
EFFECTS OF REDUCED GOVERNMENT DEFICIENCY PAYMENTS ON POST- HARVEST WHEAT MARKETING STRATEGIES

**BRIAN D. ADAM
STEVEN BETTS
B. WADE BRORSEN***

Effects of reducing government deficiency payments on a wheat producer's post-harvest marketing strategies are evaluated. The deficiency payment is predicted using an average option pricing model to properly value both intrinsic and time values of the deficiency payment. The biggest loss to producers from reducing deficiency payments is reduced revenue. The deficiency payment program was no better than hedging strategies in reducing post-harvest risk, and when grain was sold at harvest, it even increased post-harvest risk. Many producers will compensate for reduced deficiency payments by increasing use of futures or options contracts. For some producers, however, the optimal strategy is to sell wheat at harvest, because of high opportunity cost, storage cost, or risk aversion. © 2000 John Wiley & Sons, Inc. Jrl Fut Mark 20:243–263, 2000

*Correspondence author, Department of Agricultural Economics, 526 Agricultural Hall, Oklahoma State University Stillwater, OK 74078-6026.

-
- *Brian D. Adam is a Professor in the Department of Agricultural Economics, Oklahoma State University in Stillwater, Oklahoma.*
 - *Steven Betts is a former Graduate Research Assistant in the Department of Agricultural Economics, Oklahoma State University in Stillwater, Oklahoma.*
 - *B. Wade Brorsen is a Regents Professor in the Department of Agricultural Economics, Oklahoma State University in Stillwater, Oklahoma.*

INTRODUCTION

The 1996 farm program replaced price supports and deficiency payments for several major commodities (such as corn and wheat) with revenue assurance payments that are gradually reduced over seven years. This removes the link between farm prices and farm subsidies. The objective of this article is to determine the effect of this change on a wheat producer's optimal post-harvest marketing strategies.

Because price supports and hedging strategies serve similar purposes, optimal marketing strategies are influenced by the terms of the government programs. For example, Turvey and Baker (1990) found that corn and soybean producers participating in government programs decreased use of futures and option contracts. A deficiency payment program is like a subsidized put option (Gardner, 1977; Irwin, Peck, Doering, and Brorsen, 1988), in that the amount of the payment increases as prices decrease below a target. This option is not free because of acreage reduction requirements and other compliance restrictions.

Two questions are of interest. First, are marketing strategies available to help producers minimize the post-harvest impact of changes in the government deficiency payments? Second, how much will revenue and risk change if those strategies are used? The article evaluates changes in both the income-enhancing and risk-reducing impacts of the deficiency payment program, focusing particular attention on how reducing deficiency payments affects producers' marketing risk.

Policy makers can use the results to assess the extent to which producers can offset the post-harvest effects of reduced target prices by using market-based strategies. Some have suggested that producers might be able to replace the risk-reduction features of the deficiency payment program with appropriate futures and options positions. Commodity futures exchanges can use the results to determine how changes in farm programs might affect their trading volume. The article considers a wheat producer who can sell part or all of her grain at harvest and store any remaining grain for later sale. In addition, the producer can sell and/or buy futures and options contracts. At harvest, the producer forms expectations of cash, futures, and option prices that will prevail on the date she plans to offset any hedging instruments and sell the cash commodity. She also forms an expectation of the deficiency payment.

Because the amount of the deficiency payment depends on whether the five-month or yearly average of U.S. prices is above or below the target price, its value is predicted using an average option pricing model (Kang and Brorsen; 1995; Tirupattur and Hauser, 1994). Kang and Brorsen (1995) noted that some extension applications (e.g., Anderson, 1991)

have computed the expected deficiency payment as the difference between the target price and expected harvesttime price. However, that method considers only the intrinsic value of the "option" and ignores the time value.¹ Other studies (e.g., Turvey and Baker, 1990) of commodity marketing strategies considered the time value but did not use an average option pricing model to predict the deficiency payment.

Comparisons are made between strategies chosen when the producer participates in the deficiency payment program and those chosen in the absence of the program. To assist in interpreting the results, the effects of reducing but not eliminating the program are evaluated. The effects of decreasing or eliminating deficiency payments on optimal strategies and on the producer's risk-adjusted revenue are evaluated.

PROCEDURES

Post-harvest marketing alternatives considered include immediate cash sales, delayed sales using storage, and the sale or purchase of futures and options contracts. These alternatives can be combined to form many different marketing strategies.

Marketing decisions are made at June 20 (time 1) and maintained until November 30 (time 2), when any stored grain is sold and futures and option contracts are liquidated. These dates are chosen because June 20 is the typical harvest completion date in central Oklahoma and November has the highest average cash price of the year (Anderson and Adam, 1991) as well as the highest average basis of the year over the last 5- and 10-year periods (Anderson and Sahs, 1999).² Compared to considering sales on any day during the period, the approach limits the possible combinations of strategies, but also eliminates the need for the producer to continually monitor prices (Mathews and Holthausen, 1991).

Producer revenue is calculated as:

¹Although Kang and Brorsen (1995) suggested that an average option pricing model should allow for nonnormality and stochastic volatility, they found only small differences between the payments predicted using a generalized autoregressive conditional heteroskedasticity (GARCH) average option pricing model and those predicted using a Black average option pricing model. However, both the Black average option pricing model and the GARCH average option pricing model performed considerably better than a standard Black model.

