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Valuing Counter-Cyclical Payments

Implications for Producer Risk Management and Program Administration

Gerald E. Plato, David W. Skully, and D. Demcey Johnson

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Abstract

USDA's current method for estimating expected counter-cyclical payment rates produces unintentionally biased estimates because it does not consider the variability of marketing year prices. Estimates with positive bias increase the risk of overpayment to producers who accept advance payments. According to statute, producers must reimburse the Government for any overpayments, which can lead to cash-flow problems. A model developed for this analysis improved upon the USDA method of estimating counter-cyclical payment rates by accounting for the variability in market price forecast errors. This enhanced method produced unbiased estimates. Forecasters and producers can also use the model to calculate the probabilities of repayment. Producers can use call options on commodity futures contracts to hedge against losses in expected counter-cyclical payments. Hedging, however, is only moderately effective and varies by commodity.

Keywords: 2002 Farm Act, farm and commodity policy, counter-cyclical payments, risk management, price uncertainty.

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Summary

The 2002 Farm Act instituted a new program called counter-cyclical payments. The payments supplement the incomes of producers with established base acres in wheat, soybeans, upland cotton, corn, grain sorghum, barley, oats, rice, or peanuts. Eligible producers receive payments when a designated crop's marketing-year average price falls below its effective target price, which is established by legislation. Counter-cyclical payments are tied to a fixed production base rather than actual production. Thus, producers cannot augment their payment amounts by changing their planting decisions.

The counter-cyclical payment rate after a marketing year ends equals the effective target price minus the larger of the marketing-year average price for a commodity and the commodity's national marketing loan rate, a price level specified in the Farm Act. Each month, USDA updates the forecasts of the marketing-year average prices (published in the *World Agricultural Supply and Demand Estimates* (WASDE) report). The October and February forecasts are used to calculate advance counter-cyclical payments for the current marketing year.

What Is the Issue?

USDA's current method for estimating expected counter-cyclical payment rates produces unintentionally biased estimates because it does not consider the variability of marketing year prices. Estimates with positive bias increase the risk of overpayment to producers who accept advance payments. According to statute, producers must reimburse the Government for any overpayments, which can lead to cash-flow problems for producers.

What Did the Study Find?

A model developed for this analysis improved upon the USDA method of estimating counter-cyclical payment rates by accounting for the variability in market price forecast errors. This enhanced method produced unbiased estimates. Forecasters and producers can also use the model to calculate the probabilities of repayment. Producers can use call options on commodity futures contracts to hedge against losses in expected counter-cyclical payments. Hedging, however, is only moderately effective and varies by commodity.

How Was the Study Conducted?

The model developed here uses an approach based on option pricing theory to derive an unbiased estimate of expected counter-cyclical payments and the probabilities that advance payments will have to be repaid. Data required to run the model included the policy parameters in the 2002 Farm Act, a forecast of a crop's marketing-year average price, and an estimate of forecast variability (based on the past history of WASDE forecasts).

This report also describes a simulation exercise to evaluate hedging opportunities. Expected counter-cyclical payments were hedged with call options on futures contracts. In principle, by hedging with call options, producers can reduce the risk of lower counter-cyclical payments (due to a price increase), while retaining potential gains in payments (from a price decline). Simulated price data—both marketing-year average and futures contract price forecast and outcome—were used to estimate expected payoffs from the hypothetical hedge. The correlations and variances of the simulated prices matched those found in historical price data.

Valuing Counter-Cyclical Payments

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and D. Demcey Johnson

Introduction

The 2002 Farm Security and Rural Investment Act (the 2002 Farm Act) instituted a new program called counter-cyclical payments. The payments are intended to supplement the incomes of producers with established base acres for wheat, soybeans, upland cotton, corn, sorghum, barley, oats, rice, or peanuts. Eligible producers receive payments when the marketing-year average price for a designated commodity falls below its effective target price. Effective target prices are established by legislation. The payments provide income protection through a range of statutorily specified price levels (with coverage lasting for the duration of the 2002 Farm Act) that was not available under the 1996 Farm Act.

Counter-cyclical payments replaced market loss assistance (MLA) payments that Congress granted on an ad hoc basis during 1998-2001 (see box, "Historical Background: Similar Policies That Preceded Counter-Cyclical Payments"). Like MLA payments, counter-cyclical payments are tied to historical entitlements, rather than actual production. Some restrictions apply to plantings of fruits or vegetables, but otherwise producers are free to plant whatever they like on their base acres—acres on which payments are made. This makes it difficult to generalize about the effectiveness of counter-cyclical payments as a hedge against commodity price risk. Some individuals who are eligible to receive a counter-cyclical payment do not grow the covered commodity. Others do grow the covered commodity but use futures or options to manage their price risk. In either case, recipients are likely to view counter-cyclical payments not as a hedging instrument but as a separate financial asset (unrelated to production) characterized by risk and return. From this perspective, it is important to understand the expected value of counter-cyclical payments and the associated risks.

The 2002 Farm Act authorizes the U.S. Secretary of Agriculture to make advance counter-cyclical payments in October and in February if the latest USDA forecast of the marketing-year average price (updated monthly) for a crop falls below its effective target. However, USDA price forecasts, like all price forecasts, are subject to error—as producers of some commodities

Historical Background: Similar Policies That Preceded Counter-Cyclical Payments

Counter-cyclical payments are similar to deficiency payments that were first authorized by the Agriculture and Consumer Protection Act of 1973 (the 1973 Farm Act). Deficiency payments were eliminated by the Federal Agriculture Improvement and Reform Act of 1996 (the 1996 Farm Act).

The deficiency payment rate for a commodity equaled its target price minus the larger of its national loan rate and a market price. Before the 1985 Farm Act, only the average farm market price for the first 5 months of the marketing year was used to calculate deficiency payments. After the 1985 Farm Act went into effect (beginning with the 1986 crop year) both the 5-month and the 12-month average farm market prices were used to determine deficiency payment rates The 1990 Farm Act continued these provisions through the 1995 crop year.

A commodity's deficiency payment for a farm equaled the product of the commodity's deficiency payment rate, the farm's payment yield, and the farm's payment acres. Young et al. (2005) explain the procedures used for determining payment yields and payment acres.

