yield insurance—provides protection against production risk, while CRC protects producers against cumulative revenue shortfall due to any unfavorable combination of yields and prices.[2]

The choice of agricultural insurance coverage has been extensively studied in the literature. Relevant to the present study are two areas of inquiry. The first is concerned with the factors that explain the qualitative choice of a particular program among several alternatives, for instance revenue insurance as opposed to yield insurance. The second addresses the questions of under what conditions and to what extent do government support payments duplicate the safety net features of insurance products.

Using a survey of Midwestern corn and soybean farmers, Sherrick et al. find that insurance demand (particularly for revenue insurance) increases with leverage, risk, and farm size but decreases with wealth. Revenue insurance users tend to be younger, less experienced, more highly leveraged, and also tend to farm a greater number of acres, a smaller proportion of which they own. Determinants of revenue insurance demand differ from those of yield insurance. While the use of revenue insurance is increasing in farm size, debt-to-asset ratio, and in the importance given to risk management strategies, the use of yield insurance is decreasing in all of these factors.

The difference in the determinants of participation in revenue insurance versus yield insurance is also analyzed by Mishra and Goodwin using 1998 farm-level data from the Agricultural Resource Management Survey (ARMS). They find that government payments positively affect the yield insurance decision but not the revenue insurance decision, while conversely the value of production positively affects the revenue insurance but not the yield insurance decision. Education level, farm size, and tenure type also explain well the adoption of revenue insurance but not yield insurance.

Revenue insurance programs appear to be more efficient and less costly to taxpayers than are traditional agricultural support programs (Gray, Richardson, and McClasky; Harwood et al.; Hennessey, Babcock, and Hayes). In addition, revenue insurance programs appear to have lower administrative costs (Skees et al.).

A related issue is whether the choice of insurance products is affected by other gov-

[1] In contrast, direct payment is calculated as a fixed payment rate per *unit of crop weight* multiplied by a preset yield and also applied to 85% of base acres.

[2] This is certainly not an exhaustive list of insurance products available to the crop producers. A detailed description of various insurance programs can be found, for example, at the Risk Management Agency's website at http://www.rma.usda.gov.

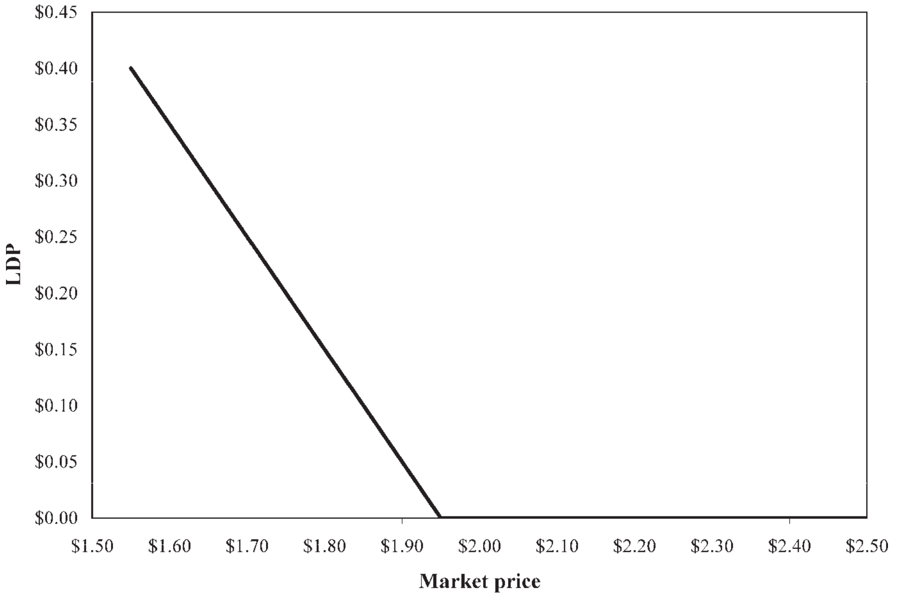


Figure 1. Loan Deficiency Payments as a Function of the Market Price, Corn

ernment payments. Makki and Somwaru find that crop (yield) insurance is widely perceived by recipients as an income supplement (i.e., subsidy). Hauser, Sherrick, and Schnitkey report that yield insurance but not revenue insurance is strongly negatively correlated with CCP.

How exactly indemnities of insurance payments are related to government payments is not a trivial question. For instance, revenue insurance is affected by both price and yield conditions but counter-cyclical payments are not, so that the two are not substitutes, contrary to the perceptions of many producers. At the same time, the structure of government payments closely resembles payoffs of market price risk management instruments such as options. In particular, loan deficiency payments can be interpreted as free put options with the strike equal to the marketing loan rate (Figure 1) and thus can be considered as substitutes for futures and options hedging (Coble, Heifner, and Zuniga; Mahul).

Similarly, the payoff structure of CCP can be interpreted as a put option bear spread (Skully and Plato). The bear spread is an option strategy that guarantees a payoff up to a certain level whenever the price of the underlying asset drops below the predetermined level (Figure 2).

Revenue insurance is often seen as a better choice to manage revenue risk as it protects producers from revenue shortfalls regardless of whether they are caused by low prices or low yields. However, if realizations of prices and yields are relatively independent, then managing price and yield risk separately would have an overall effect similar to that achieved by using revenue insurance.

The main goal of this paper is to investigate the hypothesis that such government payment programs as LDP and CCP—which in effect act as costless or fully subsidized price insurance—combined with yield insurance may be a viable alternative to revenue insurance, at least in the case of crops and geographic regions for which yields and prices are relatively uncorrelated.

More specifically, we analyze the risk-reducing effectiveness of APH insurance as opposed to CRC in the presence of government payments. Furthermore, we also investigate potential changes in the relative risk effectiveness of these contracts under the proposals of the 2007 Farm Bill, which essentially replace the price-based CCP program with a revenue-based one.