²Using averages ignores potential gain from selective hedging if expected basis gain is higher than average (e.g., if harvest-time basis is lower than average). Similarly, contracts expiring later than the December contract may provide higher basis gain, along with somewhat higher risk. Results presented later consider these possibilities.

$$\begin{aligned} \text{Producer Revenue} = & \text{Revenue from cash sale} + \text{Deficiency payment} \\ & + \text{Findley payment} + \text{Net revenue from futures/options transactions} \\ & - \text{Storage costs} - \text{Commission costs.} \end{aligned}$$

The producer revenue equation is written as:

$$\begin{aligned} R = & r((P_{c1}Y_cA_h)\beta) + (1 - \beta)((P_{c2} - SC\Delta T) Y_cA_h) \\ & + G((DP_t + FP_t)Y_pA_{dp} + I_{dp}) + \sum_j [p_{j2} - r_{p_{j1}}]NP_j \\ & + \sum_i [c_{i2} - r_{c_{i1}}]NC_i + [f_2 - f_1]NF - (rtc_o)\text{abs}(NP_j) \\ & \text{abs}(NC_i) - (rtc_f)\text{abs}(NF) \end{aligned} \quad (1)$$

where:

R	= revenue from marketing activities (in time 2 dollars)
P_{ct}	= cash price received at time t, $t = 1, 2$
Y_c, Y_p	= actual and program yield, respectively
β	= % of wheat sold at time 1
A_h, A_{dp}	= acres harvested and acres eligible for deficiency payments, respectively
G	= 1 if participating in government program; 0 otherwise
DP_t, FP_t	= deficiency payment and Findley payment, respectively
I_{dp}	= interest earned on the March, December, and July DP's, adjusted to time 2 dollars
p_{jt}	= put option premium at the jth strike price at time t, $t = 1, 2$
r	= interest rate + unity, $(1 + (i/365)) \times (T, i = 6\% \text{ or } 10\%$ (r adjusts time 1 values to time 2 terms)
NP_j, NC_i	= number of puts, calls, and futures contracts (negative values indicate sales)
NF	
c_{it}	= call option premium at the ith strike price at time t, $t = 1, 2$
f_t	= futures price at time t, $t = 1, 2$
SC	= daily storage costs per bushel (\$0.02/bu/month, or \$0.00067/bu/day)
tc_o, tc_f	= transaction cost for an option (put or call) or futures contract (\$80/contract for options, \$70/contract for futures
ΔT	= number of days between time 1 and time 2 (163)

The first term in (1) is the revenue, adjusted to time 2 dollars, from

selling a proportion β of the wheat harvested at time 1. The second term is the revenue from selling any remaining wheat $(1 - \beta)$ at time 2, subtracting the cost of storing from time 1 to time 2. The third term calculates the value in time 2 dollars of the deficiency payment and Findley payment applied to the program yield on the eligible acres, with associated interest. The remaining terms represent returns from buying and/or selling puts, calls, and futures contracts.

Revenue from marketing strategies that allow the producer to buy and sell puts, calls, and futures contracts, as well as store wheat, is calculated using (1). The producer is assumed to have harvested 10,000 bushels of wheat. At harvest, the producer may buy or sell zero, one, or two 5000-bushel contracts of each of the following: futures contracts, put options at each of three strike prices, and call options at each of three strike prices. The producer may sell all, one-half, or none of the crop at harvest. Any wheat produced but not sold at harvest is sold on November 30 at the prevailing Gulf price minus transportation from Oklahoma. For example, one strategy the producer considers is to sell 50% of the crop at harvest, buy two calls at an in-the-money strike price, sell an in-the-money put, and sell two out-of-the-money puts. A strategy the producer would not consider is to sell 50% of the crop at harvest and buy three futures contracts because three futures contracts exceeds the limit of buying or selling two contracts. In all, 234,375 combinations of cash sale, futures contracts, and put and call options are considered.³

The producer is assumed to choose strategies in order to maximize expected utility. Since the choices are discrete, optimums are found by simulating each of the choices and then selecting the choice (strategy) with the highest expected utility. Three different levels of producer risk aversion—high, medium, and low—are considered.⁴ For each of the 234,375 combinations of cash sale, futures contracts, and put and call options (strategies), and for each level of producer risk aversion, expected utility is calculated using a mean-variance specification.⁵ Because of the

³Not all of these strategies would be considered hedging for IRS purposes. In order to make the analysis general, we allow the producer to select any strategy that maximizes expected utility. Hedging here indicates only that the producer has a cash position. In all cases the strategies actually selected are no more speculative than holding a long cash position with no offsetting futures or options positions.

⁴The Arrow-Pratt risk aversion parameter associated with the "medium risk aversion" level is adapted [using the procedure suggested by Raskin and Cochran (1986)] from literature that either elicited producers' risk aversion levels or estimated the level based on production responses. The "low" and "high" levels are simple adjustments of this estimated level to capture a broader range of producer risk preferences.

⁵Theoretically, other specifications of expected utility are more appealing. However, empirical work by Garcia, Adam, and Hauser in a context similar to that of this article suggested little difference

complexities created by options, the expected utilities are calculated using Monte Carlo integration. With mean-variance, expected utility is measured as the certainty equivalent, or risk-adjusted dollars.⁶ Thus, economic significance is used rather than statistical significance.

Price patterns are simulated using parameters estimated from historical data and by adjusting these parameters to represent expected changes in price variability without the deficiency payment program. Four market environments, or scenarios, are considered. In the first scenario, target price is set at its 1995/96 level (\$4.00/bu.), the target price in effect during the last year of the deficiency payment program. In a second scenario, the target price is reduced to the average of previous June monthly average U.S. prices (\$3.17/bu.), reflecting alternative farm policy proposals to reduce target prices.⁷ Both of these assume the producer participates in the government deficiency payment program. In the third and fourth scenarios it is assumed that no deficiency payment program exists. If the deficiency payment program encouraged producers to produce more than they otherwise would, resulting in higher stocks, price volatility probably will increase without a program. To allow for the possibility that prices will become more volatile without a government program, it is assumed in the third scenario that prices are 50% more volatile than under the deficiency payment program.