Advanced deficiency payments based on payment rate forecasts were authorized by the 1986 Farm Act. Generally, repayments were required when total deficiency payments based on market price outcome were smaller than advance deficiency payments based on price forecasts.

The 1996 Farm Act replaced deficiency payments with fixed payment rates called Production Flexibility Contract (PFC) rates. PFC payments were unaffected by production and market price outcomes. A farm's total fixed payment each year equaled the product of the established fixed payment rate, the farm's payment yield, and the farm's payment acres. Payment yields were fixed at 1985 levels and payment acres were fixed at 1996 levels. Direct payments in the 2002 Farm Act replaced the PFC payments in the 1996 Farm Act.

The PFC payments were supplemented by Marketing Loss Assistance (MLA) payments in fiscal years 1999, 2000, and 2001 to compensate producers for low prices. These payments were authorized and appropriated by ad hoc emergency assistance acts, passed in response to low commodity prices. Counter-cyclical payments in the 2002 Farm Act essentially replaced MLA payments. The 2002 Farm Act, like the 1996 Farm Act, continued fixed payments, but they are now called direct payments and are unrelated to current production or market prices.

have learned when, as a result of higher prices late in a marketing year, advance payments had to be repaid to the Government. Our analysis provides a way to estimate probabilities of repayment given the underlying uncertainty about commodity prices—information that can benefit both payment recipients and program managers.

As part of its baseline analysis, USDA develops long-term projections of budgetary outlays for commodity programs. Recently, the baseline analysis has incorporated stochastic simulations, which capture the effects of yield uncertainty on prices and (consequently) commodity-program expenditures over a 10-year period (*USDA Agricultural Baseline Projections to 2015*, February 2006). The analysis presented here also makes use of stochastic simulation; however, this analysis is more short term, focusing on price uncertainty within a marketing year.

We developed an easy-to-implement computer program for estimating expected counter-cyclical payments and the probability that advance payments will have to be repaid, given a forecast of the marketing-year average price for a designated commodity. Data required to run the program are the WASDE price forecast, an estimate of forecast variability, and the policy parameters for counter-cyclical payments (outlined in the 2002 Farm Act).

Forecast price error plays an important role in the analysis. When expected counter-cyclical payment rates do not account for forecast error, they can be seriously biased. Our method provides a more reliable picture of expected counter-cyclical payments. We also investigate the risks associated with counter-cyclical payments from a producer perspective, and possibilities for hedging these risks.

The Counter-Cyclical Policy Instrument

Counter-cyclical payments are available on a designated commodity under the 2002 Farm Act when the commodity's marketing-year average price is less than its effective target price. The counter-cyclical payment rate equals the effective target price minus the higher of the commodity's marketing-year average price and the commodity's national loan rate. The payment amount for an eligible producer equals the product of the payment rate, the producer's payment acres, and the producer's payment yield.[1]

Counter-Cyclical Payment Rate

Counter-cyclical payment rates depend on the marketing-year average price and several policy parameters. Target prices, direct payment rates, and national loan rates for the nine eligible crops are specified in the 2002 Farm Act and are shown in table 1. For convenience, we refer to the effective target price for eligible crops. This price equals the target price minus the direct payment rate (table 1). Equation 1 shows how the counter-cyclical payment rate is calculated.[2, 3]

$$(1) \qquad CCP\ rate = \max\{ET - \max[P, LR], 0\}$$

where ET is the effective target, P is the actual marketing-year average price, and LR is the national loan rate for the eligible crop. In other words, the payment rate is the difference (if positive) between the effective target price and the higher of the marketing-year average price and the loan rate. A crop's maximum counter-cyclical payment rate equals its effective target price minus its national loan rate. As shown in equation 1, this occurs whenever the marketing year average price is less than the national loan rate.

Figure 1 depicts the method used to calculate counter-cyclical payment rates for soybeans. The effective soybean target price is $5.36 per bushel, and the national soybean loan rate is $5.00 per bushel. The soybean counter-cyclical payment rate is zero when the marketing-year average soybean price is greater than or equal to the effective target price ($5.36 per bushel). The payment rate is maximized at $0.36 per bushel when the marketing-year average soybean price is less than or equal to the national loan rate ($5.00 per bushel). For intermediate prices—between the effective target and the national loan rate—the payment rate is offset (reduced) as the soybean price moves higher. Similar relationships hold for all the designated crops.

The marketing-year average price is a weighted national average of prices received by farmers. Weights reflect the proportion of the crop sold in each month.

USDA, National Agricultural Statistics Service (NASS) calculates marketing-year average price outcomes and publishes them in its monthly *Agricultural Prices* (table 2). USDA makes final counter-cyclical payments

[1]A producer is one who assumes crop production and price risk. This can be an owner-operator, landlord, tenant, or share cropper (the 2002 Farm Act sec., 1001 Definitions). A landlord receiving cash rent is not a producer, but a landlord receiving crop share is a producer. We do not discuss procedures used to divide counter-cyclical payments among multiple producers on a farm.

[2]Target prices are slightly higher and loan rates are slightly lower for five of the crops for marketing years 2004-07, compared with marketing years 2002 and 2003. The direct payment rate remains the same for all nine crops for the duration of the 2002 Farm Act. Maximum counter-cyclical payment rates for the five crops were increased by the sum of the target price increases and loan rate decreases.

[3]This is mathematically equivalent to the statutory formula in the 2002 Farm Act (Public Law 107-171, May 13, 2002). Our formulation makes use of the effective target price, rather than showing the target price and direct payment rate separately. This makes clear where the level of price protection actually begins.

for a commodity after the publication of the commodity's marketing-year average price outcome.