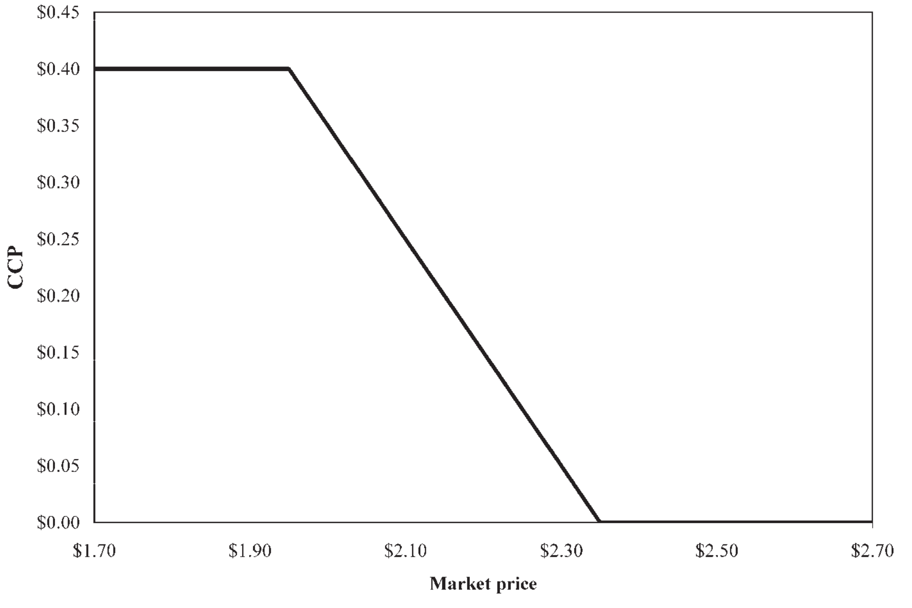


Figure 2. Counter-Cyclical Payments as a Function of the Market Price, Corn

A secondary contribution made at the theoretical level is the application of a copula approach to model the joint distributions of prices and yields. The copula approach allows for a more flexible and accurate representation of dependence between random variables compared with more restrictive assumptions, such as multivariate normality.

The rest of the paper is organized as follows. The next section presents a theoretical framework for the evaluation of revenues under different combinations of government payments and insurance contracts as well as the expected utility approach to compare risky alternatives. This is followed by a section that describes the modeling methodology (including a copula approach) and the data used in the analysis. The results are presented and discussed next. The last section provides concluding remarks.

Theoretical Framework

We assume a representative farmer receives revenue from the sale of crops on the spot market and collects government program payments, if applicable. To make the analysis more tractable, we assume the farmer produces only one commodity, corn. Government payment programs included in the analysis are DPs, CCPs, and LDPs. In addition, the ACR and RCCP proposals of the 2007 Farm Bill are considered. We further assume that the producer may purchase one of two primary insurance products—APH or CRC. For simplicity's sake, we assume that the producer is eligible for all government payments and that his/her planted acres are equal to the base acres for the purpose of calculating DPs and CCPs.

Direct Payments

DPs are a fixed-payment program that is calculated as a product of direct payment rate p_{DP} and base yield y_{DP} and is paid on 85% of base acres a, such that

$$(1) \quad DP = 0.85a \cdot y_{DP}p_{DP}$$

Loan Deficiency Payments

The FAIR Act of 1996 included a program of nonrecourse marketing assistance loans and LDPs. The nonrecourse loans permit storage to sell at a later date, presumably when prices are higher, and being nonrecourse the loans can be repaid to the Commodity Credit

Corporation at loan maturity using the crop itself. Instead of taking the loan, an LDP option may be chosen. The latter pays whenever the commodity price p falls below the loan rate p_{LDP}.[3] The payment applies to the total amount of production $a \cdot y$, where a is acreage and y is the realized yield, so that

$$LDP = a \cdot y \max(p_{LDP} - p, 0) \quad (2)$$

Counter-Cyclical Payments

Introduced in 2002 as a new income support program, CCPs are available for producers of wheat, feed grains, rice, cotton, and oilseeds. Payments are made when the market price—determined as the larger of the marketing loan rate p_{LDP} and marketing-year average (MYA) price p_{MYA}—is below the predetermined CCP target price p_{CCP} adjusted for direct payment rate, p_{DP}. Unlike LDPs, CCPs do not depend on actual production levels. Instead, a fixed CCP yield is applied to 85% of base acres so that

$$CCP = 0.85a \cdot y_{CCP} \max[p_{CCP} - p_{DP} - \max(p_{MYA}, p_{LDP}), 0] \quad (3)$$

Actual Production History

APH insurance is the longest running and the most traditional crop insurance program and is only meant to insure against the risk of low yield. APH pays out when actual yield is less than a stated guaranteed yield. The latter equals the APH yield[4] times the producer-chosen coverage level, η_{APH}, which ranges from 50% to 85% in 5% increments. The APH per acre payment equals the yield shortfall multiplied by the indemnity price, which is selected by the farmer as 60% to 100% of the price established by the Federal Crop Insurance Corporation (FCIC). Overall,

$$APH(\eta_{CRC}) = a \cdot p_{APH} \max(\eta_{APH} y_{APH} - y, 0). \quad (4)$$

Crop Revenue Coverage

CRC is the most widely available revenue insurance contract. It provides insurance against low yields, low prices, or both. An indemnity is paid if the actual gross revenue is less than the revenue guarantee. Furthermore, a majority of the CRC contracts are purchased with the harvest price option, which allows for calculation of the revenue guarantee using the larger of planting time and harvest time prices. Overall,

$$CRC(\eta_{CRC}) = a \max[\eta_{CRC} \cdot y_{APH} \max(p_{CRC}, p_{Harv}) - y \cdot p, 0], \quad (5)$$

where y and p are the realized yield and price, respectively, y_{APH} is the APH yield, η_{CRC} is the selected coverage level (between 50% and 85% in 5% increments), p_{CRC} is the base (planting time) price, and p_{Harv} is the harvest time price.[5]

Both APH and CRC contracts are subsidized, but still they require premium payments on the part of the producer. The premiums are established by the RMA based on location, production history, contract type, and coverage selection.

Revenue Counter-Cyclical Payments (RCCP) and Average Crop Revenue (ACR) Program

Under the House version of the 2007 Farm Bill, producers may elect to receive RCCPs instead of CCPs. RCCPs are triggered whenever the national actual revenue falls below the national target revenue, R_{US}, that is preset for the duration of the Farm Bill (Shurley and Smith). The national actual revenue is determined as the product of the realized average national yield, y_{US}, and the larger of the

[3] Commodity prices for the purposes of LDP settlement are determined by the local Farm Service Agency offices.

[4] APH yields are generally calculated as a 6- to 10-year average of actual farm-level yields subject to additional conditions. The reader may refer to relevant RMA publications for specific details.