Some evidence suggests that price volatility might increase by more than 50% in the absence of government support prices. A graph provided by Crain and Lee (1996) suggests that prices were two to three times more volatile under programs that resulted in a greater market orientation than under other program regimes. Thus, in the fourth scenario, it is assumed that prices are twice as volatile as those assumed in the first two scenarios.

All four scenarios set harvest-time prices at their average June 20 price over the last 20 years. Since harvest-time prices are set at historical averages, the model is not appropriate for recommending particular strategies in a particular year. Rather, the model is designed to assess the

between mean-variance results and results from a decreasing absolute risk aversion specification. Similarly, preliminary results in this application showed little difference between the two specifications. Mean-variance was used here because it's reduced computation time allowed for a much larger number of draws in the Monte-Carlo integration.

⁶Certainty equivalent is expected utility minus a risk premium (Robison and Barry, 1987; Cox and Rubinstein, 1985, p.320). In the case of mean-variance, certainty equivalent is expected utility. The three levels of risk aversion used here are adapted from the coefficients used by Adam, Garcia, and Hauser, using the adjustment suggested by Raskin and Cochrane (1986). After adjustment, low risk aversion is assumed to be characterized by an Arrow-Pratt (AP) absolute risk aversion parameter of 0.465; medium risk aversion, AP = 23; high risk aversion, AP = 6,977.

⁷This reduces the intrinsic value of the deficiency payment "option" and increases its time value, since it is nearly "at-the-money".

average effect that reducing or eliminating government deficiency payments might have on producers' marketing strategies.

The simulation is based on prices occurring over 1974–1994, except that futures and options markets are assumed efficient.⁸ In other words, we assume that the June 20 December futures price is the best available predictor of the November 30 December futures price. This means that although on any given year the November 30 price could be higher or lower than the June 20 price, the average November 30 futures price is the same as the average June 20 price. Similarly, it is assumed that the options premiums on June 20 equal their expected value.⁹ Also, since no set-aside was required for the last two years of the deficiency payment program, the percent of base acres required to be set aside is set at zero. It is assumed that the flex acres requirement is met using acres other than those considered in this analysis.¹⁰

Commercial storage costs were assumed to be two cents/bu./month (see Anderson and Noyes, 1989). In addition, a producer incurs an opportunity cost of foregone interest by not selling the wheat. The annualized interest rate assumed here is 10%, the average interest rate over the period 1974–1993 charged by the Bank for Cooperatives. Finally, sensitivity of the results to alternate interest rates is considered.

Simulation of Deficiency Payments and Market Prices

The government deficiency payment (DP) is computed using program guidelines existing during the last year of the program. The total defi-

⁸In actuality, however, the data indicate that on average the futures price rose 3 cents per bushel from June 20 to November 30. In some years the price dropped, and in some years the price rose, but if a producer had purchased a futures contract on June 20 and sold it on November 30 every year from 1974 to 1993, the average profit would have been 3 cents per bushel. Since there is no assurance that this will continue, and because even if it did continue there would be some years when such a strategy would lose considerable amounts of money, we are assuming for this analysis that, on average, futures prices do not increase or decrease.

⁹Empirically, this is accomplished by setting the June 20 futures price equal to the mean of the distribution of November 30 futures prices, and by setting initial options premiums equal to their computed value over the period of simulation. One implication of this assumption is that a higher cash price is equivalent to a higher basis.

¹⁰We have not included the effects of the CCC loan program since it has not been an important post-harvest marketing tool for most wheat producers for at least the last five years. In an attempt to reduce its role in holding stocks, the USDA reduced the loan rate so that in most years it is below market price. Thus, only a few producers need to use it. Currently, the loan rate is \$2.58/bu. In theory, the simulations conducted under the deficiency payment scenarios may have overstated risk since simulated prices were not truncated at the loan rate. However, in 5,000 replications under historical price patterns, national average prices generated by the model that were below the loan rate were not observed. Under the non-deficiency payment scenarios (w/50% higher and 100% higher volatility), though, simulated prices do reach the loan rate. By not including the loan rate we have overestimated the risk that farmers face without a deficiency payment program, and have biased the results in favor of a strategy of either selling at harvest or hedging and storing until later.

ciency payment is composed of a payment at sign-up (March), a payment in December, and a payment in July of the following year. The final DP is based on the marketing year average (MYA) price, which is the average of the U.S. monthly average prices from June 1 of the current year through May 31 of the following year, weighted by amount sold.

Since the MYA price is not known when the March or December DPs are issued, USDA uses an estimate to calculate the March DP. Because of the uncertainty of the estimate, the March DP is only one half of the difference between the target price and the expected marketing year price. The December DP is based on a weighted average of the U.S. monthly average prices for the first five months of the marketing year plus 10 cents. If the March DP exceeds the calculated December DP (i.e., if prices rise after the initial payment by more than enough to make the deficiency payment smaller), no payment is made in December.

Finally, the July DP is calculated using the actual (12-month) MYA price to determine if additional DP is to be received. If both the December DP and July DP are below the initial payment, the producer must pay back the difference. The following equation summarizes the calculation of the total DP:

$$\begin{aligned} \text{Deficiency Payment} = & \text{March}_{\text{DP}} + \text{December}_{\text{DP}} \\ & + \text{July}_{\text{DP}} - \text{Payback.} \end{aligned}$$

Because the deficiency payment is based on the difference between the target price and the marketing year average price, incorporating the deficiency payment into a producer's expectations requires predicting the MYA.¹¹ Figure 1 is a diagram of the simulation described here. Price patterns are simulated using Monte Carlo methods with 5,000 replications. Prices are assumed to be distributed lognormally.¹² Monthly prices are used rather than daily because the deficiency payment is computed based on a monthly survey. Volatilities and means of these prices are calculated for each month over the years 1974–1994.¹³

The following equation is used to generate the prices (Naylor, Balintfy, Burdick, and Chu, 1966; Mapp, 1989; Arias, 1995, pp.29–30):

¹¹Deficiency Payment = max[max(Target Price – (5-month average price + 0.10), Target Price – MYA), 0].