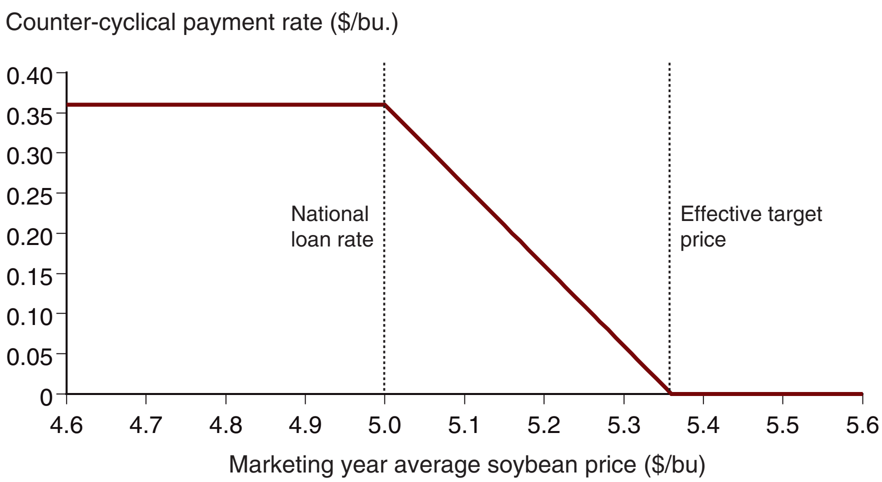
It is important to distinguish between actual prices and price forecasts. Actual marketing-year average prices are calculated only at the end of a marketing year, based on 12 months of price information. USDA makes price forecasts during the marketing year. USDA publishes its price forecasts monthly (for the current marketing year) in *World Agricultural Supply and Demand Estimates* (WASDE). Producers can receive advance counter-cyclical payments, if authorized by the Secretary, in October and February if the forecast of the marketing-year average price for a crop is less than its effective target.

Equation 1 also provides a means to project counter-cyclical payment rates: the WASDE price forecast can be substituted for P (the actual marketing-year average price) in the calculation.[4] However, the results do not necessarily represent an unbiased estimate of the counter-cyclical payment.

[4]Essentially, this is how USDA, Farm Service Agency (FSA) projects counter-cyclical payments to determine advance payments in October and February.

Figure 1

Soybean counter-cyclical payment rate for a marketing year using USDA method



Source: USDA, Economic Research Service.

Table1

Policy variable levels for calculating counter-cyclical payment rates

Item	Target price		Direct payment rate,	Effective target price		National loan rate	
	2002-03	2004-07	2002-07	2002-03	2004-07	2002-03	2004-07
Barley $/bu	2.21	2.24	0.24	1.97	2.00	1.88	1.85
Corn $/bu	2.60	2.63	0.28	2.32	2.35	1.98	1.95
Oats $/bu	1.400	1.440	0.024	1.376	1.416	1.350	1.330
Sorghum $/bu	2.54	2.57	0.35	2.19	2.22	1.98	1.95
Peanuts $/ton	495	495	36	459	459	355	355
Soybeans $/bu	5.80	5.80	0.44	5.36	5.36	5.00	5.00
Rice $/cwt	10.50	10.50	2.35	8.15	8.15	6.50	6.50
Upland cotton $/lb	0.724	0.724	0.0667	0.6573	0.6573	0.520	0.520
Wheat $/bu	3.86	3.92	0.52	3.34	3.40	2.80	2.75

Source: Prepared by USDA, Economic Research Service using data from Westcott et al., 2002.

Table 2
Marketing-year start and end dates and marketing-year average-price release months

Commodity	Marketing year	Released in monthly *Agricultural Prices*
Barley	June 1 to May 31	June
Corn	September 1 to August 31	September
Oats	June 1 to May 31	June
Sorghum	September 1 to August 31	September
Peanuts	August 1 to July 31	August
Soybeans	September 1 to August 31	September
Rice	August 1 to July 31	January
Upland cotton	August 1 to July 31	October
Wheat	June 1 to May 31	June

Source: Prepared by USDA, Economic Research Service using USDA, National Agricultural Statistics Service, *Agricultural Prices*.

Total Counter-Cyclical Payments

As shown in equation 2, total counter-cyclical payments for a given crop and producer are calculated as the product of the counter-cyclical payment rate, the farm's payment acres for the crop, and the farm's program yield for the crop. Payment acres equal 0.85 times a farm's base acres.

$$(2)\quad TCCP = CCP\ rate \times payment\ acres \times CCP\ program\ yield$$

A farm's base program acres are determined by the farm's planting history and one-time base updating choices provided by the 2002 Farm Act. A farm's counter-cyclical program yield is based on its yield history. Young et al. (2005) examined producers' choices in base acre and program yield updating.

Advance Payments, Final Payments, and Repayment Situations

Producers choose to accept or decline offers of advance payments. Advance partial payment rates in October can equal up to 35 percent of the forecast total counter-cyclical payment rate for the marketing year. Advance payment rates in February can equal up to 70 percent of the forecast total counter-cyclical payment rate for the marketing year.

If the February advance payment rate is greater than the October payment rate, USDA offers producers who accepted the October payment a reduced February payment. The reduced advance February payment rate offered equals the advance February rate minus the October rate.

The total counter-cyclical payment rate is based on the average marketing-year price outcome reported by USDA, NASS. It can be calculated (using equation 1) at the end of a marketing year. The total rate is the final rate if no advance payment was accepted. Otherwise, the final rate equals the total payment rate minus advance payment rate(s) received.

If the sum of advance payments accepted exceeds the total payment rate, producers are obliged to repay the difference to the Government.[5] A producer can choose to let the Commodity Credit Corporation (CCC) automatically reduce future direct and counter-cyclical payments by the amount of the overpayment. For the 2003 crop, reductions could be made from October 2004 to October 2005.[6] For the 2004 crop, reductions could be made from October 2005 to October 2006. The 2002 crop had no overpayments.

If payment reductions over a designated period are not large enough to meet the repayment obligation, producers must repay the remaining balance according to the procedures established under the Debt Collection Improvement Act of 1996 (1996 DCIA). Producers may also repay the balance by submitting a check to the CCC. Again, 1996 DCIA procedures apply.

[5]Advance payment timing is different for the 2007 marketing year. For marketing year 2007, an advance payment equal to 40 percent of the expected counter-cyclical payment can be made after the first 6 months (see 2002 Farm Act, title I, sec. 1104 and sec. 1304).

[6]The offset period was extended from March 2005 to October 2005 (*Federal Register*, March 21, 2005).

Forecasting Expected Counter-Cyclical Payment Rates

In designing a model to estimate expected counter-cyclical payment rates, we modified a procedure that is used to analyze a special class of options—specifically, those with payments based on an average price. Option pricing theory and methods are appropriate for estimating counter-cyclical payment rates because the returns from buying a put option at the effective target price and selling a put option at the national loan rate equals the counter-cyclical payment rate[7] (app. A).