[5] Base and harvest prices are determined as monthly average of corresponding futures prices (Risk Management Agency 2004).

marketing year average price, p_{MYA}, and marketing loan rate, p_{LDP}. The RCCP payment rate, p_{RCCP}, is calculated as

$$p_{RCCP} = \max(R_{US} - y_{US}\max(p_{MYA}, p_{LDP}), 0)/y_{NP},$$

where y_{NP} is a national payment yield also preset for the duration of the bill. The RCCP rate is then applied to 85% of base acres times CCP yield so that

$$\begin{aligned} RCCP &= 0.85a \cdot y_{CCP}\,p_{RCCP} \\ &= 0.85a \cdot y_{CCP} \\ &\quad \times \max(R_{US} - y_{US}\max(p_{MYA}, p_{LDP}), 0)/y_{NP}. \end{aligned} \tag{6}$$

Under the Senate version, electing for ACR replaces both DPs and CCPs. The ACR payment is calculated as a sum of a fixed component and a revenue component. The former is calculated as a fixed per acre payment p_{ACRF} times 85% of base acres and is analogous to DPs. The latter is triggered when the actual state revenue, ASR, falls below the ACR program guarantee ACR_{Guar} and is calculated as the difference between the two adjusted to 90% of the ratio of APH yield to state projected (trend) yield, so that

$$ACR_R = \max(ACR_{Guar} - ASR, 0) \cdot 0.9 \cdot y_{APH}/\bar{y}_{State}.$$

The ACR program guarantee, in turn, is set at 90% of a product of the state trend, $\bar{y}_{State}$, and the CRC base price,[6] p_{CRC}, while the actual state revenue is determined as the realized state average yield, y_{State}, multiplied by the CRC harvest price, p_{Harv}. The per acre payment is received on the base acres so that

$$\begin{aligned} ACR &= ACR_F + ARC_R = 0.85a \cdot p_{ACRF} \\ &\quad + a\max(\bar{y}_{State}\,p_{CRC} - y_{State}\,p_{Harv}, 0) \\ &\quad \times 0.9 y_{APH}/\bar{y}_{State}, \end{aligned} \tag{7}$$

where $\bar{y}_{State}$ is the state projected (trend) yield based on 1980–2006 yields (Shurley and Smith).

For the purpose of our analysis, the risk-reducing effectiveness of APH is compared with that of CRC in three scenarios—2002 Farm Bill, RCCP proposal, and ACR proposal. Given a selection of corresponding coverage levels, the total wealth of the representative farmer in each case will be determined as follows:

$$\begin{aligned} W_{APH,2002} &= w_0 + LDP + DP + CCP \\ &\quad + APH(\eta_{APH}) - a \cdot \Pi(\eta_{APH}), \\ W_{CRC,2002} &= w_0 + LDP + DP + CCP \\ &\quad + CRC(\eta_{CRC}) - a \cdot \Pi(\eta_{CRC}), \end{aligned} \tag{8a}$$

$$\begin{aligned} W_{APH,RCCP} &= w_0 + LDP + DP + RCCP \\ &\quad + APH(\eta_{APH}) - a \cdot \Pi(\eta_{APH}), \\ W_{CRC,RCCP} &= w_0 + LDP + DP + RCCP \\ &\quad + CRC(\eta_{CRC}) - a \cdot \Pi(\eta_{CRC}), \end{aligned} \tag{8b}$$

$$\begin{aligned} W_{APH,ACR} &= w_0 + LDP + ACR \\ &\quad + APH(\eta_{APH}) - a \cdot \Pi(\eta_{APH}), \\ W_{CRC,ACR} &= w_0 + LDP + ACR \\ &\quad + CRC(\eta_{CRC}) - a \cdot \Pi(\eta_{CRC}), \end{aligned} \tag{8c}$$

where w_0 is an initial level of wealth, and $\Pi(\cdot)$ are per acre premiums determined by the contract type and selected coverage level.

Expected Utility and Certainty-Equivalent Wealth

We assume that in order to compare risky alternatives presented in Equations (8a–c), a producer uses the expected utility framework. More specifically, in each of the scenarios, the producer first selects the coverage levels η_{APH} and η_{CRC} that maximize expected utility for the respective insurance products, and then selects the insurance contract with the highest achievable level of expected utility. More formally, the producer first solves for

$$\begin{aligned} \eta^*_{APH} &= \arg\max \mathbf{E}U(W_{APH,\cdot}), \\ \eta^*_{CRC} &= \arg\max \mathbf{E}U(W_{CRC,\cdot}), \end{aligned}$$

and then selects either APH or CRC based on a comparison of $\mathbf{E}U(W_{APH,\cdot} \mid \eta^*_{APH})$ and $\mathbf{E}U(W_{CRC,\cdot} \mid \eta^*_{CRC})$. For illustrative purposes, the expected utility can be converted to a certainty–equivalent wealth, CEW, such that

[6] More specifically, a 3-year average of these prices.

$U(CEW) = \mathbf{E}U(W)$. Risky alternatives can therefore be compared in terms of a certain wealth the producer would be willing to accept in lieu of the random amount. The specific form and parameterization of the utility function is discussed in the next section.

Simulation Methodology and Data Analysis

Several variables needed to compute payoffs in Equations (2–7) are nondeterministic. These include farm-level yield, y, harvest cash price, p, marketing year average price, p_{MYA}, CRC harvest price, p_{Harv}, realized average national yield, y_{US}, and realized state average yield, y_{State}. If a number of realizations of these variables are generated, a Monte Carlo approach can then be used to calculate the expected utilities of final wealth in Equations (8a–c).

The variables of interest have to be simulated based on historical data, with an emphasis placed on preserving the joint dependence structure between yields and prices. However, estimation of a full joint distribution of six variables is a challenging task complicated by the shortness of available data series and by distortions introduced by the agricultural policies.

A common approach in the literature is to impose observed price–yield correlations on generated price and yield series, therefore essentially to model the price–yield relationship as a multivariate normal distribution (e.g., Coble, Heifner, and Zuniga). Farm-level yields are typically modeled as a parametric distribution around parametric or nonparametric distributions of county-level yields (e.g., Ker and Goodwin; Schnitkey, Sherrick, and Irwin; Vedenov et al.). However, these approaches may impose rather strict and not always realistic assumptions. An alternative methodology for modeling joint distributions that provides more flexibility and that relies on less restrictive assumptions is a copula approach. Copulas are widely used in the financial literature (e.g., Cherubini, Luciano, and Vecchiato) but generally have not found their way yet into the agricultural economics literature.