¹²Although some research suggests that prices are not distributed lognormally, lognormality is assumed here for convenience.

¹³U.S. monthly average prices and volumes sold are from USDA. Futures and cash prices are from Technical Tools.

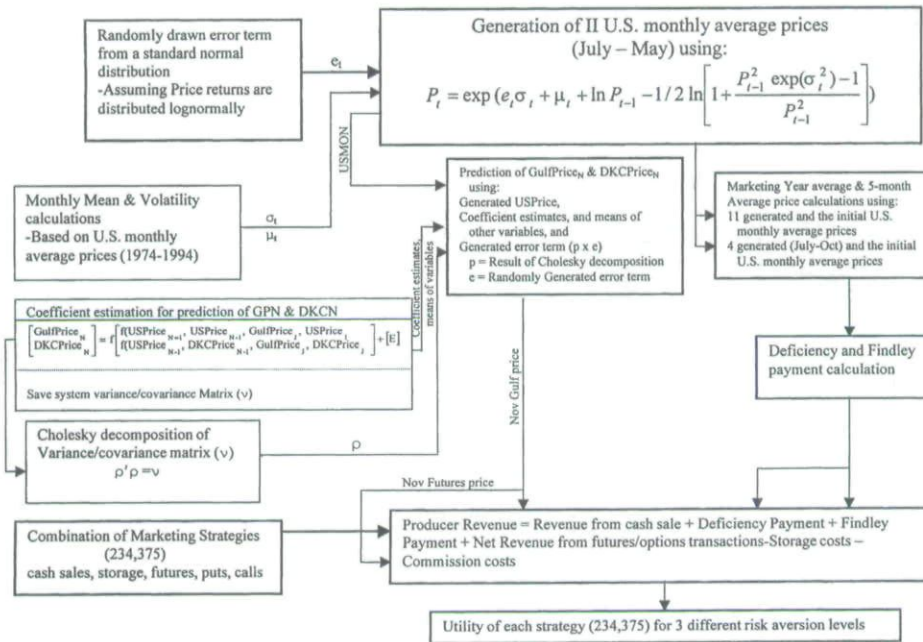


FIGURE 1
Scheme of simulation.

$$P_t = \exp\left(\ln P_{t-1} + e_t \sigma_t + \mu_t - \frac{1}{2} \ln\left[1 + \frac{P_{t-1}^2 \exp(\sigma_t^2) - 1}{P_{t-1}^2}\right]\right) \quad (2)$$

where:

P_t = U.S. monthly average price in month t

e_t = random error term generated with the Monte Carlo approach (taken from a standard normal distribution), using antithetic variates for increased precision

σ_t = volatility of log price returns of historical US monthly average prices in month t

μ_t = means of log price returns of historical U.S. average prices in month t .

Each of the 5,000 replications generates twelve U.S. monthly average prices (June–May) that are used to calculate the MYA and five-month average prices. Figure 2 illustrates a sample of 10 of the 5,000 monthly average price replications. To simulate November 30 Gulf cash price and November 30 December Kansas City futures prices, given the generated

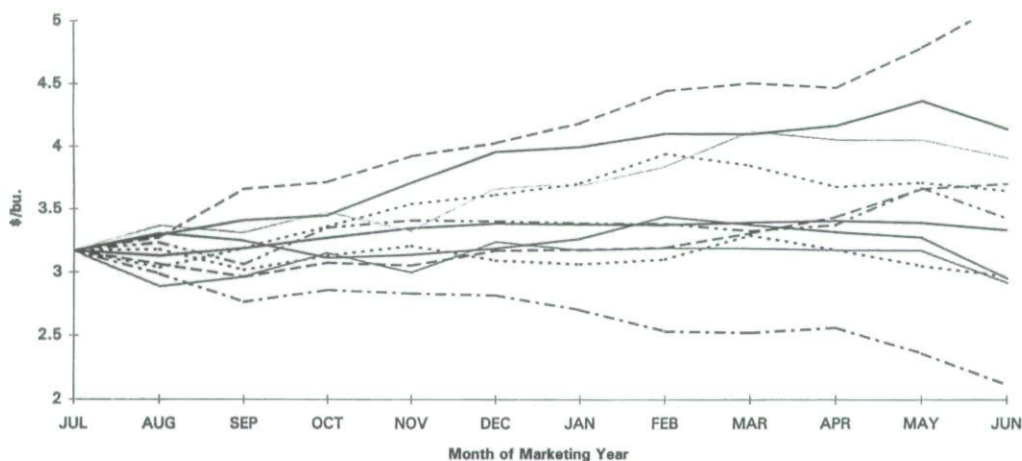


FIGURE 2

National average price: Selected years from simulation (assuming historic volatility).

U.S. monthly average prices, historical relationships among the three price series are estimated. Specifically, the spread between November 30 Gulf cash and U.S. November average price, and the basis between November 30 Gulf cash and November 30 December contract Kansas City futures price, are regressed on: (i) the previous year's spread between November 30 Gulf cash and U.S. November average price; (ii) the previous year's basis between U.S. November average and November 30 December Kansas City futures price; (iii) the spread between June 20 Gulf and U.S. June average price; and (iv) the June 20 basis between Gulf cash and December Kansas City futures prices.