The option pricing procedure used requires only four variables: two policy variables and two market variables. The two policy variables are the effective target price (target price minus direct payment) and the national loan rate. The two market variables are the USDA-WASDE marketing-year average price forecast and its variability (app. B). All but forecast variability are provided. Forecast variability must be estimated.

Analysts typically use two approaches to estimate price variability for use in option pricing models. One approach uses option trading data to estimate expected price variability. The other uses time series price data to estimate historical price variability.

We designed an alternative approach that estimates the variability of marketing-year average price forecast errors. The forecast errors were calculated by subtracting USDA-WASDE forecasts from USDA, NASS reported price outcomes. The forecast errors measure the variability of price outcomes about price expectations (app. C). The forecasts were taken from the October and February WASDE reports for marketing years 1980 through 2004, and they reflect the midpoints of the USDA-WASDE projected price ranges.[8]

As the marketing year progresses, uncertainty about the (eventual) marketing-year average price lessens. Thus, estimates of forecast variability are considerably lower in February than in October (table 3). The focus of this analysis, however, is not comparing the forecast variability estimates, but examining and comparing the effects of forecast variability on the level and variability of counter-cyclical payment rates.

Using the forecast variability estimates, we estimated the relationships between forecasted marketing-year average prices and expected counter-cyclical

Table 3
Variability of WASDE forecast errors of marketing-year average price—marketing years 1980-2004

Commodity	October variability	February variability
Corn	0.08	0.04
Oats	0.07	0.03
Sorghum	0.08	0.05
Soybeans	0.08	0.04
Rice	0.12	0.07
Wheat	0.04	0.02

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors.

[7]A put option provides price protection by providing a payment equal to its strike price minus the price being protected when its outcome is less than the strike price.

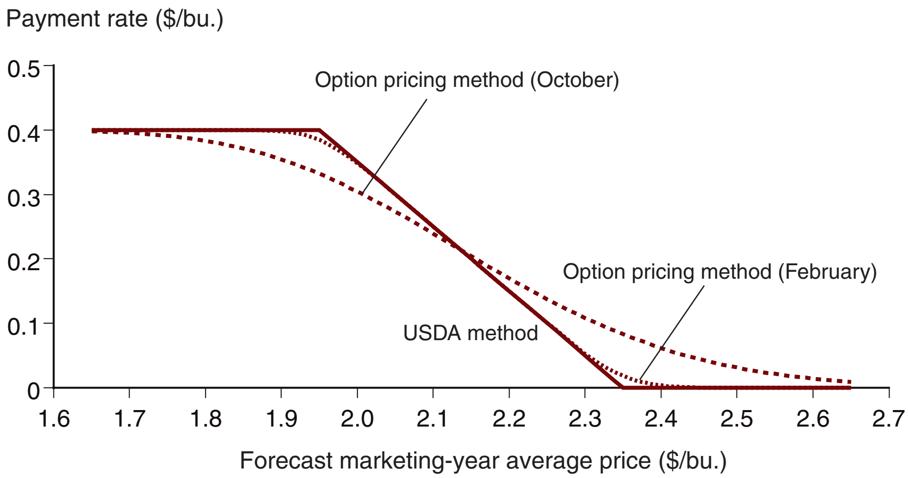
[8]USDA, FSA uses midpoint price forecasts in estimating counter-cyclical payments. This choice is not mandated by legislation.

payment rates for corn, wheat, soybeans, and rice (figs. 2, 3, 4, 5). Data for the solid lines (USDA method) were obtained by calculating the counter-cyclical payment rate using equation 1 at 1-cent intervals for forecasted marketing-year average prices. The leftward kink in each solid line in figures 2 through 5 occurs at the national loan rate, and the rightward kink occurs at the effective target price. The levels for the national loan rates and target prices in figures 2 through 5 are the 2004-07 crop year levels (see table 1).

Data for the dashed lines (option pricing method) were obtained by solving the option pricing model in appendix B at 1-cent intervals for forecasted prices. These calculations account for forecast variability. The range for the forecasted price begins below the national loan rate and extends above the effective target price.

Figure 2

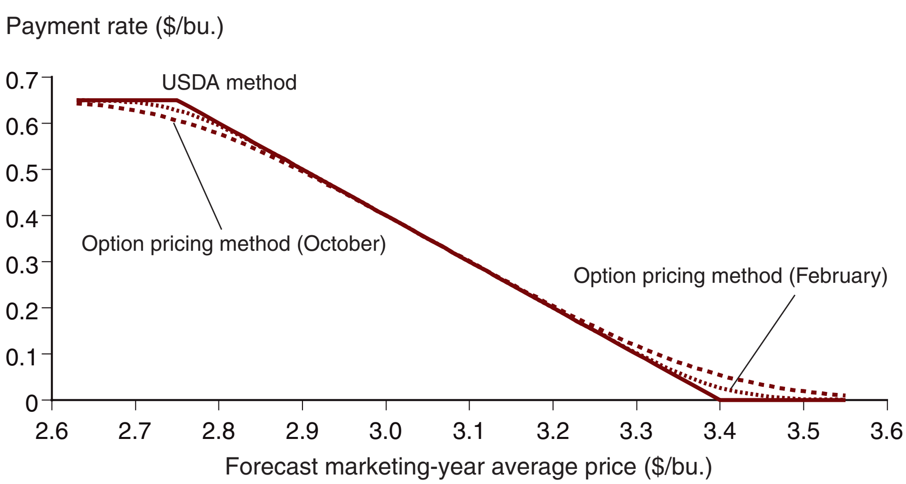
Expected counter-cyclical payment rates for corn



Source: Prepared by USDA, Economic Research Service using WASDE corn forecast errors and the 2004-2007 corn national loan rate and effective target price.