Overview of Copulas

The following presentation is based on Nelsen, which provides a more thorough treatment of the subject. Generally speaking, a copula may be described as a function relating a joint distribution and its marginals. In a two-dimensional case, a copula is defined as a function $C(u, v) : [0, 1] \times [0, 1] \rightarrow [0, 1]$ such that $C(u, 0) = C(0, v) = 0$, $C(u, 1) = u$ and $C(1, v) = v$, for all $u, v \in [0, 1]$, and $C(u_2, v_2) - C(u_2, v_1) - C(u_1, v_2) + C(u_1, v_1) > 0$. Any copula function by itself represents a joint distribution of two random variables with uniform marginal distributions on [0, 1].

Sklar's Theorem states that any continuous joint cumulative density function $F(x, y) = \Pr\{X \leq x, Y \leq y\}$ is related to its marginal density functions $F_x(x) = \Pr\{X \leq x\}$ and $F_y(y) = \Pr\{Y \leq y\}$ through a unique copula function $C_F(\cdot, \cdot)$ such that $F(x, y) = C_F(F_x(x), F_y(y))$. Conversely, any copula function $C(\cdot, \cdot)$ applied to the cumulative density functions of any two random variables $F_x(x) = \Pr\{X \leq x\}$ and $F_y(y) = \Pr\{Y \leq y\}$ generates a cumulative density function $F_C(x, y) = C(F_x(x), F_y(y))$ of x and y with the marginals $F_x(x)$ and $F_y(y)$. The latter property allows estimation of joint distributions given marginal CDFs of variables of interest and a choice of a copula. The selected copula function describes the dependence structure between the random variables without the need to explicitly specify the functional form of the joint CDF (Chen and Huang).

A copula approach can be applied to Monte Carlo analysis in a relatively straightforward fashion. Given an n-dimensional copula function $C_n(u_1, u_2, \ldots, u_n)$ and a vector of n marginal CDFs $\{F_1, F_2, \ldots, F_n\}$ of random variables $\{x_1, x_2, \ldots, x_n\}$, the following method can be used to generate random draws from the joint distribution $F_C(x_1, x_2, \ldots, x_n)$ of these variables implied by the copula (Cherubini, Luciano, and Vecciato). First, the required number N of random draws of vectors $\{u_1, u_2, \ldots, u_n\}_{i=1}^{N}$ are generated from the copula itself. Second, each generated vector is transformed using the inverse CDFs $\{F_1, F_2, \ldots, F_n\}$. The resulting random vectors

$$\{x_1, x_2, \ldots, x_n\}_{i=1}^{N} = \{F_1^{-1}(u_1), F_2^{-1}(u_2), \ldots, F_n^{-1}(u_n)\}_{i=1}^{N}$$

are the desired random draws from $F_C(x_1, x_2, \ldots, x_n)$.

The choice of a copula itself is a nontrivial matter, since there are an infinite number of functions satisfying copula conditions. Several functional forms for copulas have been used in the financial literature. The Gaussian copula, which corresponds to the joint multivariate normal distribution, is especially popular and can be used when the dependence structure between the random variables is elliptical (Nelsen). An alternative approach is to use a nonparametric empirical kernel copula, which is related to multivariate kernel density distributions (Wand and Jones). The advantage of the kernel copula is that it imposes no assumptions on the dependence structure between the random variables, but rather determines it from the data. We use both Gaussian and empirical kernel density copulas to generate the random draws required for the analysis.[7]

Simulation Approach

Historical data are available for national, state, and county yields, as well as for cash, MYA, and futures prices for major commodities. Yield series in some cases go as far back as 70–80 years. Price series are generally available for up to 40 years. However, farm-level yield series are usually much shorter and rarely extend past 10–15 years. Given the data limitations, estimating a marginal distribution of yields for a single farm would be unrealistic. Instead, a representative farm in a given county was modeled. Since county data series are usually longer and more reliable, we used all available farm-level yield series for a given county to calculate farm-level shocks relative to the realized county yield. The marginal distributions of national, state, and county yields and farm-level shocks were then estimated from the historical data using the nonparametric kernel density approach (Ker and Goodwin; Wand and Jones).

Following Coble, Heifner, and Zuniga, we assumed that the local cash prices, p, and the marketing year average prices, p_{MYA}, are driven by the harvest-time futures prices f_1, which are also used by the RMA to determine the CRC harvest price, p_{Harv}. Therefore, we modeled p and p_{MYA} as

$$(9)\qquad \begin{aligned} p &= b_0 + b_1 f_1 + \varepsilon, \\ \varepsilon &\sim N(0, \sigma^2), \\ p_{MYA} &= b_0^{MYA} + b_1^{MYA} f_1 + \varepsilon^{MYA}, \\ \varepsilon^{MYA} &\sim N(0, \sigma_{MYA}^2), \end{aligned}$$

where the residual terms are independent shocks with zero mean and appropriate variance.

Furthermore, we modeled the harvest-time futures price f_1 as a log-normally distributed shock applied to the (known) planting time futures price f_0 so that

$$(10)\qquad \begin{aligned} f_1 &= f_0 \exp(d \ln f), \\ &\text{where } d \ln f \sim N\left(\mu_f, \sigma_f^2\right). \end{aligned}$$

Finally, since the futures markets are national in scope, we assumed that the dependence structure present in the historical data on national yields and harvest time futures prices adequately represents the relationship between yields and prices.

The necessary realizations of yields and prices were then generated in several steps. First, a Gaussian copula was used to generate draws from the joint distribution of $d \ln f$ and national yields y_{US}. That is, the inverse log-normal CDF and inverse kernel-density CDF, respectively, were applied to the pairs of random draws generated from the Gaussian copula.[8] The generated realizations of $d \ln f$

[7] The issue of the optimal copula selection is outside of the scope of this paper. The reader may refer to Nelsen for further references.

[8] Technical details of generating random draws from parametric and nonparametric copulas are omitted here due to space considerations and available from the authors upon request. The reader may also refer to Cherubini, Luciano, and Vecciato for more information.

