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Hedging a Government Entitlement: The Case of Countercyclical Payments

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This research evaluates whether the introduction of countercyclical payments creates an incentive for program crop producers to hedge the expected government payment using futures and/or options. Results indicate that some level of countercyclical payment hedging is optimal for risk-averse decision makers. However, optimal hedge ratios depend on planting time expectations of marketing year average price as well as on what crop, if any, has been planted on countercyclical payment base acres. These results suggest that the ability to hedge may make these payments more decoupled but also illustrate the distortion of producer behavior induced by farm programs.

Key Words: countercyclical payment, expected utility, hedging, policy, risk

JEL Classifications: Q12, Q13, Q18

The similarity between certain government agricultural policy programs and market-based risk management tools such as futures and options has been well known at least since the time of Gardner's (1977) seminal article. More recently, the introduction of Production Flexibility Contract (PFC) payments by the Federal Agriculture Improvement and Reform (FAIR) Act of 1996 has been argued as a natural step in a trend toward more market-oriented policies (Collins and Glauber). PFC payments were succeeded by direct payments in the Farm Security and Rural Investment Act (FSRIA) of 2002, and both programs represent fixed area-based payments essentially decoupled from producers' planting decisions. The payments also do not respond to price uncertainty, so they lack the option-like characteristics of the deficiency payment program they replaced. However, Hanson, Myers, and Hilker—as well as Adams, Betts, and Brorsen—note that the loan deficiency payment (LDP) program retained under the FAIR Act and continued by FSRIA substitutes for forward pricing because of similarities to a free put option with a strike price equal to the loan rate. However, the loan program is distinct from a put option in that the quantity protected is not predetermined but equals actual production.

In contrast to the FAIR Act, crop prices were significantly lower in 2002 when FSRIA became law. When these low crop prices began in the late 1990s, Congress increased the support provided through PFC payments by supplementing them with market loss assistance (MLA) payments. MLA payments were equal to 50% of a producer's PFC payment in 1998 and were increased to 100% of the PFC payment for the three subsequent crop years. In writing the 2002 farm bill, policymakers wanted to institute a program that captured the essential attributes of MLA payments: provide assistance during periods of low prices but also decouple this assistance from acreage decisions. FSRIA created countercyclical pay-

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ments (CCPs) to achieve the results of MLA payments while simultaneously eliminating their ad hoc nature.[1]

While CCPs may have been a logical political compromise, these payments also present program crop producers with an entitlement possessing a unique combination of characteristics relative to previous programs. First, CCPs vary with the marketing year average (MYA) price level rather than with posted county prices. Second, because the payments are decoupled from acreage decisions, producers can receive CCPs because of low prices for their base crop while at the same time they can respond to market signals and plant another crop or no crop at all.[2] Third, CCP calculations use a predetermined base yield, a distinction from the loan program that pays on actual production. Finally, the CCP by construction covers a specific and limited range of price risks.

Interestingly, producers and market advisers quickly recognized that CCPs give rise to unique risk management decisions. Various proposals to "hedge" these payments with market-based futures and options strategies emerged shortly after FSRIA became law (Anderson; Scott). For example, Anderson states, "The practical approach to protecting the 52-cent trigger level for reducing the [cotton] CCP is to first hedge using December and/or March calls." The strategies suggested to producers differ not only regarding the value of hedging when planting the base crop versus another crop but also in their level of consistency with the efficient market hypothesis. Regardless of the specific content of the hedging recommendations, the irony of producers attempting to use market instruments to hedge against the possibility of losing *government-provided* risk protection perhaps illustrates an unprecedented interaction between public policy and private risk markets.

This paper investigates the use of market instruments by a risk-averse producer to hedge the countercyclical payment for cotton. Cotton has received the most attention because of the fluctuations in its market price since the introduction of countercyclical payments, but the analysis is applicable to other program crops since the payments are constructed the same. The initial objective of this research is to determine if existing futures contracts and/or options on these contracts can be used effectively to hedge countercyclical payments. Additionally, the research attempts to determine under what circumstances, if any, a risk-averse decision maker might find it optimal to pursue such hedging strategies. These objectives hold broader implications for the characteristics of countercyclical payments in the context of international trade agreements. If countercyclical payments can be effectively hedged with private market instruments, then these payments can be considered to be more effectively decoupled than if the only available hedge is to plant the base crop.

The model constructed for the analysis of CCPs is unique for a number of reasons. One reason is that the very nature of the CCP poses novel modeling challenges. Also, the MYA price that triggers the CCP is a 12-month weighted average, so taking positions in any one month may not be optimal. Ultimately, we do find scenarios where hedging the countercyclical payment is optimal. However, in many cases our results directly contradict strategies being proposed by many marketing advisers and consultants.

More significantly, the results of this study have broader implications for the development of farm policy. Because CCPs are technically decoupled from production, producers do not have to plant the base crop in order to receive a CCP. If prices for the base crop are expected to be low, a producer can plant an alternative program crop with prospects for higher market returns (or even no crop at all) while

[1] A number of fact sheets are available from the USDA–Farm Service Agency providing additional information on the various farm program payments and details on the specific operation of these programs (USDA–Farm Service Agency).

[2] The exception was the Flex Acres provisions of the Food, Agriculture, Conservation, and Trade Act of 1990 that allowed up to 15% of payment acres to be planted to an alternative crop. Under the current legislation, producers are not allowed to plant fruits or vegetables on program crop acreage.

still receiving a CCP on the base crop. The dilemma for a producer is that if prices on the base crop rise, the CCP can decline (or disappear altogether). In this case, the producer will not get a CCP and also will not have a crop to sell at the higher market price. This situation represents a fairly strong incentive for producers to plant the base crop on their base acres.

The evaluation of CCPs entails novel issues relative to past investigations of policy instruments. Glauber and Miranda have demonstrated that a natural hedge exists between price and yield for many program crops and that this relationship has a profound effect on the degree of risk protection afforded by government price risk protection programs. They found while coupled price protection programs may be highly correlated with price risk, they are less correlated with revenue shortfalls. Decoupled CCPs generate the possibility that when no crop or an alternative crop is planted, a quite different hedging relationship could occur between the risk associated with the policy instrument and the producer's normal price and production risk.