Figure 3

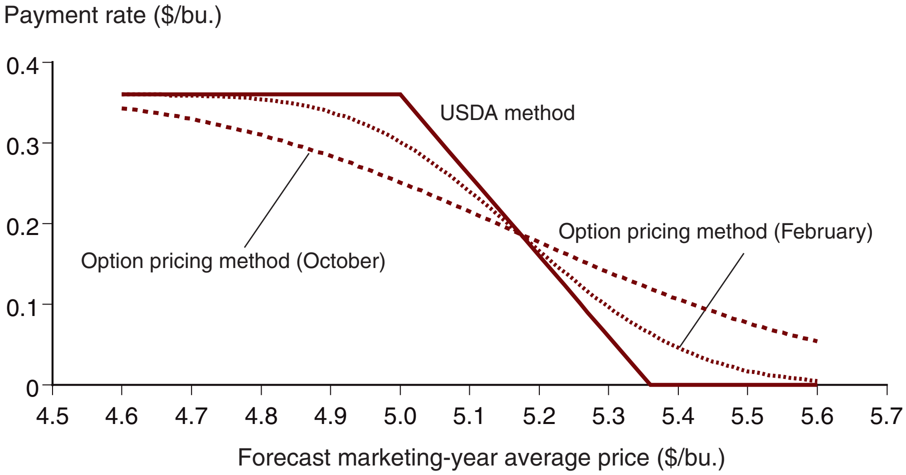
Expected counter-cyclical payment rates for wheat



Source: Prepared by USDA, Economic Research Service using WASDE wheat forecast errors and the 2004-2007 wheat national loan rate and effective target price.

Figure 4

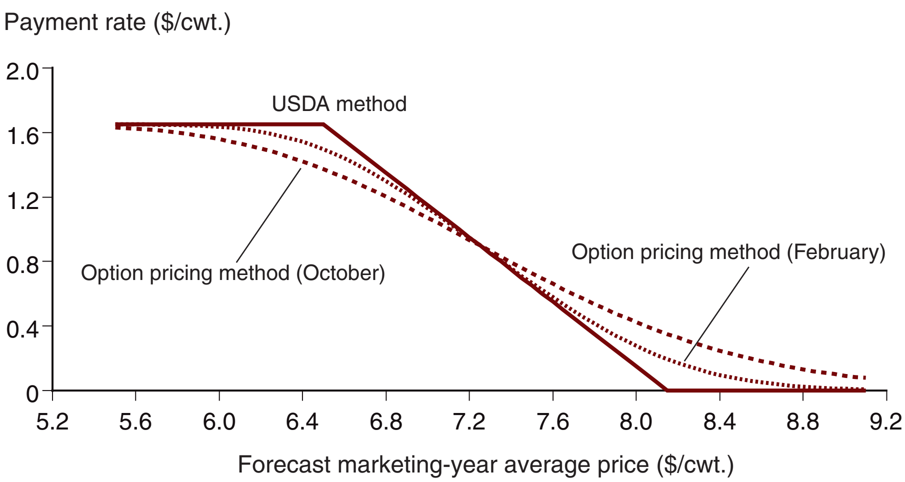
Expected counter-cyclical payment rates for soybeans



Source: Prepared by USDA, Economic Research Service using WASDE soybean forecast errors and the 2004-2007 soybean national loan rate and effective target price.

Figure 5

Expected counter-cyclical payment rates for rice



Source: Prepared by USDA, Economic Research Service using WASDE rice forecast errors and the 2004-2007 rice national loan rate and effective target price.

The vertical difference between a dashed and solid line in figures 2 through 5 is called time value in the options pricing literature.[9] Here, time value indicates the extent of bias (for a given price forecast) when projections of the counter-cyclical payment rate do not take account of forecast variability:[10]

- If time value is positive (dashed line above solid line), a projection based simply on the forecast marketing-year average price entails *negative bias*. That is, the counter-cyclical rate is underestimated.
- If time value is negative (dashed line below solid line), a projection based simply on the forecast marketing-year average price entails *positive bias*. That is, the counter-cyclical rate is overestimated.

[9]When applied to options, time value is derived as the difference between two values: the current option premium, and its intrinsic value (the buyer's return from immediate exercise). Time value is computed similarly in our context—as the difference between two values—with the added complexity that time value can be either positive or negative due to the characteristics of counter-cyclical payments (see appendix D for details).

[10]In our context, time value equals the value of expected counter-cyclical payments when forecast variability is taken into account (indicated by dashed line) *minus* the value of the payment implied by the current forecast of the marketing-year average price (indicated by solid line).

When time value is positive, the expectation is that the counter-cyclical payment will rise relative to the estimate based simply on the current marketing-year price forecast. In the options pricing literature, positive time value is interpreted as the expected reward for waiting.[11] Conversely, when time value is negative, the expectation is that the counter-cyclical payment will fall relative to the estimate based simply on the current price forecast. We interpret negative time value as the penalty for not being able to receive the counter-cyclical payment immediately based on the current marketing year price forecast.

Forecast variability has a large influence on the expected counter-cyclical payment rate. This can be seen by examining the differences between the solid lines and dashed lines for corn, soybeans, and rice. The differences are much larger for October than for February, reflecting the much larger forecast variability for October (see table 3). The differences are much smaller for wheat in part because October is the fifth month of the wheat marketing year while October is the second month of the marketing year for corn and soybeans and the third month of the marketing year for rice. Forecast variability declines as less time remains in the marketing year.

October time values can be large for soybeans and rice. For soybeans, estimated maximum positive and negative time values are +12 and -11 cents per bushel. For rice, the corresponding estimates are +35 and -28 cents per cwt. (+20 cents and -16 cents per bushel).

Maximum October time values are smaller for wheat and corn. For wheat, the maximum time values are +6 and -5 cents per bushel. For corn, the maximum time values are +8 and -7 cents per bushel. The smaller time values for wheat are due to lower forecast variability. Those for corn are due to lower price levels.

Not considering positive time value (bias) reduces advance partial payment levels and their frequency. No advance partial payments are made when forecasted price is greater than the effective target price, although the expected counter-cyclical payment rate can be large. Not considering positive time value also reduces producer repayment levels and frequency. This may be considered as beneficial to producers.

Not considering positive time value underestimates USDA budget cost. One policy choice is to continue not accounting for positive time value in calculating advance partial payments but to account for it in estimating the budgetary cost of counter-cyclical payments.

Not considering negative time value has opposite effects. Producer advance partial payments and repayment frequencies are increased, and expected budgetary costs are overestimated.

[11]In the context of options pricing, time value reflects the chance of a favorable price movement prior to option expiration. High time value discourages immediate exercise.