Table 1. Summary of County, State, and National Yield and Price Data for Corn

	Kossuth, IA	Jackson, TX	Iowa	Texas	U.S.
2006 Planted acreage, thousand acres	306	62.7	14,300	1,760	78,327
			Yields		
Base year trend, $\bar{y}$, bu/ac	163.9	100.0	158.9	126.6	137.3
DP and CCP yield, $y_{DP} = y_{CCP}$, bu/ac	146.1	80.9	—	—	—
APH yield, y_{APH}, bu/ac	156.3	75.4	—	—	—
Correlation between detrended yields and log-difference in futures prices	−0.25	−0.08	−0.32	−0.06	−0.53
			Parameters of Cash Price Regression		
b_0	—	—	−0.004 (0.963)	0.476 (0.002)	—
b_1	—	—	0.911 (0.000)	0.858 (0.000)	—
σ	—	—	0.131	0.222	—
Adjusted R^2	—	—	0.948	0.829	—
			Parameters of MYA Price Regression		
b_0^{MYA}	—	—	0.347 (0.020)	0.638 (0.000)	—
b_1^{MYA}	—	—	0.775 (0.000)	0.784 (0.000)	—
σ^{MYA}	—	—	0.216	0.230	—
Adjusted R^2	—	—	0.849	0.814	—

Notes: Base year refers to 2006. DP and CCP yields are 1998–2001 averages of actual yields. APH yields for base year are 10-year averages (1996–2005) of actual yields. Regression parameters are explained in Equation (9). Numbers in parentheses are *p*-values.

were then used to calculate the harvest–time futures prices f_1 from Equation (10) and therefore the CRC harvest prices $p_{Harv} = f_1$. The cash price, p, and MYA price, p_{MYA}, were generated according to Equation (9) with additional random shocks drawn from the normal distributions implied by the regressions in Equation (9).

At the second step, a similar procedure was applied to generate realizations of state and county yields conditional on the national yields generated at the first step. In particular, the inverse kernel density marginal CDFs of the corresponding yield distributions were applied to the random draws from a three-dimensional kernel copula derived from the historical data on national, state, and county yields and conditional on the previously generated national yields.

Finally, realizations of farm-level yields, y, were generated using a two-dimensional kernel copula derived from the historical data on farm-level and county-level yields and conditional on the realizations of county yields generated at the second step.

Once the realizations of all the relevant variables were generated, the payoffs of government payment programs and insurance contracts in Equations (2–7) could be evaluated and the expected utility of the final wealth for each scenario in Equations (8a–c) calculated.

Data and Parameterization

For the purpose of the present paper, corn production was compared in Iowa and Texas. Iowa is the largest corn-growing state in the country and tends to have yields that are highly correlated with national prices. Corn production in Texas is on a much smaller scale and, as a consequence, yields are less closely related to prices. It was therefore hypothesized that the risk-reducing effectiveness of APH insurance combined with government payments (DP, LDP, CCP) may be comparable

Table 2. Parameters of Government Payments and Insurance Contracts for Corn in 2006

	Iowa	Texas
	Current Programs	
DP rate, p_{DP}, \$/bu	\$0.28	
Target price for CCPs, p_{CCP}, \$/bu	\$2.63	
Marketing loan rate, p_{LDP}, \$/bu	\$1.82	\$2.06
APH established price, p_{APH}, \$/bu	\$2.00	\$2.00
CRC base price, p_{CRC}, \$/bu	\$2.59	\$2.38
	2007 Farm Bill Programs	
RCCPs		
National target revenue, R_{US}, \$/ac	\$344.12	
National payment yield, y_{NP}, bu/ac	114.4	
Average crop revenue program		
Fixed component rate, p_{ACRF}, \$/ac	\$15	
State average (trend) yield, $\bar{y}_{State}$, bu/ac	158.9	126.6

Sources: RMA website, http://www.rma.usda.gov; FSA website, http://www.fsa.usda.gov; Shurley and Smith 2007.

Table 3. Parameters of Utility Function

	Risk Aversion, γ	
Risk Premium, θ	Kossuth, IA	Jackson, TX
0%	0	0
5%	5.1	2.8
10%	9.2	6.0

with, if not superior to, that of CRC in Texas, but not necessarily in Iowa.

Representative farms were assumed to be located in Kossuth County, Iowa, and Jackson County, Texas. Both counties are among the largest corn-producing counties in their respective states. Each representative 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.

Farm-level yield data for Kossuth County, Iowa, (743 observations) and Jackson County, Texas (49 observations), from 1980 to 1994 were obtained from an RMA data set. County-, state-, and national-level yields from 1968 trough 2006 were collected from the National Agricultural Statistical Service (NASS). Farm-level data were converted to multiplicative shocks relative to the corresponding county yields. For county, state, and national yields, a simple log-linear trend was fitted to each series and all observations were converted to multiplicative shocks relative to the trend. The year 2006 was selected as a base (trend) year, since it was the latest year for which all data were available.

Futures prices for December corn contracts from 1969 through 2007 were obtained from the Chicago Board of Trade (CBOT). Following the RMA procedures (RMA 2003), February average futures prices were used as the CRC base price, p_{CRC}, as well as a proxy for the planting-time futures prices f_0, while October average futures prices were used as the CRC harvest price, p_{Harv}, as well as a proxy for the harvest-time futures prices f_1. Normality of the log-difference of futures prices $d \ln f$ could not be rejected at the 92% confidence level, therefore the sample mean and standard deviation of the data series for $d \ln f$ were used as parameters of the normal distribution in (10).

Cash prices were approximated by the average October prices received by producers in corresponding states.[9] These and market year average prices from 1968 to 2007 were also obtained from NASS. Both data series were regressed on $d \ln f$ in order to determine the parameters in Equation (9). The information on and selected statistics of historical data series are summarized in Table 1. Note that the detrended county yields and log-difference in futures prices exhibit much stronger negative correlation for Kossuth County, Iowa, than they do for Jackson County, Texas. Furthermore, the cash price basis in Texas is much higher than in Iowa, where national prices tend to be tracked quite closely.

[9] October was chosen to match the procedure applied to the futures prices.