This problem is unique from an analytical perspective in that the risk of CCP declines is bounded between the loan rate and the target price less the direct payment rate. Thus, the countercyclical payment is analogous to an entitlement to a free put option against the MYA price with a strike price equal to the target price less the direct payment rate less the value of a put option with a strike price equal to the loan rate. This protection is available on a fixed, predetermined quantity of the crop rather than actual production, as is the case with the LDP. Furthermore, the MYA price is a weighted average of national cash sales over a 12-month period. Thus, attempts to hedge this risk will be complicated by basis risk and temporal complexity. For certain crops such as wheat, CCPs are issued without regard to the type of wheat produced. Yet a producer taking a position in the futures market could do so according to a particular class of wheat, such as hard red spring wheat on the Minneapolis Grain Exchange.

Review of Related Studies

As previously noted, Gardner (1977) was among the first to characterize nonrecourse loan support prices as a put option. The free government put option in the form of support prices had real economic value to producers because these transfers from the government were approximately equal to the value of put options with a strike price at the loan rate. Glauber and Miranda also examine the marketing loan program as well as the deficiency payment program since both programs create a floor under price. Their concern is the impact of these programs on the "natural hedge," which for many crops can protect producers from changes in yield. Glauber and Miranda found many counties where these programs destabilized revenues. While such programs may achieve their goal of stabilizing price, they undermine the natural hedge. Gardner (2002) has also noted how farm policy can often have unexpected consequences in terms of uncertainty for various sectors of agriculture.

Turvey and Baker found that farm programs affect the demand for futures and options, specifically decreasing their use in the presence of loan rates and target prices. The use of futures and options may be underestimated by considering exposure to the market alone to the exclusion of participation in farm programs. Adams, Betts, and Brosen found deficiency payments to be of no greater value than hedging in reducing post-harvest risk and also determined that the payments can actually increase risk when grain is sold at harvest. Selling at harvest was found to be the best strategy for some producers, based on high opportunity cost, storage cost, or risk aversion, but many producers increased their use of futures and options when the benefits of deficiency payments were decreased. Viewing the marketing loan program of the FAIR Act as an implicit put option, Hanson, Myers, and Hilker found reason for risk-averse producers to use futures and options—specifically selling puts—to further reduce risk while still participating in the loan program. Additionally, they found that

(1)

$$\underset{h_i}{MAX}\ L = \int_{\underline{0}}^{\hat{P}_i^l}\int_{\underline{0}}^{\hat{P}_i^f}\int_{\underline{0}}^{\hat{P}_i^m}\int_{0}^{\hat{Y}} U\left[W_0 + A_i[P_i^l Y_i - C(Y)_i] + h_i\left(\delta(P_i^f - P_i^s) - R_i\right) + 0.85\left(P_i^t - D_i - P_i^m\right)\overline{A}_i\overline{Y}_i\right] g(P_i^h, P_i^f, P_i^m Y_i)\, dP_i^h dP_i^f dP_i^m dY_i$$
$$+ \int_{\underline{P_i^L}}^{\hat{P}_i^h}\int_{\underline{0}}^{\hat{P}_i^f}\int_{P_i^L}^{P_i^{T-D}}\int_{0}^{\hat{Y}} U\left[W_0 + A_i[P_i^h Y_i - C(Y)_i] + h_i\left(\delta(P_i^f - P_i^s) - R_i\right) + 0.85\left(P_i^t - D_i - P_i^m\right)\overline{A}_i\overline{Y}_i\right] g(P_i^h, P_i^f, P_i^m Y_i)\, dP_i^h dP_i^f dP_i^m dY_i$$
$$+ \int_{\underline{P_i^{T-D}}}^{\hat{P}_i^h}\int_{\underline{0}}^{\hat{P}_i^f}\int_{P_i^{T-D}}^{\hat{P}_i^M}\int_{0}^{\hat{Y}} U\left[W_0 + A_i[P_i^h Y_i - C(Y)_i] + h_i\left(\delta(P_i^f - P_i^s) - R_i\right)_i\right] g(P_i^h, P_i^f, P_i^m Y_i)\, dP_i^h dP_i^f dP_i^m dY_i$$

the presence of yield and basis risk necessitates the use of futures and options in order to achieve the optimal hedge position.

A Model of Producer Risk with Countercyclical Payments

We examine the behavior of a farmer provided with CCPs and the opportunity to hedge using options. The farmer is assumed to maximize expected utility according to a von Neumann–Morgenstern utility function defined over end-of-season wealth $U(W)$ and that is strictly increasing, concave, and twice continuously differentiable. The decision variable of interest in this study is h, the quantity hedged with call options or futures contracts. The producer is assumed to have already made the acreage allocation between crops and to calculate the expected utility of ending wealth $EU(W_i)$ across all possible outcomes. This limits the analysis to within-season risk management decisions rather than encompassing the acreage decision, which may be affected by farm program provisions as well.

In this model, parameters of commodity program i include the target price, P_i^t; the loan rate, P_i^l; and the direct payment rate, D_i. Three random price variables—harvest time crop price (P_i^h), futures price at harvest month contract expiration (P_i^f), and marketing year average price (P_j^m)—are defined over the interval $[\underline{0}, \hat{P}_i^j]$, where $\hat{P}_i^j = \infty$ for all three prices. Ending wealth including a CCP can be partitioned into three scenarios defined according to where P_i^m falls relative to P_i^l and $P_i^t - D_i$. That is, the CCP is at its maximum when $P_i^m \leq P_i^l$; it declines but is still positive for all $P_i^l < P_i^m < P_i^t - D_i$ and becomes zero when $P_i^m \geq P_i^t - D_i$. Initial wealth is represented by W_0. In this case the producer by assumption plants crop i on farm program crop base i with base acres $\overline{A}_i$ and program yield $\overline{Y}_i$. However, allowing the planted crop $i \neq j$ in the empirical analysis reflects the possibility of planting an alternative crop on the crop base.

The utility maximization problem may then be expressed as in Equation (1) (see above equation). Random farm yield is denoted by Y_i, and defined over the bounds $\left[0, \hat{Y}_i\right]$, where $\hat{Y}_i$ represents the upper limit of stochastic yield. The probability density is denoted by $g(P_i^h, P_i^f, P_i^m, Y_i)$ with the random variables potentially correlated with each other as determined by the data. A concave cost function is denoted $C(Y)_i$, and crop planted acres are denoted by A_i. The decision variable is the quantity of the crop program base hedged, h_i, with P_i^s denoting the strike price and P_i^f the futures price underlying the option contract. For call options, the indicator variable δ is one if the option is in the money ($P_i^f > P_i^s$); otherwise, δ is zero. The option premium per unit, R_i, is assumed unbiased, implying that $E(P_i^f > P_i^s) - R_i = 0$ before commissions and margin cost. The decision variable h_i takes a positive value if the option is purchased and a negative value when an option is written. In the case of using a futures hedge rather than an option, δ equals one and P_i^s denotes the initial futures position taken, while P_i^f becomes the futures price when the hedge is lifted. In this case, R_i reflects commissions and margin cost.