Estimating Counter-Cyclical Repayment Frequencies and Repayment Rates

Repaying counter-cyclical payments can cause cash-flow problems for producers, especially if the counter-cyclical payment instrument is not used to protect crop price. Central to the decision concerning the use of an advance counter-cyclical payment is its expected repayment probability and repayment rate.

We estimated expected repayment probabilities and expected repayment rates for the advance payments offered for the 2002, 2003, and 2004 marketing years using the option pricing procedure discussed in appendix B.[12] Data for making our estimated repayment probabilities and rates included the WASDE marketing-year average price forecasts for the 2002, 2003, and 2004 marketing years, the historical variability of WASDE marketing-year average price forecasts, and the effective target prices and national loan rates. We omitted peanuts and upland cotton from this part of our analysis because these two commodities do not have a history of WASDE forecast errors.

The large range of estimated repayment probabilities draws attention to the need for producers to be aware of their current situation regarding repayment probabilities (table 4). We estimated that the probabilities of repaying the entire advance payment were less than ½ percent for rice in both October and February in the 2002 marketing year and for corn and sorghum in February of the 2004 marketing year. The corresponding estimated repayment rates were small relative to the advance payments.[13] For example, for corn in February of the 2004 marketing year, the total advance payment was \$0.28 (\$0.14 + \$0.14) per bushel and the estimated repayment rate was \$-0.0023 per bushel.

At the other extreme, the probability estimate of repaying the entire advance payment for sorghum in February for the 2003 marketing year was 99 percent. We estimated that nearly all the corn advance in February of the 2003 marketing year would be repaid. The estimated probability of repaying all or part of the advance payment for corn was 98 percent (91 percent plus 7 percent).

We further compared the estimates in table 4 to understand the influences of WASDE price forecasts, forecast variability, effective target prices, and national loan rates on repayment probabilities and rates. The large variation in estimated repayment probabilities and rates provides an opportunity to sort out the influences of these variables. Understanding the influences of these variables, in turn, enables us to understand why there is such a large range in estimated repayment probabilities.

Estimated corn repayment probabilities and rates vary considerably between the 2003 and 2004 marketing years in February due to the higher WASDE February corn price forecast for the 2003 marketing year. The February corn price forecast for the 2003 marketing year was 13 cents per bushel above the effective target price while the corresponding forecast for 2004 was 40 cents

[12]We simulated marketing-year price outcomes and corresponding counter-cyclical payment rate outcomes given a USDA-WASDE marketing-year average price forecast and the advance payment rate based on the price forecast. Then we tabulated the repayment frequency and calculated the average repayment rate from the simulated payment rate outcomes and the advance payment rate. The tabulated frequencies are our repayment probability estimates.

[13]USDA, FSA reports counter-cyclical payment rates to four decimal places.

Table 4

Estimated repayment probabilities and rates, for advance counter-cyclical payments made in the 2002, 2003, and 2004 marketing years

Commodity	Marketing-year average price[1]			Counter-cyclical payment rates[1]			Probability of total repayment, %		Probability of partial repayment, %		Expected repayment rate[1,3]	
	October (forecast)	February (forecast)	Final (actual)	October advance payment	February advance payment	Final payment[2]	October	February	October	February	October	February
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
							2002					
Rice	4.10	3.80	4.49	0.5775	0.5775	0.4950	<1/2	<1/2	<1/2	<1/2	<-.0005	<-.0005
							2003					
Corn	2.10	2.45	2.42	0.0770	0	-0.0770	10	91	10	7	-0.0109	-0.0737
Sorghum	2.15	2.45	2.39	0.0140	0	-0.0140	39	99	3	<1/2	-0.0058	-0.0138
Rice	6.35	7.25	8.08	0.5775	0.0525	-0.5600	2	4	5	24	-0.0195	-0.0880
Wheat	3.25	3.35	3.40	0.0315	0	-0.0315	24	56	8	17	-0.0087	-0.0203
							2004					
Corn	1.95	1.95	2.06	0.1400	0.1400	0.0100	1	<1/2	4	6	-0.0035	-0.0023
Oats	1.40	1.40	1.48	0.0056	0.0056	-0.0112	43	34	2	11	-0.0024	-0.0045
Sorghum	1.90	1.70	1.79	0.0945	0.0945	0.0810	2	<1/2	5	<1/2	-0.0041	<-.0005
Soybeans	5.10	5.10	5.74	0.0910	0.0910	-0.1820	25	10	7	24	-0.0261	-0.0378
Rice	7.25	7.40	7.33	0.3150	0.2100	0.2950	15	8	9	24	-0.0608	-0.0946
Wheat	3.30	3.375	3.40	0.0350	0	-0.0350	22	35	8	20	-0.0091	-0.0159

[1] Prices and payment rates are in $/cwt for rice and $/bu for other commodities.

[2] Negative final payment indicates repayment to government.

[3] Calculated as difference between expected counter-cyclical payment rate (taking account of forecast variability) and advance payments received to date.

Source: Prepared by USDA, Economic Research Service using USDA, Farm Service Agency reported advance payments and WASDE forecast errors.

per bushel below the effective target price. The estimated repayment rate of $-0.0737 per bushel in February for the 2003 marketing year is just slightly below the entire advance October payment of $0.0777 per bushel. Our corresponding estimated repayment rate for the 2004 marketing year is $-0.0023 per bushel, although the total advance payment in February is much larger—$0.28 ($0.14 + $ 0.14) per bushel versus $0.077 per bushel. The estimated total repayment probability in February for the 2004 marketing year was less than ½ percent while that for the 2003 marketing year was 91 percent. The repayment probability and rate estimates for corn in the 2003 and 2004 marketing years emphasizes the need to consider the influence of the level of the price forecast relative to the effective target price.

The variation in the sorghum repayment probability and rate estimates for the 2003 and 2004 marketing years mirrors those for corn and reinforces the need to consider the influence of the WASDE price forecast level relative to the effective target price. The large sorghum WASDE price forecast in February relative to the effective target price for the 2003 marketing year had the same effect as that for corn. The estimated repayment rate in February of the 2003 marketing year was essentially equal to advance payment. The estimated repayment probability was 99 percent. The estimated sorghum repayment probability was less than ½ percent in February of the 2004 marketing year. The estimated repayment rate is less than $0.0005 per bushel, an extremely small amount compared with the advance payment rate of $0.1890 (0.0945 + 0.0945) per bushel.