Table 4. Risk-Reducing Effectiveness of APH versus CRC under Provisions of 2002 Farm Bill

	Maximum Achievable CE Wealth, $ Thousands		Coverage Level Required	
Risk Premium	APH	CRC	APH	CRC
Kossuth County, IA				
0%	$95.20	$96.23	80%	85%
5%	$93.25	$94.99	85%	85%
10%	$91.95	$94.17	85%	85%
Jackson County, TX				
0%	$80.50	$80.47	55%	50%
5%	$77.43	$77.47	75%	70%
10%	$74.76	$74.95	75%	75%

Parameters of the government payments and insurance programs for the base year (2006) were obtained from the RMA and Farm Service Agency (FSA) websites (FSA; RMA 2007). For simplicity's sake, both DP and CCP yields were set to the corresponding 1998–2001 yield averages. Details on the proposed RCCP and ACR programs were obtained from Shurley and Smith and applied to the base year. APH price election was set to 100%. Actual premiums for APH and CRC insurance contracts for various coverage levels were obtained using the RMA premium calculator and county-specific information for 2006. The parameters of government programs are summarized in Table 2.

For the analysis, 20,000 random draws of all relevant variables were generated following the procedure described above. The generated results were then used to calculate the expected utility of final wealth for different scenarios and coverage levels. A CRRA power utility function

$$U(x;\ \gamma) = \frac{x^{1-\gamma}}{1-\gamma}$$

was used for the expected utility analysis. Following Babcock, Choi, and Feinerman, the risk aversion parameter γ was selected so as to represent the risk premium a producer would be willing to forgo in order to replace a risky payoff with its expected value. More specifically, for a given risk premium θ and a risky payoff x, the corresponding parameter γ of the utility function was determined from the condition

$$U((1-\theta)\mathbf{E}x;\gamma) = \mathbf{E}U(x;\ \gamma). \qquad (11)$$

Risk premiums were set to 0% (risk-neutrality), 5%, and 10%, and the net wealth without any form of government support was used as the reference risky payoff in Equation (11). The corresponding levels of risk aversion γ are summarized in Table 3. Note that the same risk premium corresponds to a higher level of risk aversion for Iowa than for Texas, which reflects higher risk associated with crop production in Texas.[10]

Results

Presented in Table 4 are the maximum achievable levels of certainty-equivalent wealth for APH and CRC contracts in the presence of government payments under the provisions of the 2002 Farm Bill. The certainty-equivalent wealth for different coverage levels of insurance contracts are also shown in Figures 3 and 4 for a risk premium of 10%.

The producer's expected utility is generally increasing in the coverage level and the maximum risk reduction is almost always achieved at the highest available coverage levels. That the risk-neutral producer (risk premium of 0%) would select a coverage level

[10] Intuitively, a producer must be less risk averse to forego the same portion of certain revenue when presented with higher risk than when presented with lower risk.

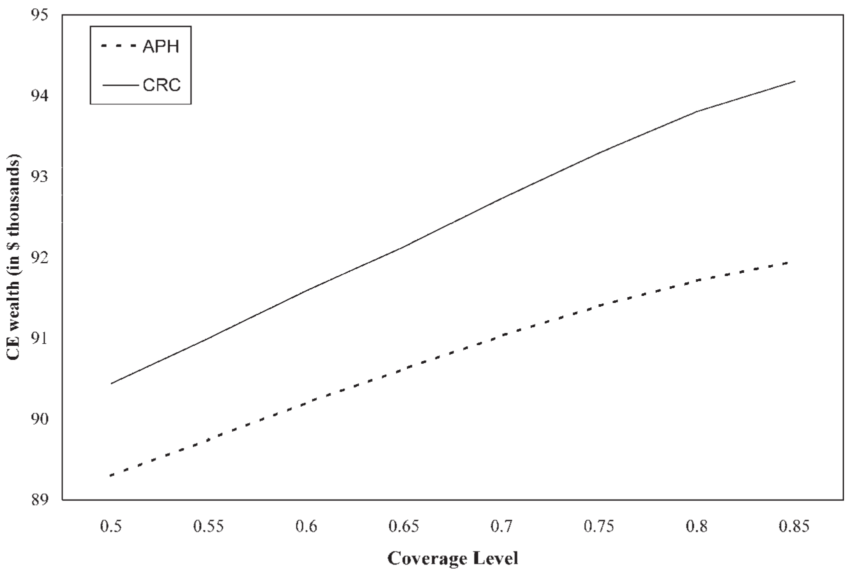


Figure 3. Risk-Reducing Effectiveness of APH versus CRC under Provisions of 2002 Farm Bill, Kossuth County, IA (Risk Premium of 10%)

higher than the minimum is explained by the fact that the insurance premiums are not actuarially fair, although in Texas this effect is not nearly as pronounced as it is in Iowa.

For a risk-averse producer, CRC turns out to be a more efficient risk management instrument in both the Iowa and Texas counties analyzed. While the result for Iowa is as expected, the dominance of CRC in Texas is contrary to our hypothesis. However, the performance of APH is much closer to that of CRC for Texas than for Iowa.

A possible explanation of this result may be the discrepancy between the APH and CRC contract prices. The former is established by the FCIC and does not change during the growing

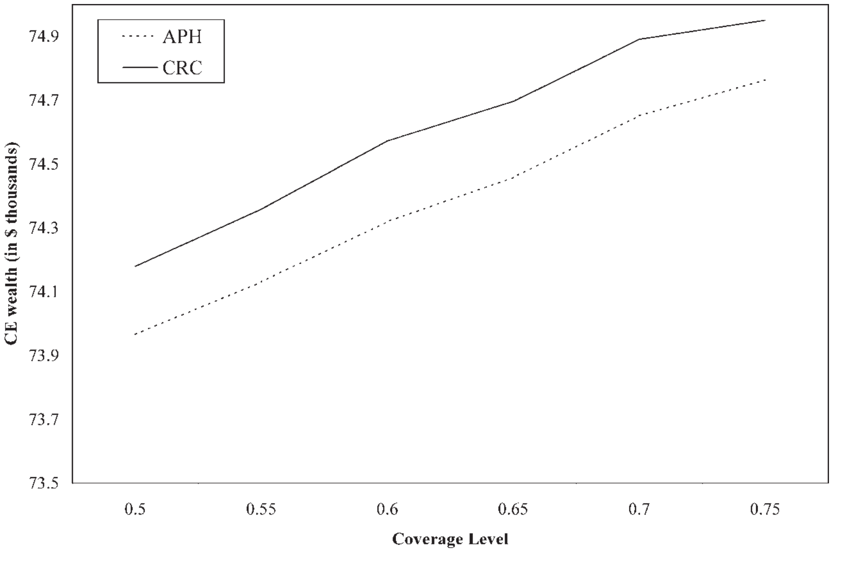


Figure 4. Risk-Reducing Effectiveness of APH versus CRC under Provisions of 2002 Farm Bill, Jackson County, TX (Risk Premium of 10%)