These relationships are estimated using the seemingly unrelated regression (SUR) approach in SHAZAM (1993). SUR provides more efficient estimates since it allows the error structure from one equation to affect estimates of the related equation. To model the randomness in the relationships among the series, the estimated regression is combined with a randomly generated error vector that considers the correlations between these equations. The 2×2 Cholesky decomposition of the variance/covariance matrix of the SUR system is multiplied by a $2 \times 5,000$ matrix of randomly generated error terms (using antithetic variates for increased precision) to produce the error vector used in generating the price differences:

$$\begin{aligned}
 & \left[\frac{\text{GulfPrice}_N - \text{USPrice}_N}{\text{GulfPrice}_N - \text{DKCPrice}_N} \right] = \\
 & \left[\begin{aligned} & .26618 + (.20771 \text{GulfPrice}_{N-1} - .32973 \text{USPrice}_{N-1}) \\ & + (.28786 \text{GulfPrice}_j - .12229 \text{USPrice}_j) \\ & - .10213 + (.22391 \text{USPrice}_{N-1} - .12180 \text{DKCPrice}_{N-1}) \\ & - (.080841 \text{GulfPrice}_j + .049737 \text{DKCPrice}_j) \end{aligned} \right] \\
 & + \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \quad (3)
 \end{aligned}$$

where:

USPrice _N	= U.S. monthly average price for November
USPrice _{N-1}	= Previous year's U.S. monthly average price for November
USPrice _j	= U.S. monthly average price for June
GulfPrice _N	= Gulf price on November 30
GulfPrice _{N-1}	= Previous year's Gulf price on November 30
GulfPrice _j	= Gulf price on June 20
DKCPrice _N	= December Kansas City futures contract price on November 30
DKCPrice _{N-1}	= Previous year's November 30 price of the December Kansas City futures contract
DKCPrice _j	= December Kansas City futures contract price on June 20
v ₁ , v ₂	= error terms

Expression (3) allows basis risk since a separate random component is included in each of the three series: November 30 Gulf cash price (GulfPrice_N), November U.S. monthly average price (USPrice_N), and November 30 price of the December Kansas City futures contract (DKCPrice_N).

To start each year's simulation, ten-year average prices are used. June U.S. monthly average price is set at \$3.17/bu., June 20 Gulf cash price is set at \$3.82/bu., and June 20 December KCBT price is set at \$3.61/bu. Since Oklahoma cash price is Gulf cash price minus a 75¢/bu. transportation charge, harvest-time basis (Oklahoma cash price minus KC December futures price) is -54¢/bu. For the no-deficiency-payment-program scenarios, increased volatility of U.S. monthly average prices is simulated by increasing the value of (ϵ in expression (2)). This increases volatility of futures prices and cash prices generated through expression (3).

Using the simulated U.S. monthly average prices in expression (3) provides 5,000 observations of each of the following prices: MYA price, five-month average price, November 30 Gulf price (localized to central Oklahoma by subtracting a constant transportation cost of 75¢/bu.), and the November 30 price of the December Kansas City futures contract. These simulations result in a November 30 basis (Oklahoma cash price minus KC December futures price) that has a mean of 26¢/bu. and a standard deviation of 12¢/bu. The simulated prices, together with the specified June 20 cash and futures prices, are used in expression (1) to evaluate the expected utility of each of the 234,375 post-harvest marketing strategies the producer considers.

Results

Results indicate that the biggest loss to producers from reducing deficiency payments is reduced revenue. Although the deficiency payment helps reduce revenue risk, marketing strategies are available that can reduce post-harvest risk nearly as well as or better than the deficiency payment program. A further result is that reducing or eliminating government deficiency payments would motivate many producers to increase use of futures or options, but not necessarily all producers.

Tables I–III present results for the four scenarios (deficiency payment program with target price of \$4.00; deficiency payment program with target price of \$3.17; no deficiency payment program, with 50% increase in price volatility; and no deficiency payment program, with 100% increase in price volatility) for three different levels of risk aversion. Table I indicates that under each scenario, producers with low risk aversion store all of their wheat at harvest and sell it on November 30; no futures or options are used. When risk matters little, the gain in cash price from harvest to November more than offsets the storage cost.¹⁴

Table I also shows that standard deviation of simulated returns from the unhedged storage strategy increases as deficiency payments are reduced or eliminated. The increased risk comes primarily from lowering or removing the “floor” on prices. However, with low risk aversion, the effect on risk of reducing or eliminating the deficiency payment is not enough to change the producer’s optimal strategy.

In contrast, Table II indicates that reducing or eliminating the deficiency payment increases risk enough to change the optimal strategy of producers with medium risk aversion. Under the \$4.00 target price sce-

¹⁴The cash price assumed here is the Gulf price less \$0.75/bu. for transportation costs. Thus, the cash prices should approximate central Oklahoma prices.

TABLE I
Optimal Post-Harvest Marketing Strategy for a Wheat Producer: Low Risk Aversion

	Participation in Government Program Target Price = \$4.00/bu.	Participation in Government Program Target Price = \$3.17/bu.	No Government Program (50% Higher Volatility)	No Government Program (100% Higher Volatility)
Expected Revenue (\$/bu)	\$4.01	\$3.29	\$3.23	\$3.23
Lowest and Highest	\$3.26	\$2.47	\$1.69	\$1.34
Returns in 5,000 Years (\$/bu)	\$5.13	\$4.88	\$6.01	\$7.36
Standard Deviation (\$/bu)	\$0.24	\$0.30	\$0.51	\$0.70
Risk-Adjusted Return (\$/bu)	\$4.01	\$3.29	\$3.23	\$3.23
Risk-Reducing Benefits Lost by Reducing Deficiency Payment (Compared to \$4.00 Target Price program) (\$/bu) ^a	—	\$0.00	\$0.00	\$0.00
Expected Deficiency and Findley Payments, and Interest (\$/bu)	\$0.79	\$0.06	\$0	\$0
Percent sold at Harvest	0	0	0	0
Futures				
Put (\$0.10 Out-of-the-Money)				
Call (\$0.10 In-the-Money)				

^aThese results are calculated using three decimal points rather than the two reported in the table.