The CCP is at its maximum anytime $P_i^m \leq P_i^l$ as presented by the first term of Equation (1). In this case, the payment per unit of production will be 85% of the difference between P_i^t and the sum of P_i^l and D_i. To determine the total CCP, this product is multiplied by program base acres and base yield, as represented by $\overline{A}_i$ and $\overline{Y}_i$, respectively. The second term in Equation (1) is defined

(2)

$$E\left[U_1'\left(\left[W_0 + A_i[P_i^l Y_i - C(Y)_i] + h_i\left(\delta(P_i^f - P_i^s) - R_i\right) + 0.85\left(P_i^t - D_i - P_i^l\right)\bar{A}_i\bar{Y}_i\right]\right)\left\{\delta(P_i^f - P_i^s) - R_i\right\}\right]$$
$$+ E\left[U_2'\left(\left[W_0 + A_i[P_i^h Y_i - C(Y)_i] + h_i\left(\delta(P_i^f - P_i^s) - R_i\right) + 0.85\left(P_i^t - D_i - P_i^m\right)\bar{A}_i\bar{Y}_i\right]\right)\left\{\delta(P_i^f - P_i^s) - R_i\right\}\right]$$
$$+ E\left[U_3'\left(W_0 + A_i[P_i^h Y_i - C(Y)_i] + h_i\left(\delta(P_i^f - P_i^s) - R_i\right)\right)\left\{\delta(P_i^f - P_i^s) - R_i\right\}\right] = 0,$$

over the interval $P_i^l < P_i^m < P_i^t - D_i$. In this range the CCP declines from the maximum level as P^m rises above P^l to approach $P_i^t - D_i$. The third term depicts the scenario for $P_i^m \geq P_i^t - D_i$, where the producer is left with market returns and the value of the call option, if any.

First-order conditions for expected utility maximization may then be written in expectation form as in Equation (2) (see above equation) where the subscript on U identifies the terms from Equation (1). Examination of Equation (2) reveals some obvious results that are useful to understanding this problem. The first term reflects the scenario where market price is below the loan rate and price risk is irrelevant in that producer price becomes a constant, P_i^l. Also over this range, the countercyclical payment is at its maximum. Thus, if expectations are bounded to this range, there is no price risk for the producer and no uncertainty in the CCP. The only remaining risk is yield risk, which is not mitigated by either the hedge or the CCP. Over this range, the problem becomes superfluous in that hedging either the crop or CCP will have little value because of the presence of the government program.

The second term is an area where cash price risk is relevant (as price is above the loan rate), and the CCP is also at risk. In this range it is important to note that when the producer is growing the crop on which the CCP is based and if base and planted acres are approximately equal to each other, the CCP and price risk would largely offset since losses (gains) in the market are offset by gains (losses) in CCP. Note, however, that if an alternative crop (or no crop) is planted, then increases in price will cause a decline in CCP without an associated gain in the value of the growing crop.

In the third term, the expected CCP has gone to zero, as has the LDP, the other government-provided price protection. Thus, within this range the producer is faced with essentially the traditional hedging decision with market price risk complicated by yield risk. Given the partition of expectations as shown in Equation (2), the total effect of hedging is conditioned on the probability of prices falling into the various partitions. This examination of the maximization problem of hedging the CCP is followed by the numerical results illustrating this decision problem in the next section.

Data and Methods

A numerical optimization of the hedging decision in the context of multiple crops analyzes a representative Mississippi cotton/soybean farm, since hedging cotton CCPs appears to have received the most attention to date. However, the dynamics of the CCP risk appear to be similar in all program crops. Stochastic simulation is used to evaluate the impact on expected utility of hedging the cotton CCP with futures hedges and call options on the New York Board of Trade (NYBOT) December cotton futures contract. Production of all cotton, all soybeans, a mix of half cotton and half soybeans, and no crop on cotton base acres are examined in this study. A constant relative risk aversion (CRRA) utility function is used to calculate a certainty equivalent (CE) for the set of simulated returns. A numerical grid search in 1% intervals is used to solve for the CE-maximizing hedge ratio.

Contract months for cotton futures and options on the NYBOT include March, May, July, October, and December. The primary analysis examines the use of December futures and options, with additional analysis that examines taking positions in multiple contract months. The December contract falls within the November through January period when

Table 1. Data Used to Develop Simulation Model to Evaluate Cotton CCP Hedging[a]

Description of Price Series	Mean	Standard Deviation
Feb. average price of Oct. cotton futures	66.21	9.85
Nov. average price of Oct. cotton futures	64.84	13.51
Feb. average of Dec. cotton futures	65.23	8.93
Nov. average of Dec. cotton futures	64.80	12.49
Feb. (planting year) average of Mar. cotton futures	67.32	12.09
Feb. (marketing year) average of Mar. cotton futures	67.11	13.69
Feb. average of May cotton futures	68.01	11.86
Apr. average of May cotton futures	68.36	15.60
Feb. average of Jul. cotton futures	68.42	11.43
Jun. average of Jul. cotton futures	69.77	14.93
Cotton MYA price	59.00	10.31
National average Nov. cotton cash price	60.35	10.49
National average Nov. soybean price	5.83	1.08
Bolivar County, MS, yields		
Cotton	850.21	220.96
Soybeans	30.68	10.31

[a] Cotton prices in cents per pound; soybean prices in dollars per bushel.

the bulk of cotton marketing takes place, which means that prices in these months will have the greatest influence on the MYA price (Coble and Anderson).

Price data forming the basis of the model consist of February (i.e., planting time)[3] average prices and average prices for the month prior to expiration on NYBOT cotton futures, the national MYA price of cotton (U.S. Department of Agriculture–National Agricultural Statistics Service [USDA–NASS]), and November (i.e., harvest time) cotton and soybean national average cash prices (USDA–NASS). Cotton and soybean yield data for Bolivar County, MS, from NASS for 1970 to 2001 were linearly detrended and provide measures of county yield variability. The variability of these county-level yields was augmented by estimates of the difference between the variability of farm-level and county-level yields so that the yield series used for this simulation more accurately reflects farm-level yield variability (Coble, Zuniga, and Heifner). Table 1 describes the price and yield data used in this study.