Table 5. Risk-Reducing Effectiveness of APH versus CRC under Provisions of 2002 Farm Bill, Counterfactual APH Prices

		Maximum Achievable CE Wealth, $ Thousands		Coverage Level Required	
Risk Premium	APH Price	APH	CRC	APH	CRC
Kossuth County, IA					
0%	$2.50	$95.47	$96.23	85%	85%
5%	$2.50	$93.74	$94.99	85%	85%
10%	$2.50	$92.59	$94.17	85%	85%
Jackson County, TX					
0%	$2.00	$80.50	$80.47	60%	50%
5%	$2.10	$77.50	$77.47	75%	70%
10%	$2.20	$74.98	$74.95	75%	75%

season. The CRC base price is based on the planting-time futures prices and may further increase during the growing season. In the base year (2006), the established APH price was $2.00/bu, while the CRC base price was $2.59/bu in Iowa and $2.38 in Texas (Table 2). To verify this conjecture, we ran simulations over a (counterfactual) range of higher APH prices, p_{APH}, between $2.05/bu and $2.50/bu. The results of this analysis are presented in Table 5 as well as in Figures 5 and 6 for the case of a 10% risk premium.

For Iowa, APH does not catch up to CRC even for the established APH price set at $2.50/bu. For Texas, on the other hand, there is a range of reasonable contract prices at which APH matches or even dominates CRC. Specifically, APH becomes competitive with CRC at the APH price of p_{APH} = $2.20/bu and dominates it at any coverage level at p_{APH}

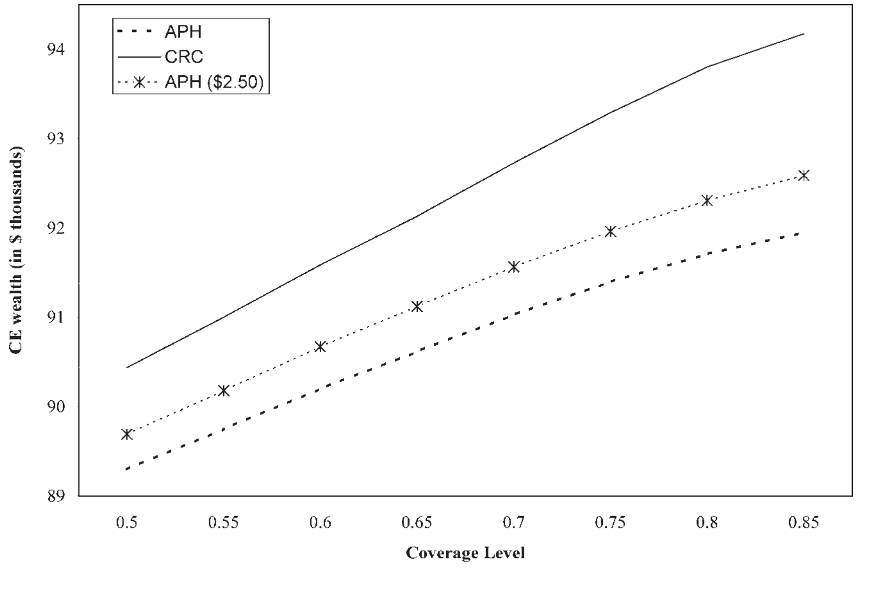


Figure 5. Risk-Reducing Effectiveness of APH versus CRC under Provisions of 2002 Farm Bill, Counterfactual APH Prices, Kossuth County, IA (Risk Premium of 10%)

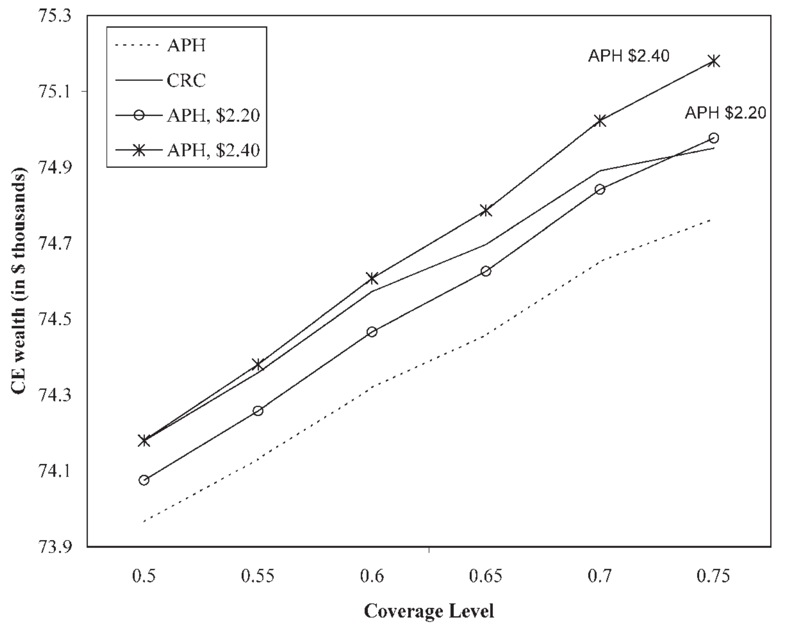
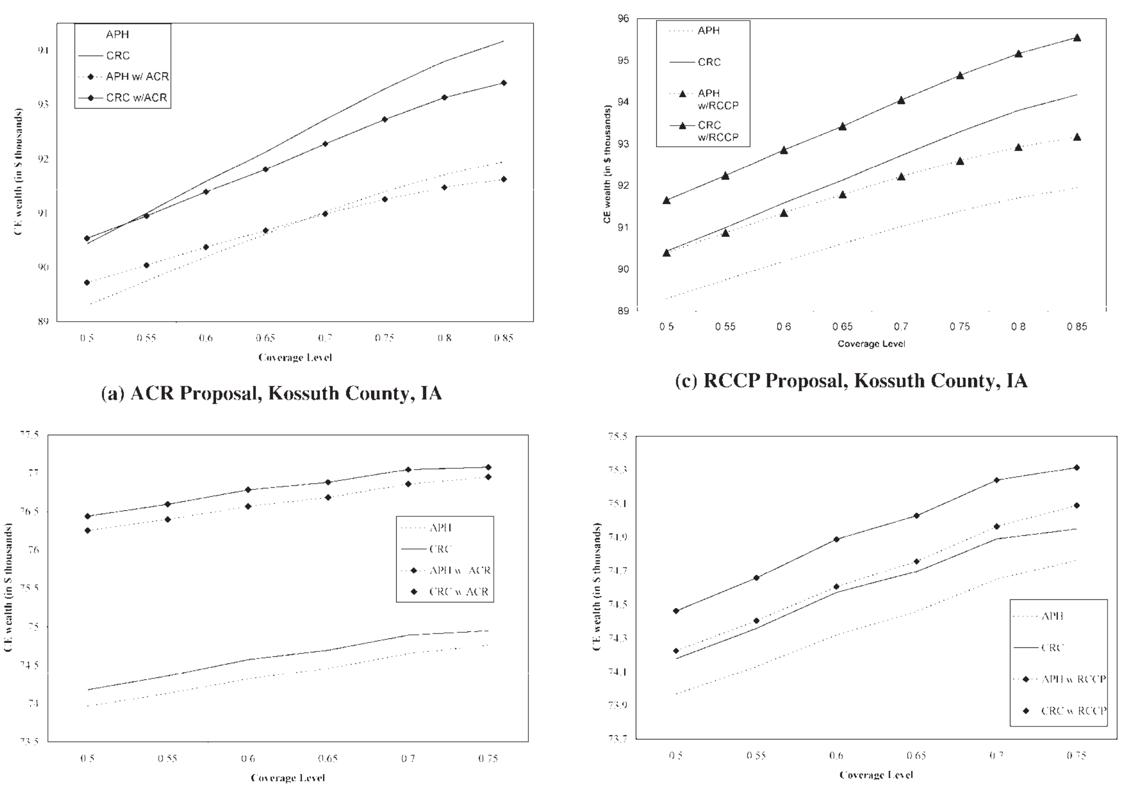