TABLE II
Optimal Post-Harvest Marketing Strategy for a Wheat Producer: Medium Risk Aversion

	Participation in Government Program Target Price = \$4.00/bu.	Participation in Government Program Target Price = \$3.17/bu.	No Government Program (50% Higher Volatility)	No Government Program (100% Higher Volatility)
Expected Revenue (\$/bu)	\$4.01	\$3.28	\$3.22	\$3.22
Lowest and Highest Returns in 5,000 Years (\$/bu)	\$3.26	\$2.66	\$1.95	\$2.89
Standard Deviation (\$/bu)	\$5.13	\$3.95	\$3.65	\$3.54
Risk-Adjusted Return (\$/bu)	\$0.24	\$0.14	\$0.24	\$0.08
Risk-Reducing Benefits Lost by Reducing Deficiency Payment (Compared to \$4.00 Target Price program) ^a (\$/bu)	—	\$0.00	\$0.00	\$0.00
Expected Deficiency and Findley Payments, and Interest (\$/bu)	\$0.79	\$0.06	\$0	\$0
Percent sold at Harvest	0	0	0	0
Futures				Sell 2 Contracts
Put (\$0.10 Out-of-the-Money)				
Call (\$0.10 In-the-Money)		Sell 2 Contracts	Sell 2 Contracts	

^aThese results are calculated using three decimal points rather than the two reported in the table.

TABLE III
Optimal Post-Harvest Marketing Strategy for a Wheat Producer: High Risk Aversion

	Participation in Government Program Target Price = \$4.00/bu.	Participation in Government Program Target Price = \$3.17/bu.	No Government Program (50% Higher Volatility)	No Government Program (100% Higher Volatility)
Expected Revenue (\$/bu)	\$4.00	\$3.28	\$3.21	\$3.21
Lowest and Highest	\$3.34	\$2.66	\$2.89	\$3.21
Returns in 5,000 Years (\$/bu)	\$4.54	\$3.95	\$3.54	\$3.21
Standard Deviation (\$/bu)	\$0.15	\$0.14	\$0.08	\$0
Risk-Adjusted Return (\$/bu)	\$4.00	\$3.27	\$3.21	\$3.21
Risk-Reducing Benefits Lost by Reducing Deficiency Payment (Compared to \$4.00 Target Price program) ^a (\$/bu)	—	\$0.00	\$0.00	\$0.00
Expected Deficiency and Findley Payments, and Interest (\$/bu)	\$0.79	\$0.06	\$0	\$0
Percent sold at Harvest	50	0	0	100
Futures			Sell 2 Contracts	
Put (\$0.10 Out-of-the-Money)				
Call (\$0.10 In-the-Money)		Sell 2 Contracts		

^aThese results are calculated using three decimal points rather than the two reported in the table.

nario, those producers would store all of their wheat at harvest and sell it in November. The deficiency payment program provides sufficient protection against price risk to allow them to keep their grain in storage.

Under both the scenario with the target price reduced to \$3.17 and the scenario with no program and 50% higher volatility, the optimal strategy is to store all wheat at harvest and hedge by selling two in-the-money calls. Compared with an unhedged storage strategy, selling two calls reduces the standard deviation of revenue, one measure of risk, by about 50 percent. Under the \$3.17 target price scenario, standard deviation declined from \$0.30/bu. to \$0.14/bu. (compare the second column, third line in Table I with the second column, third line in Table II) and under the 50% higher volatility scenario it declined from \$0.51/bu. to \$0.24/bu. (compare the third column, third line of Table 1 with the third column, third line of Table 2). Under the 100% higher volatility scenario, producers reduce standard deviation by nearly 90% (compared to an unhedged storage strategy) by selling two futures contracts. Thus, producers with medium risk aversion use futures and options strategies to replace the deficiency payment program.

Table III indicates that under the \$4.00 target price scenario producers with high risk aversion sell half of their crop at harvest and store the other half for sale in November. While producers with medium risk aversion would store all wheat at harvest for sale in November, the deficiency payment does not sufficiently reduce price risk for producers with high risk aversion—the imperfect correlation between producers' price received and the average price from which the deficiency payment is calculated limits its risk-reduction ability. Storing all wheat at harvest for sale in November would increase expected revenue by \$0.01, but would also increase standard deviation to \$0.24, reducing risk-adjusted return for producers with high risk aversion to \$3.99 (see Table IV). Selling all wheat at harvest would also increase risk compared to the optimal strategy since it increases standard deviation of returns to \$0.22, \$0.07 higher than the \$0.15 achieved with the optimal strategy.

Under a target price of \$3.17, producers with high risk aversion would store wheat at harvest and hedge by selling two call options. Selling two futures contracts instead of two call options would better hedge the price risk alone, but the deficiency payment is an additional uncertain source of revenue. It partly offsets the price risk, so maximizing risk-adjusted return requires these producers to hedge less completely. Under the scenario with no deficiency payment and 50% higher volatility, however, a full hedge (storing and selling two futures contracts) is optimal since the only source of risk is price risk.