[3] Cotton planting does not actually begin in February; however, decisions about what to plant are generally made at that time if not earlier. For this reason, the February price is more relevant in the context of this particular problem than a price from April, when planting would occur.

A total of 5,000 price and yield observations are simulated based on this historical data. The precise technique employed for simulating cash and futures prices was influenced by the fact that the optimal hedge for the CCP will depend critically on the planting time price expectation. For example, if the planting time expectation is for a cotton MYA of $0.40 per pound, there may be relatively little incentive to hedge the CCP since a very large price increase would be required to reach a price level where the CCP would begin to diminish. This is a much different situation than if the planting time expectation is for a cotton MYA of $0.55. In that case, any increase in price would reduce the expected CCP. For this reason, it is desirable to simulate the CCP hedging decision with the planting time price expectation as an exogenous variable so that the impact of different planting time price expectations on optimal CCP hedging can be directly investigated.

To facilitate the treatment of planting time price expectations as an exogenous variable, the ratio of the February average price of the December cotton futures contract to each of the other relevant prices is calculated. Specifically, for each year of historic data, the February average price of the December cotton futures contract was divided into the

harvest time price on the December cotton futures contract, the cotton MYA price, the November cash price for cotton, and the November cash price for soybeans. In short, each price series was converted to a series of price ratios as follows:

$$(3) \quad PR_{ij} = \frac{P_{ij}}{FEBCTZ_i},$$

where PR_{ij} is the price ratio, P_{ij} is the observation from year i on price series j (i.e., harvest time price of the December futures contract, cotton MYA, November cash cotton price, and November cash soybean price), and $FEBCTZ_i$ is the February average price of the December cotton futures contract in year i.

Price ratios constructed as in Equation (3) were used to calculate appropriate prices and yields for any specified level of *FEBCTZ* (i.e., the planting time price on the harvest time cotton futures contract).[4] A total of 5,000 correlated price ratios and cotton and soybean yields were simulated. Correlated price ratios and yields were simulated using the procedure described by Phoon, Quek, and Huang. In this procedure, a rank (or Spearman) correlation matrix, $\boldsymbol{\rho}_s$, is calculated.[5] An eigen decomposition of $\boldsymbol{\rho}_s$ results in a matrix of eigenvalues ε and eigenvector eps$\hat{\varepsilon}$. Correlated standard normal deviates ($\hat{Z}$) are generated using

$$(4) \quad \widehat{Z} = \sqrt{\varepsilon} Z \hat{\varepsilon},$$

where Z is a vector of independent standard normal deviates. These correlated standard normal deviates are converted to correlated uniform deviates on the (0,1) interval by a transformation on the standard normal cumulative distribution function. The uniform deviates are used as probabilities in an inverse transformation on each of the marginal distributions for the variables being simulated (in this case, price ratios and yields). For any specified value of the February price of the December cotton contract, simulated ratios can be converted back into prices whose average level will be appropriate for the that level of the December futures price. This procedure is easily extended to include additional futures contract delivery months. The notable feature of this simulation routine is that it allows the simulation of correlated variables with mixed marginal distributions, permitting the simulation of correlated prices and yields. In the present context, prices (and thus the price ratios directly simulated) are assumed to be lognormally distributed. Yields are simulated nonparametrically using their empirical distributions.

Simulated prices and yields are used to calculate the cotton CCP, hedging returns, crop returns, and loan deficiency payments. To calculate the CCP, a cotton base of 1,000 acres with a program yield of 850 pounds per acre is assumed. Farm program parameters from FSRIA for 2004 are used. The cotton loan rate is \$0.52 per pound, the cotton direct payment rate is \$0.0667 per pound, and the target price is \$0.724 per pound. Additionally, the soybean loan rate of \$5.00 per bushel is used to calculate any loan deficiency payments for the alternative crop, but the alternative crop is assumed not to be associated with any program base acres or yields.[6] The cotton CCP rate will be at a maximum (\$0.1373 per pound) when the MYA price is at or below the loan rate.[7] As the MYA price rises above the loan

[4] Note that simulated price ratios and yields are used to calculate returns and estimate the optimal hedge ratio at each specified level of *FEBCTZ*. Thus, the resulting hedge ratios are conditional on the beginning price level. This is appropriate since the beginning price (*FEBCTZ*) is known with certainty at the time the hedging decision is being made.

[5] In this case, $\boldsymbol{\rho}_s$ included the correlations among all price ratios (i.e., the November price on the December cotton futures contract, the harvest time cash cotton price, the harvest time soybean price, and the cotton marketing year average price, each divided by the February price on the December cotton futures contract as shown in Equation [3]) and yields.

[6] FSRIA made soybeans a program crop for the first time in 2002 and includes specific procedures for establishing soybean base acres and yields according to a producer's planting history. Thus, for purposes of our scenario, the producer's planting history is assumed insufficient to establish soybean base acres or yields.

[7] In such a case, the loan rate plus the direct payment rate results in what FSRIA defines as an effective price of \$0.5867 per pound. The difference between this effective price and the target price is \$0.1373 per pound.

rate, the CCP declines. When the MYA price reaches \$0.6573 per pound, the CCP rate becomes zero because at that price the effective price equals the target price (\$0.6573 + \$0.0667 = \$0.724).[8] The variable costs of production are assumed to be \$450 per acre and \$75 per acre for cotton and soybeans, respectively (Mississippi State University).

Simulated returns from all sources (CCP, loan deficiency payments, hedging activities, and crop production) are converted to utility values using a constant relative risk aversion (CRRA) utility function. The CRRA utility function is represented mathematically as

$$(5) \quad E(U)_r = \sum_{i=1}^{n} \omega_i \frac{W_i^{1-r}}{1-r}, \quad r \neq 1$$

or

$$(6) \quad E(U)_r = \sum_{i=1}^{n} \omega_i \ln(W_i), \quad r = 1,$$

where $W_i = W_0 + NR_i$, r is a risk aversion coefficient, and ω_i is the weight associated with each observation i. W_i represents simulated ending wealth, and initial wealth is represented by W_0. NR_i represents total net returns and includes returns from crop production, hedging returns, countercyclical payments, and loan deficiency payments. Utility values are calculated for risk aversion coefficients of 1, 2, and 3 with $r = 1$ representing slight, $r = 2$ representing moderate, and $r = 3$ representing strong risk aversion. Three different levels of initial wealth are also considered: \$150,000, \$250,000, and \$350,000.