Estimated rice total repayment probabilities were low for the 2002 and 2003 marketing years. For the 2002 marketing year, estimated total repayment probabilities in October and in February were less than ½ percent. For the 2003 marketing year, the corresponding estimates were 2 and 4 percent. Yet $0.56 per cwt of $0.63 ($0.5775 + $0.0525) per cwt advance payment rate in the 2003 marketing year had to be repaid.[14] This example points out that unexpected outcomes do occur and that maximum losses from counter-cyclical payments need to be considered in addition to estimated repayment probabilities and rates.

[14]On a per bushel basis, the rice repayment rate is $0.32 per bushel.

Our probability estimates for rice in February of the 2003 marketing year do indicate a significant chance of repayment. We estimated a 29-percent (4 +24) probability that all or some of the advance would have to be repaid. The expected repayment rate is $-0.0880 per bushel. These estimates could raise concerns about the need for repayment.

For February of the 2004 marketing year, we estimated total and partial rice repayment probabilities of 8 and 24 percent and an expected repayment rate of $0.09 per cwt. However, no repayment was required.

Soybeans in the 2004 marketing year provide the other example of a large counter-cyclical repayment rate. However, the large repayment rate for soybeans was not as unexpected as it was for rice in the 2003 marketing year. For October, we estimated that there was a 25-percent repayment probability that the entire 2004 advance payment would have to be repaid. The probability of repaying the entire advance decreased to 10 percent in February even though the total advance in February was two times as large as the total advance in October. Both the October and February WASDE forecasts were $5.10 per bushel. The estimated February repayment rate was lower because the variability of the WASDE marketing-year average price forecast was lower for February than for October. The unexpected total soybean counter-cyclical repayment, especially as viewed from February, again points out the need to consider maximum possible repayment. The soybean example also points out the need to consider differences in the variability of the WASDE marketing-year average price forecasts between October and February.

Oats in the 2004 marketing year had small advance payment rates and large estimated repayment probabilities because the WASDE price forecast of $1.40 per bushel was just below the effective target price of $1.416 per bushel. The estimated total repayment probability in October was 43 percent. The entire advance payment had to be repaid. This example draws attention to large repayment probabilities that are associated with small advance payments. The WASDE marketing-year price forecast in this situation was just slightly below the effective target price, implying that that the marketing-year average outcome would be above the target price about as frequently as it would be below it.

Wheat in October of the 2003 and 2004 marketing years had nearly equal advance payments because the WASDE wheat price forecasts were $0.09 and $0.10 per bushel below the effective target prices, respectively. As would be expected, the estimated repayment probabilities are slightly larger in October of the 2003 marketing year. The estimated repayment rate is slightly larger for October of the 2004 marketing year because of the slightly larger advance payment rate. The estimated total repayment probability was higher in February of the 2003 marketing year because the WASDE wheat price forecast was $0.01 per bushel higher than the effective support price while the price forecast in February of the 2004 marketing year was $0.025 lower.

Hedging Expected Counter-Cyclical Payments

A producer eligible to receive a counter-cyclical payment for a crop may choose not to use the payment to reduce the crop's price risks.[15] Instead, a producer may choose a different way to reduce a crop's price risk, not to reduce a crop's price risk, or not to plant the crop. Choosing not to use counter-cyclical payments to reduce a crop's price risk raises the question: Can the expected counter-cyclical payment be hedged (insured) using existing financial instruments? Hedging an expected counter-cyclical payment involves protecting against loss of a counter-cyclical payment from an increase in the expected marketing-year average price.

This analysis examines the use of call options on futures contracts to hedge the expected counter-cyclical payment rate.[16] Call options can be used to hedge against the risk of a price rise because call options are a one-sided bet, paying out when a price rises above a specified level (the strike price) and paying nothing when a price falls below that level. Payments of call options on futures contracts tend to move opposite to counter-cyclical payments. Thus, a hedge with call options on futures contracts allows producers to protect against declines in counter-cyclical payments while capturing increases in counter-cyclical payments when prices fall.

The objective is to use call options in a way that makes their return move in opposition to the counter-cyclical payment rate. It is not possible to have call option gains move exactly opposite to the counter-cyclical payment rate losses (that is, to form a perfect hedge) because futures prices are not perfectly correlated with marketing-year average prices. We estimated the degree to which call options on futures contracts can reduce the variance of counter-cyclical payment rate losses.

We used appendix tables E-1, E-3, and E-5 and the policy parameters in table 1 to estimate counter-cyclical payment losses and the returns to hedging with call options on futures. The three appendix tables are based on the USDA-WASDE forecast errors and corresponding futures price forecast errors in the first month of the marketing year for marketing years 1977-2003.[17] Appendix E describes how the data were used to examine the hedging effectiveness of call options on futures contracts.[18] We estimated hedges that reduce the variance of counter-cyclical payment losses by the maximum amount. Table 5 shows the results from the hedging examination.

We estimated small reductions in the variance of counter-cyclical payment losses from hedging with call options for corn and soybeans (table 5). Our hedge ratio estimates—call option bushels to eligible counter-cyclical bushels—were also small. The largest corn variance reduction was 34 percent and the largest total hedge ratio was 0.31 (.00 + 0.31) call option bushels per eligible counter-cyclical payment bushel. The March corn call option contract provided almost all of the price protection because the hedge ratio for the corn December contract was essentially zero. The largest soybean variance reduction was 18 percent, and the largest total hedge ratio was 0.09 (0.01 + 0.02 + 0.06) call option bushels per eligible counter-cyclical payment bushel.

[15]Maximizing crop price risk reduction (hedging effectiveness) with counter-cyclical payments involves matching the ratio of sales each month to the amount eligible for counter-cyclical payments with the weights used to calculate the marketing-year average price. The monthly weights must be estimated because they are not known until the end of the marketing year. Hedging effectiveness depends on the precision in estimating the monthly weights and on the level of correlation between local and national marketing year prices.

[16]A call option on a futures contract provides the buyer with the right to receive a payment at option expiration at the rate equal to the futures price at contract expiration minus the option's strike price if the rate is greater than zero. An option seller must pay at this rate if greater than zero. No payment is given or received if the rate is less than or equal to zero, that is, if the futures price at expiration is less than or equal to the strike price. The payment rules provide protection against the price rising above the option's strike price.