Figure 6. Risk-Reducing Effectiveness of APH versus CRC under Provisions of 2002 Farm Bill, Counterfactual APH Prices, Jackson County, TX (Risk Premium of 10%)



(a) ACR Proposal, Kossuth County, IA

(c) RCCP Proposal, Kossuth County, IA

(b) ACR Proposal, Jackson County, TX

(d) RCCP Proposal, Jackson County, TX

Figure 7. Risk-Reducing Effectiveness of APH versus CRC under Proposals of 2007 Farm Bill

Table 6. Risk-Reducing Effectiveness of APH versus CRC under Proposals of 2007 Farm Bill, Counterfactual APH Prices

		Maximum Achievable CE Wealth, $ Thousands		Coverage Level Required	
Risk Premium	APH Price	APH	CRC	APH	CRC
Kossuth County, IA					
ACR Proposal					
0%	$2.50	$94.78	$95.55	85%	85%
5%	$2.50	$93.20	$94.27	85%	85%
10%	$2.50	$92.11	$93.40	85%	85%
RCCP Proposal					
0%	$2.50	$97.14	$97.91	85%	85%
5%	$2.50	$95.18	$96.49	85%	85%
10%	$2.50	$93.85	$95.55	85%	85%
Jackson County, TX					
ACR Proposal					
0%	$2.00	$82.11	$82.08	60%	50%
5%	$2.05	$79.42	$79.41	75%	70%
10%	$2.15	$77.10	$77.08	75%	75%
RCCP Proposal					
0%	$2.00	81.48	81.45	60%	50%
5%	$2.10	78.12	78.10	75%	70%
10%	$2.20	75.32	75.32	75%	75%

= $2.40/bu. At lower levels of risk aversion, APH becomes competitive with CRC at APH prices that are even closer to the actual level. Thus, in the presence of government payments, APH could be fairly competitive for Texas corn production with only minor increases in the APH base price, while CRC would dominate APH in Iowa even at significantly higher APH prices.

Lastly, we performed the same analysis under the 2007 Farm Bill proposals, namely with RCCP replacing price-based CCP, and the ACR program replacing both DPs and CCPs. The results are presented in Table 6 and in Figure 7.

The results in Figure 7 show that the RCCP proposal improves the risk-reducing effectiveness of both APH and CRC regardless of location. On the other hand, ACR improves the effectiveness of both contracts in Texas but actually reduces their effectiveness in Iowa, particularly for high coverage levels. This suggests that the ACR program may replicate insurance contracts in high yield-price correlation areas. Table 6 indicates that the 2007 Farm Bill proposals generally do not affect the comparative performance of APH compared with CRC. For Iowa, neither ACR nor RCCP allows APH to be competitive with CRC, although APH is somewhat closer to CRC under ACR. For Texas, APH can become competitive with CRC under a small adjustment of the established APH price. Moreover, the required adjustment under the ACR program is smaller than it is under both RCCP and the 2002 Farm Bill provisions.

Conclusion

This paper investigates the conditions under which yield (APH) insurance may provide a competitive alternative to revenue (CRC) insurance in the presence of such government payments as LDP and CCP, both of which provide, in effect, costless price insurance. Results for corn in a high-production region

(Kossuth County, Iowa) and in a low-production region (Jackson County, Texas) are compared. The analysis indicates that APH has the potential to compete with CRC in geographical areas characterized by low yield–price correlation, although this is conditional on the relationship between the APH established price and the CRC base price. The competitiveness of APH in Texas holds both under the provisions of the 2002 Farm Bill and under the proposals of the 2007 Farm Bill that were known at the time this paper was written.

The analysis of the programs included in the House and Senate versions of the bill indicates that the introduction of RCCP will improve the risk-reducing effectiveness of both APH and CRC contracts. However, the effect of ACR varies substantially between the high and low price–yield correlation areas. Furthermore, APH becomes competitive with CRC in the presence of ACR under smaller adjustments of the established APH prices, suggesting that ACR may replicate to some extent the safety net provided by other programs and available insurance contracts.

The paper also makes a contribution at the methodological level through the application of a copula approach to model the joint distributions of prices and yields. This approach provides greater accuracy and flexibility in capturing the dependence structure between several random variables than does the imposition of more restrictive parametric assumptions such as multivariate normality.

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