Certainty equivalents (CEs) for each hedge ratio are calculated by inverting Equation (5) or (6) as appropriate. The CE represents the highest sure payment a decision maker would be willing to take to avoid a risky outcome (Hardaker, Huirne, and Anderson). For any two alternatives i and j, if $CE_i > CE_j$, then alternative i is preferred to j. Therefore, the optimal hedge ratio under any given pricing option can be taken to be that which results in the highest CE. The equations for calculating the CE from the CRRA utility functions used here are

$$(7) \quad CE_r = \left[\overline{U}(1-r)\right]^{\left(\frac{1}{1-r}\right)} - W_0, \quad r \neq 1$$

or

$$(8) \quad CE_r = e^{\overline{U}} - W_0, \quad r = 1,$$

where $\overline{U}$ is a value for utility calculated from Equation (10) or (11).

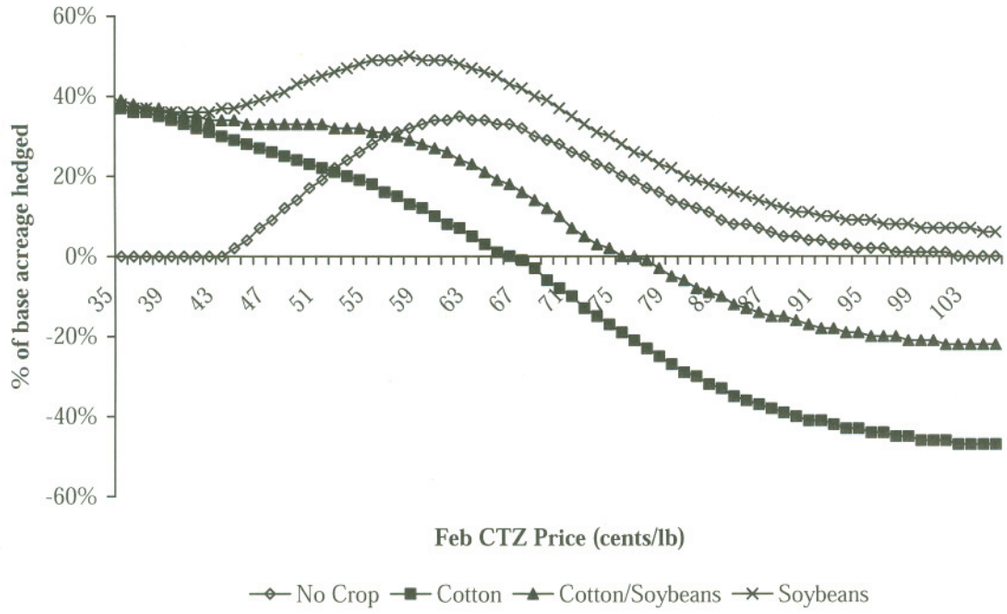
The authors hypothesize that the optimal hedge ratio will be highest when the planting time futures price implies a MYA price close to the loan rate. As expected prices fall below the loan rate, the hedge ratio should decline along with the probability of a price increase reducing the CCP. Alternatively, as prices increase above the target price less the direct payment rate, the likelihood of receiving any CCP diminishes, rendering hedging irrelevant.

We hypothesize planting cotton on cotton base acres will result in an optimal hedge ratio close to zero since any price changes affecting the CCP will have an offsetting effect on the value of the crop. On the other hand, if nothing is planted on the cotton base acreage, the hedge ratio could be quite high since price changes affecting the CCP will not be offset by changes in crop value. When an alternative program crop is grown on the base acres, the hedge ratio will depend on the correlation between prices of the base and alternative crops. A higher correlation corresponds to a lower optimal hedge ratio for the CCP. Under any of these scenarios, the fact that yield risk is zero (since base acres and program yields are known with certainty) will mitigate in favor of a higher optimal hedge ratio.

Results

Primary results of the simulation are revealed through four figures measuring optimal hedge ratios under differing planting scenarios and expected price levels. Figure 1 shows the results for the scenarios where the producer is using

[8] A \$65,000-per-person, per-year payment limit applies on the CCP; however, the three-entity rule, which also applies to CCPs, effectively doubles this limit. Given the farm size modeled in this paper, the payment limit is not binding.



Note: Positive hedge ratios denote a long position on the December Cotton futures contract. Conversely, negative hedge ratios denote a short position on that contract. Transactions fees equal $0.05 per hundredweight. Results are for constant relative risk aversion coefficient of 1 (slightly risk averse).

Figure 1. Optimal CCP Hedge Ratios for a Slightly Risk-Averse Decision Maker (R = 1) Using a Futures Hedge Assuming Alternative Crops Planted on Cotton Base: Correlated Prices and Yields

a December futures hedge to manage risk in the presence of market price risk, a countercyclical payment, and a loan deficiency payment. As mentioned earlier, four scenarios are included for this farm with cotton base acreage. These four scenarios are 1) the cotton base acreage is planted entirely to cotton, 2) it is planted to a mixture of 50% cotton and 50% soybeans, 3) it is planted entirely to soybeans, or 4) the acreage is left fallow.[9]

The *x*-axis of Figure 1 reflects February expectations of the December cotton futures contract. Because the outcomes are conditioned on price expectations relative to various farm policy parameters, optimal hedging across a range of harvest time price expectations is analyzed. The *y*-axis reflects the percentage of base production (i.e., base acres × base yield). The producer is also assumed to be slightly risk averse.[10] Positive values of the hedge ratio reflect a long position in the futures market (i.e., the purchase of a December cotton futures contract). Negative values

[9] The treatment of acreage decisions as given is somewhat limiting. As Figure 1 clearly shows, optimal hedging rates are sensitive to the amount of base acreage that is planted. This suggests possible interactions between acreage and hedging decisions. Moreover, there may be longer-run dynamic interactions between planting decisions and base acreage since current acreage decisions could (depending on future policy developments) affect future base acreage. Nonetheless, the scenarios presented here do permit useful insight into the interactions and relationships between underlying production and market risks during the growing season along with the risk associated with the potential loss of the countercyclical payment.

[10] As noted, sensitivity analysis was conducted with respect to the risk aversion level, and we find no change in the direction of various effects, but, as expected, greater risk aversion leads to somewhat greater value given to risk reduction. With respect to initial wealth, higher (lower) initial wealth values resulted in slightly lower (higher) hedge ratios. Each $100,000 change in initial wealth was associated with a change in the optimal hedge ratio of about two percentage points (in the opposite direction).

on the y-axis reflect a short position (i.e., the sale of the December cotton futures contract).