TABLE IV

Risk-Adjusted Returns (\$/bu.) for Optimal Strategy Compared with Simple Standard Strategies

	<i>Participation in Government Program Target Price = \$4.00/bu.</i>	<i>Participation in Government Program Target Price = \$3.17/bu.</i>	<i>No Government Program (50% Higher Volatility)</i>	<i>No Government Program (100% Higher Volatility)</i>
Low Risk Aversion				
Optimal Strategy	\$4.01	\$3.29	\$3.23	\$3.23
Selling at Harvest	\$3.98 (0.7%)	\$3.27 (0.6%)	\$3.21 (0.6%)	\$3.21 (0.6%)
Selling in November	\$4.01 (0%)	\$3.29 (0%)	\$3.23 (0%)	\$3.23 (0%)
Simple Hedge	\$4.00 (0.2%)	\$3.27 (0.6%)	\$3.22 (0.3%)	\$3.22 (0.3%)
Medium Risk Aversion				
Optimal Strategy	\$4.01	\$3.28	\$3.22	\$3.22
Selling at Harvest	\$3.99 (0.7%)	\$3.27 (0.5%)	\$3.21 (0.3%)	\$3.21 (0.3%)
Selling in November	\$4.01 (0%)	\$3.28 (0%)	\$3.20 (0%)	\$3.17 (1.2%)
Simple Hedge	\$3.99 (0.5%)	\$3.27 (0.3%)	\$3.21 (0.3%)	\$3.22 (0%)
High Risk Aversion				
Optimal Strategy	\$4.00	\$3.27	\$3.21	\$3.21
Selling at Harvest	\$3.98 (0.7%)	\$3.26 (0.3%)	\$3.21 (0%)	\$3.21 (0%)
Selling in November	\$3.99 (0.5%)	\$3.26 (0.3%)	\$3.14 (2%)	\$3.06 (4.7%)
Simple Hedge	\$3.97 (1.0%)	\$3.26 (0.3%)	\$3.21 (0%)	\$3.21 (0%)

Under the scenario with no deficiency payment and 100% higher volatility, producers with high risk aversion find that even hedging with futures contracts does not sufficiently reduce risk, so they decide to sell all wheat at harvest. This reduces risk to zero.

To more specifically answer the question of whether these marketing strategies are capable of replacing the risk-reducing aspects of the deficiency payment program, the fifth line of each table calculates the risk-reduction benefit lost by the producer when the deficiency payment is reduced or eliminated. For example, in Table III the risk-adjusted return in the scenario with target price of \$4.00 is \$4.00/bu., while the risk-adjusted return with a \$3.17 target price is \$3.27/bu. Subtracting the deficiency payment plus interest in the second scenario (\$0.06) from the

deficiency payment plus interest in the first scenario (\$0.79) gives a difference in deficiency payments between the two scenarios of \$0.73. Subtracting this reduction in expected deficiency payment from the risk-adjusted return for the \$4.00 target price scenario gives $\$4.00 - \$0.73 = \$3.27$. This is the same return as the risk-adjusted return under the \$3.17 target price scenario. Thus, although producers lose \$0.73 in expected deficiency payment revenue, they lose no risk-reduction benefit when the deficiency payment is reduced. This result also holds for producers with low and medium risk aversion. The main benefit that producers receive from the deficiency payment is an increase in income since the risk-reducing benefit is small.

Comparison with Simple Standard Strategies

Table IV compares risk-adjusted returns for the optimal strategy chosen by producers of each level of risk aversion with the simple standard strategies of selling at harvest, selling in November, and a simple hedge. For example, under the \$4.00 target price scenario, a producer with medium risk aversion achieves a risk-adjusted return of \$4.01/bu. by choosing the optimal strategy identified in Table II, but achieves a risk-adjusted return of \$3.99/bu. when selling at harvest, a reduction of 0.5%. Comparing the producer's optimal strategies with standard strategies suggests that the losses from choosing one of these simple strategies instead of the optimal strategy are relatively small, but are somewhat larger for more risk averse producers.

Also, eliminating deficiency payments increases the importance of those choices. The highest percentage losses occur when producers with medium or high risk aversion store wheat at harvest for later sale, with no hedge protection. With no deficiency payment, these producers would find a straight hedge or sale at harvest the best simple strategy.

To summarize, after subtracting the income increase due to the deficiency payment program, producers lose little risk-reduction benefit when target prices are reduced or eliminated. A far bigger loss to producers is the revenue-increasing aspects of the deficiency payment program, although this loss would be smaller than reported here when participating in the government program required a set-aside of eligible acres.¹⁵

¹⁵If the producer was not able to meet the Flex Acres from other base acres, so that a portion of the acres assumed here were used for Flex Acres, the standard deviation of returns for the scenarios with participation in the government program would be higher than reported here.

Sensitivity to Changes in Interest Rate/Expected Basis Gain

The above results assumed commercial storage costs of 2¢/bu./month, and a cost of capital of 10%, the average rate over the time period. Results reported by Betts (1996) indicate that if a producer faces storage costs that are only slightly higher (1¢/bu./month higher) or has a cost of capital two percentage points higher than the average rate, the optimal strategy under all of the scenarios is to sell wheat at harvest because the total cost of storage and foregone interest is higher. This is consistent with the results obtained by Anderson and Adam (1991). Then, the producer faces no further price or revenue risk, and hedging is not needed.¹⁶

However, if storage costs are sufficiently reduced, even producers with medium and high risk aversion store and hedge their grain. A set of tables available from the authors shows the results of applying the analysis described above in an environment where interest rates are 6% instead of 10%. Since the model assumes that the futures market is efficient, lowering interest rates is essentially the same as increasing the expected basis gain; the net return from hedging is increased by lowering storage costs. A reduction in interest rates from 10% to 6% has the same effect as increasing basis gain from June 20 to November 30 by five cents/bushel. Thus, reducing the interest rate increases the expected return both for storing and selling later and for storing, hedging and selling later, relative to selling at harvest.¹⁷

With reduced interest rates, the results indicate that for all scenarios and for all levels of risk aversion, producers will store grain at harvest for later sale. For producers with medium and high risk aversion, under scenarios where the deficiency payment is reduced or eliminated and price volatility increases, their long cash position is hedged by selling call options or futures contracts.¹⁸

¹⁶The exception to this is that under the deficiency payment program with a \$4.00 target price, if a risk averse producer sells all wheat at harvest, he would hedge the deficiency payment by some combination of selling puts, buying futures contracts, and buying calls. Because there is no cash position to offset it, the deficiency payment introduces risk.