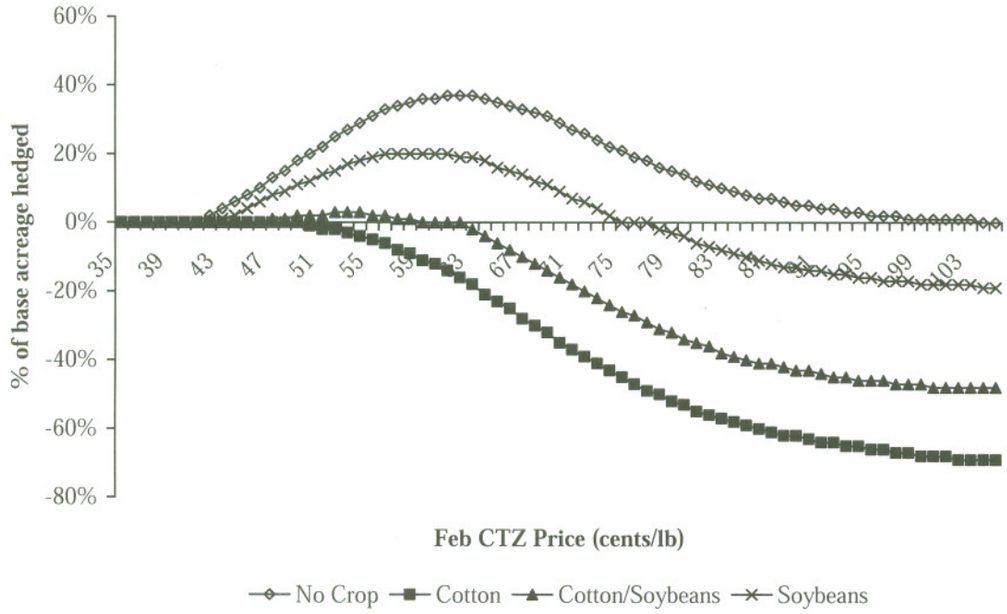
All three of the scenarios in which base acres are planted start very similarly, with hedge ratios of a little under 40%, When cotton is planted on cotton base, hedge ratios decline steadily, becoming negative (i.e., transitioning from long to short hedging) at a beginning price of about $0.66 per pound. When a cotton/soybean combination or just soybeans are planted on base acres, hedge ratios show some increase (i.e., increased long hedging) through roughly the middle of the range of prices over which a CCP would be received. Hedge ratios then decline, actually denoting short hedging in the case of the cotton/soybean combination. When no crop is planted, hedge ratios begin at zero at low beginning price levels, increasing through roughly the middle of the range of prices over which a CCP would be received, again becoming zero at lower prices.

Interpretation of these results is complicated by the large number of correlations that must be considered here (not just the correlation between cotton price and cotton yield and soybean price and soybean yield but also the correlations between both crops' yields and the cotton MYA and cotton futures prices). While the simulation technique applied here does accommodate price/yield correlations, for the crops and locations considered here (cotton and soybeans in the Mississippi Delta region), it may make more sense to consider results assuming zero price/yield correlations. The correlation between cotton MYA price and county-level cotton yields for Bolivar County, MS, over the 1975–2002 time period is 0.044, obviously a very small correlation but especially suspect for its positive sign. Further, since this study investigates optimal hedging of the CCP for the base crop only, the price/yield correlation for the alternative crop is not relevant. The correlation between the base crop yield and the alternative crop MYA price may be relevant. In this location, the correlation between county-level soybean yields and the cotton MYA is −0.23. At the farm level, this correlation would likely be somewhat lower than this. Moreover, there is little reason, conceptually, to expect a very strong price/yield correlation between these particular base and alternative crops. This notion is supported by the fact that this particular price/yield correlation (soybean yield and cotton MYA price) is not very robust, varying quite widely, depending on the time period chosen.

Additional analysis was done with data simulated assuming zero price/yield correlations (though the cotton and soybean yield/yield and price/price correlations were retained). Those results are presented in Figure 2. In this figure, the results for all four planting scenarios are very similar below an expected price of about $0.42 per pound. Above that level, a clear divergence in the optimal hedging position takes place, depending on whether the producer is growing cotton.

In all scenarios, including where cotton is produced, when expected price is below the loan rate, the optimal hedge ratio is zero, indicating that the price risk protection provided by the loan rate is a very strong substitute for futures hedging. This finding is consistent with Hanson, Myers, and Hilker as well as Adams, Betts, and Brorsen. Also, below the trigger level of the countercyclical payment, small price movements do not affect the size of the countercyclical payment. When price expectations are in the $0.30- to $0.40-per-pound range, markets would have to move significantly by the time the MYA price is calculated for the producer's countercyclical payment to change.

Moving to the right in Figure 2, producers who are not planting a crop or are planting soybeans instead of cotton begin to take long positions in the market; that is, they buy the December futures contract. Given that no cotton price or production risks exist in these scenarios, producers take the position to hedge countercyclical payment risk. Perhaps the cleanest scenario to examine is when no crop is planted. In this case, the producer's optimal hedge ratio is a long position in the futures market that increases with expected price up to approximately $0.62 per pound (close to the midpoint between price expecta-



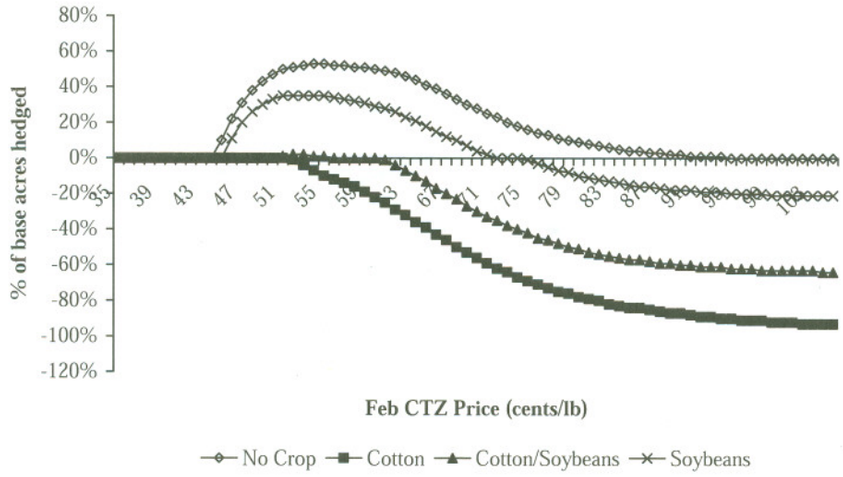
Note: Positive hedge ratios denote a long position on the December Cotton futures contract. Conversely, negative hedge ratios denote a short position on that contract. Transactions fees equal $0.05 per hundredweight. Results are for constant relative risk aversion coefficient of 1 (slightly risk averse).