¹⁷A reviewer has noted that in some years harvest basis will be lower than average making hedging relatively more attractive than the initial formulation suggests. The portion of the analysis with reduced interest rate confirms this observation. Lower storage costs (or higher expected basis gains) make hedging relatively more attractive and selling at harvest relatively less attractive as risk management alternatives to the deficiency payment program.

¹⁸The actual strategies chosen are sensitive to the assumptions about interest rate, storage costs, and other parameters of the model. But the expected values of the top strategies are similar enough that even when the optimal strategies may differ, the certainty equivalent return does not change substantially. This suggests that the simulation reflects a market that is reasonably consistent with the law of one price. As a consequence, producers are unlikely to find marketing strategies that perform substantially better on average than the simple strategies considered here, unless they have extra year-specific information.

CONCLUSIONS

The biggest loss to producers from eliminating deficiency payments is reduced revenue. While the risk-reduction features of the deficiency payment program were significant, in that a deficiency payment helped reduce revenue risk when grain was stored, the deficiency payment increased risk when grain was sold at harvest. Moreover, the results reported here indicate that the deficiency payment program was no more effective than other approaches in reducing revenue risk associated with storing grain.

Some have predicted that eliminating the deficiency payment program would lead to increased use of futures and options. These results support that prediction for many producers, since for producers with medium or high risk aversion, eliminating the deficiency payment increases hedging.¹⁹ These producers will likely store their wheat at harvest, compensating for the lack of deficiency payment protection by increasing use of futures and options contracts. However, if eliminating the deficiency payment substantially increases price volatility, producers with high risk aversion, opportunity cost, or storage cost will instead sell all wheat at harvest, eliminating all revenue risk. This study did not consider the effects on preharvest hedging strategies or the associated risk of long-term investment decisions.

BIBLIOGRAPHY

- Anderson, K. (1991). Marketing government program wheat. OSU Extension Facts No. 520, Oklahoma State University Cooperative Extension Service.
- Anderson, K., & Adam, B. D. (1991). Cash marketing wheat. OSU Extension Facts No. 516, Oklahoma State University Cooperative Extension Service.
- Anderson, K., & Sahs, R. (1999). Basis tables. Working paper, Oklahoma State University Cooperative Extension Service.
- Anderson, K. B., & Noyes, R. T. (1989). Grain storage costs in Oklahoma. OSU Extension Facts No. 210, Oklahoma State University Cooperative Extension Service.
- Arias, J. (1995). A dynamic optimal hedging model under price, basis, production and financial risk. Unpublished Ph.D. Dissertation, Oklahoma State University.

¹⁹As previously noted, producers with low risk aversion will not increase hedging. Producers with very high risk aversion will not increase hedging, and may even decrease hedging. For producers with higher risk aversion than the levels reported here, simulation results indicated that under the deficiency payment program, the optimal strategy is to sell wheat at harvest (eliminating price risk), and then to hedge the uncertain deficiency payment by, for example, buying a call option. Eliminating the deficiency payment program removes the need to hedge.

- Betts, S. P. Effects of reduced government deficiency payments on post-harvest marketing strategies. (1996). Unpublished M.S. Thesis, Oklahoma State University.
- Cox, J. C., & Rubinstein, M. (1985). *Options Markets*. Englewood Cliffs, New Jersey: Prentice-Hall.
- Crain, S. J., & Lee, J. H. (1996) Volatility in wheat spot and futures market, 1950–1993: Government farm programs, seasonality, and causality. *The Journal of Finance*, 51, 325–343.
- Gardner, B. L. (1977). Commodity options for agriculture. *American Journal of Agricultural Economics*, 59, 986–992.
- Irwin, S. H., Peck, A. E., Doering III, O. C., & Brorsen, B. W. (1988). A simulation analysis of commodity options as a policy alternative. *Options, futures, and agricultural commodity programs: Symposium proceedings* (pp. 60–71). Washington DC: U.S. Department of Agriculture, ERS, February.
- Kang, T., & Brorsen, B. W. (1995). Valuing target price support programs with average option pricing. *American Journal of Agricultural Economics*, 77, 106–118.
- Mapp, J. N. (1989). Simulation and systems modeling. In Tweeten, L. (Ed.), *Agricultural policy analysis tools for economic development*, Boulder: Westview Press.
- Mathews K. H., & Holthausen, D. M. (1991). A simple multiperiod minimum risk hedge model. *American Journal of Agricultural Economics*, 73, 1020–1026.
- Naylor, T. H., Balintfy, J. L., Burdick, D. S., & Chu, K. (1966). *Computer simulation techniques*. New York: John Wiley & Sons, Inc.
- Raskin, R., & Cochran, M. J. (1986). Interpretations and transformations of scale for the Pratt-Arrow absolute risk aversion coefficient: Implications for generalized stochastic dominance. *Western Journal of Agricultural Economics*, 11, 204–210.
- Robison, L. J., & Barry, P. J. *The competitive firm's response to risk*, New York: Macmillan Publishing Co.
- SHAZAM User's Reference Manual, Version 7.0, 1993. Technical Tools. Electronic data. Los Altos, California.
- Tirupattur, V., & Hauser, R. J. (1994). Valuation of U.S. agricultural support programs: A contingent claims analysis approach. In Brorsen, B. W. (Ed.), *NCR-134 Conference: Applied commodity price analysis, forecasting, and market risk management*, Stillwater, OK: Oklahoma State University.
- Turvey, C. G., & Baker, T. G. (1990). A farm-level financial analysis of farmers' use of futures and options under alternative farm programs. *American Journal of Agricultural Economics*, 72, 946–957.
- United States Department of Agriculture. *Agricultural Prices*, National Agricultural Statistics Service/Agricultural Statistics Board, 1974–1993 issues.

Copyright of Journal of Futures Markets is the property of John Wiley & Sons, Inc. / Business and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.