Figure 2. Optimal CCP Hedge Ratios for a Slightly Risk-Averse Decision Maker (R = 1) Using a Futures Hedge Assuming Alternative Crops Planted on Cotton Base: Zero Price/Yield Correlations

tion yielding a maximum expected CCP and one yielding zero expected CCP) and then gradually declines to a zero hedge ratio as price expectations rise above $1.00 per pound. This is consistent with the hypothesized outcome that the countercyclical payment becomes a random source of income.

In the scenario where the producer is planting soybeans, a pattern similar to planting no crop can be observed. However, as a result of planting soybeans, hedge ratio magnitudes are significantly dampened because of the correlation between cotton and soybean prices as well as because of the effect of production risk (not on cotton but on soybeans). At higher price levels the optimal hedge ratio returns to a traditional hedge as the producer takes a short position in the futures market, essentially establishing a cross hedge on soybean price risk. When a cotton/soybean combination is planted, short hedging activity increases at higher prices. Only a very small amount of long hedging (a 3% hedge ratio) of the CCP takes place when the beginning price is right around the loan rate.

The next scenario involves the producer planting cotton on cotton base acreage. Under this scenario the market price risk the producer faces is expected to essentially offset the countercyclical payment risk. The optimal hedge ratios up to about a $0.50 price expectation are zero for the producer planting cotton on cotton base acreage. The hedge ratio begins to become more negative as price expectations increase so that by the time market price expectations reach the target price, the producer's optimal hedge ratio is −40%. As price expectations increase, government programs affect the producer's decisions less. When cotton is planted on cotton base acres, the producer attempts to manage the price risk of the growing crop much in the traditional manner. Therefore, the producer takes a short position in the futures market to



Note: Positive hedge ratios denote the purchase of a call option on the December Cotton futures contract. Conversely, negative hedge ratios denote the sale of a call option on that contract. Transactions fees equal $0.05 per hundredweight. Results are for constant relative risk aversion coefficient of 1 (slightly risk averse).

Figure 3. Optimal CCP Hedge Ratios for a Slightly Risk-Averse Decision Maker (R = 1) Using Call Options Assuming Alternative Crops Planted on Cotton Base

offset the long position in the growing crop.[11] As a result, the scenarios for cotton and a cotton/soybean mix at higher price expectations are expected to be driven largely by traditional market price risk management decision making.

Importantly, Figure 2 illustrates how, over a wide range of price expectations, the optimal hedging decision would differ considerably from the scenarios where the base crop is not grown. This distinction implies a natural hedge exists between the growing crop and the CCP if the producer is growing the base crop. However, because the CCP is decoupled from current production, producers may take long positions in the futures market to mitigate the possibility of losing their payment when they do not plant the base crop, thereby forfeiting their natural hedge.

Figure 3 reports analysis similar to that presented in the previous figure, except the producer is assumed to use call options rather than futures contracts.[12] In this analysis, the negative positions reflect the producer going short in the call options market (i.e., selling a call). This implies receiving a premium for the call and then having to pay out if prices increase. The long position in Figure 3 is to buy the call, implying that the producer pays

[11] To confirm this hypothesis, the model was run without CCPs. Over a range of prices from around $0.45 per pound to $1.00 per pound, a higher level of short hedging is optimal when CCPs are not included in the analysis. At very high expected prices (over $1 per pound), the level of short hedging that is optimal is the same whether CCPs are included or not. This seems to confirm the notion that the short hedging observed to be optimal when cotton is planted on cotton base acres reflects optimal price risk management rather than hedging related to the CCP.

[12] The decision rule used to establish a strike price for the purchased call options is based on the loan rate and the expected basis. If the planting time futures price is above $0.578 cents per pound (i.e., the loan rate of $0.52 per pound plus the expected basis of $0.058 per pound), a strike price of $0.578 is selected. If the planting time futures price is above $0.578 per pound, the option is purchased at the money. This decision rule takes into account the fact that the CCP does not begin to decline until the MYA price rises above the loan rate. Thus, there is no need to protect against price increases until the expected MYA price equals the loan rate. A fair options premium (i.e., a zero net return premium) is determined by calculating the expected value of the option and dividing it by the number of pounds hedged. A transaction fee of $0.05 per hundredweight ($25 per option) is charged on each transaction.

Table 2. Certainty Equivalents Associated with Alternative Hedge Ratios at Selected Expected Price Levels: No Crop Planted on Cotton Base[a]

	Expected Price (cents/lb)			
Hedge Ratio	45.00	55.00	65.00	75.00
No crop				
0.00	96,089.52	78,213.76	47,501.96	21,031.20
Optimal	96,128.08 (0.08)	79,148.81 (0.31)	49,168.21 (0.35)	22,205.48 (0.21)
1.00	91,273.34	74,736.77	43,816.17	11,356.44
Soybeans				
0.00	172,747.13	163,167.53	151,651.52	149,429.40
Optimal	172,755.50 (0.04)	163,439.60 (0.19)	151,927.70 (0.16)	149,429.40 (0.00)
1.00	168,377.08	158,584.00	145,002.33	136,681.33
Soybeans/cotton				
0.00	128,206.45	127,195.33	132,509.69	151,626.96
Optimal	128,206.45 (0.00)	127,199.60 (0.02)	132,543.60 (−0.06)	152,513.10 (−0.26)
1.00	122,728.95	119,371.97	119,692.48	129,886.13
Cotton				
0.00	75,144.03	81,200.49	100,668.49	138,806.25
Optimal	75,144.03 (0.00)	81,232.91 (−0.05)	101,451.50 (−0.23)	142,502.00 (−0.45)
1.00	66,255.92	63,179.80	66,749.32	76,549.61

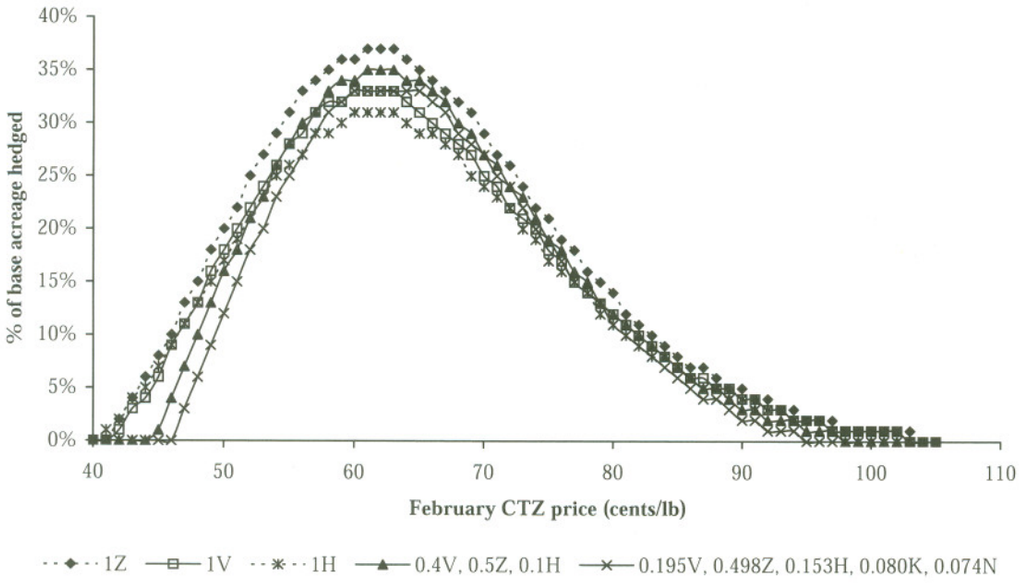
[a] Optimal hedge ratios are given in parentheses beside the associated certainty equivalent.

a premium for the call option such that if prices increase, he or she will hold a long position in the futures market. Ultimately, the plot of producer positions follows a similar pattern to that observed in the previous figure, although the magnitudes are somewhat different. The producer who has planted cotton on cotton base acreage takes no positions in the futures market until prices reach approximately $0.52 per pound. Gradually increasingly short positions are taken by selling calls, an action that is expected utility maximizing in the sense it reduces the producer's upside price variability. Such a producer would be largely protected by the loan rate and the CCP.

In the case of a farm with no crop on the base acreage, the producer would take a long position by buying call options at an expected price of approximately $0.45. Furthermore, the optimal percentage of the base acreage hedged would increase markedly as expected price approaches the trigger point for the CCP. Again, the possibility in this scenario is the loss of the CCP. The producer who does not have a natural hedge offsetting the loss of the CCP would take a long position in the call options market. This position would remain at about a 50% level until expected price reaches approximately $0.62 and then gradually decrease in size as expected CCPs fall.

To further investigate the outcome of optimal hedging strategies, certainty equivalents associated with optimal hedge ratios from Figure 2 are compared to certainty equivalents associated with nonoptimal hedge ratios. Two different nonoptimal hedge ratios are considered: zero and 100%. A hedge ratio of 100% is frequently implied in CCP hedging strategies. Table 2 summarizes the comparison of certainty equivalents at four different expected price levels.

For the case in which no crop is planted, values in Table 2 show that in the range of expected prices roughly between the loan rate and the target price (where changes in price will have an immediate impact on the level of the CCP), optimal hedging results in moderate increases in decision-maker utility. In cases where some crop is grown, the difference in certainty equivalents between zero hedging and optimal hedging tends to be quite small. These figures also illustrate the significance of



Note: Positive hedge ratios denote the purchase of a call option. Legend indicates the proportion of the total position allocated to each contract delivery month where H = Mar, K = May, N = July, V = Oct, and Z = Dec.

Figure 4. Optimal CCP Hedge Ratios Using Multiple Contract Months for a Moderately Risk-Averse Decision Maker Assuming No Crop Planted on Cotton Base

the program payments to producer returns. In all cases where a crop is grown, the certainty equivalent actually declines as expected price moves from \$0.45 (at which a full CCP and LDPs would be received) to \$0.55 (at which a reduced CCP and no LDPs would be received). It is also worth noting that in all the expected price scenarios shown here, 100% hedging (i.e., long hedging of 100% of the expected base) resulted in a lower certainty equivalent than not hedging at all, especially in cases where the optimal hedge is actually a short position. This highlights the problem with CCP hedging recommendations that do not take account of price expectations, planting decisions, local basis conditions, and other factors that are addressed in this research.

An additional simulation was conducted to determine how taking a position in multiple contract months would affect the optimal hedge ratio. Figure 4 illustrates optimal CCP hedge ratios for no crop on cotton base acreage with the futures market position (a straight long hedge) distributed across different contract months.

The legend in this Figure 4 indicates what percentage of the futures market position associated with a given hedge ratio is taken in a given contract month. Distributing the futures position across contract months based on average monthly crop marketing percentages results in optimal hedge ratios not much different from simply using the December contract. When hedging using a single month, the December contract results in slightly higher optimal hedge ratios than either October or March contracts. Distributing the position across multiple contracts had little effect on results and actually appeared to be inferior to simply hedging on the December contract. This result does not take into account that hedging with deferred contracts so far from maturity may present a problem for the hedger in terms of liquidity on those contracts (particularly in the case of hedging with options).

Implications and Conclusions

The fact farmers are contemplating using futures instruments to "hedge" their govern-

ment-provided price protection (and are sometimes being advised to do so by both public and private advisers) must surely be an unintended consequence of the 2002 farm bill. Results of this study illustrate this development, indicating that under a variety of circumstances related to expected prices, planting decisions, and decision-maker risk preferences, the use of futures instruments by producers to hedge at least a portion of the CCP is rational. On the other hand, these results indicate that the level of hedging optimal for most producers is probably less than is currently being advised. Clearly when the base crop is planted on base acres, any significant level of CCP hedging makes little sense.[13] In short, results of this study indicate that producers should be wary of marketing strategies involving CCP hedges.

Additional research is needed to extend the evaluation of CCP hedging strategies to other program crops. Further, the existence of CCPs and the desire of producers to protect their expected CCPs while maintaining full planting flexibility raise the possibility of developing market-based instruments specifically designed to address the potential loss of CCPs. The actual development of such instruments and whether producers and landowners would use them remain topics for further research.

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[13] Indeed, a producer taking a long position in the futures market to protect the CCP on the base crop would likely also be inclined to take a short position in the same market to protect the cash crop. This obviously suboptimal behavior stems from an attempt to optimize the individual components of total returns rather than simply optimizing total returns directly.

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