[17]We could not construct a data set for cotton because WASDE cotton price forecasts are prohibited by Federal law. Data sets for barley and peanuts could not be constructed because they do not trade on U.S. futures exchanges. Rice futures have not been trading long enough for us to develop a data set. We chose not to examine oats.

[18]Our hedging analysis is made on a per bushel basis. Hedging effectiveness would be reduced by matching the number of bushels in call option contracts with a producer's eligible counter-cyclical payment bushels.

Table 5

Effectiveness of hedging counter-cyclical payments and hedging ratios using call options on futures contracts

Commodity	Call option contracts	Forecasted marketing-year average price	Variance reduction in counter-cyclical losses	Ratio call option gain to counter-cyclical losses	Hedge ratios[1]
		$/bu	*Percent*		
Corn					
	Dec.	1.95	12	0.23	.24
	Dec., Mar.	1.95	22	0.41	.00 .31
	Dec., Mar., May	1.95	34	0.45	.00 .18 .11
	Dec.	1.70	8	0.19	.17
	Dec., Mar.	1.70	20	0.36	.01 .22
	Dec., Mar., May	1.70	21	0.38	.02 .13 .08
Soybeans					
	Nov.	5.10	7	0.09	.04
	Nov., Jan.	5.10	13	0.13	.00 .06
	Nov., Jan., Mar.	5.10	18	0.18	.00 .01 .04
	Nov.	4.50	6	0.11	.07
	Nov., Jan.	4.50	11	0.16	.01 .07
	Nov., Jan., Mar.	4.50	17	0.21	.01 .02 .06
Wheat					
	Sept.	2.75	29	0.38	.46
	Sept., Dec.	2.75	48	0.60	.25 .31
	Sept., Dec., Mar.	2.75	51	0.63	.27 .18 .13
	Sept.	2.25	18	0.31	.32
	Sept., Dec.	2.25	33	0.54	.21 .24
	Sept., Dec., Mar.	2.25	36	0.60	.22 .13 .12

[1]Call option bushels per counter-cyclical payment bushel. Hedge ratios are for the corresponding call option contracts in the second column.

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors and futures price forecast errors.

Estimated variance reductions in counter-cyclical payment losses and hedge ratios were considerably larger for wheat. In addition, the estimated ratios of call option gains to counter-cyclical losses were much larger for wheat. For wheat, the largest estimated variance reduction in counter-cyclical payments was 51 percent, and the largest total hedge ratio was 0.58 (0.27 + 0.18 + 0.13). The hedge included the September, December, and March contracts.

Risk of a counter-cyclical payment rate loss can be considerably less when the forecasted marketing-year average price is below the national loan rate. For example, our hedging examination for wheat estimated a 1-in-10 chance of a counter-cyclical payment rate loss with an expected loss of $0.18 per bushel when the forecast marketing-year average price was $2.25 per bushel. Expected counter-cyclical payment loss is the average loss given that there is a loss. Zero counter-cyclical payment losses (when the marketing-year average price is less than its forecast level and/or less than the national loan rate) are excluded when calculating expected loss. We estimated about a 1-in-2 chance of a loss with an expected counter-cyclical payment rate loss of $0.29 per bushel when the forecast price was equal to the national loan rate of $2.75 per bushel. Call options for hedging are less expensive with the lower $2.25 forecast price because their strike price would be far above the current futures price. A lower call option price is an important factor in deciding whether or not to hedge at the lower forecast marketing-year average price.

Maximum counter-cyclical payment rate losses are small when forecast marketing-year average prices are close to the effective target price, making hedging less attractive, although the chance of a loss may be large. We estimated an expected loss of $0.08 per bushel with a 1-in-2-chance of a loss when the forecasted wheat marketing-year average price was $3.30 per bushel—$0.10 per bushel less than the effective target price. Hedging effectiveness at the $3.30 per bushel forecast, measured by the reduction in counter-cyclical payment rate variance, was less than 12 percent.

The call option hedge does not protect the positive time value portion of the expected counter-cyclical payment. Positive time value of the expected counter-cyclical payment reflects the possibility that the marketing-year average price will be smaller than its forecast level. The call option hedge only provides protection against price increases relative to the marketing-year average price forecast level. This is advantageous for producers because positive time values should not be hedged; they reflect the potential gains in counter-cyclical payments that are associated with downside price risk.

The negative time values associated with the counter-cyclical payment rate can be hedged because they reflect the possibility that the marketing-year average price will be larger than its forecasted level, lowering payments.

Buying futures contracts is not appropriate for hedging a counter-cyclical payment. A hedge with futures can be effective when the marketing-year average price outcome is between the national loan rate and the effective target price. In this price range, losses on one side of the hedge tend to be offset by gains on the other side; however, when the marketing-year average price falls below the national loan rate, there would typically be losses on the futures side of the hedge without counter-cyclical payment gains.

Implications and Discussion

Counter-cyclical payments were designed with a view toward supporting farm incomes in a low-price environment, and without distorting production incentives. Unlike marketing loans, counter-cyclical payments are tied to historical plantings and yields, not current production. But unlike fixed, direct payments, counter-cyclical payments are linked to current market prices. Counter-cyclical payments thus represent a kind of policy hybrid—one whose implications for producers are not yet fully understood.

This report has focused on risks associated with counter-cyclical payments. The risks are associated with forecasts of the marketing-year average price for a designated commodity, the advance payments offered by USDA, and the chance that these payments will have to be repaid by producers.

The U.S. Secretary of Agriculture has some discretion about the magnitude of advance payments (although maximum levels are specified in legislation). Methods presented in this report can be used to assess the risk that attaches to advance payments, given historical uncertainty about forecasts of marketing-year average prices. Program officials are also interested in the budget exposure associated with counter-cyclical payments. As shown in this report, ignoring the variability of marketing-year average price forecasts can introduce a high degree of bias into projections of program payments. Through simulation analysis with the option pricing model we developed as part of this analysis, payments can be projected without this bias.

During the 2003 and 2004 marketing years, producers faced large repayments for rice and soybeans, respectively. This stemmed from underestimates of marketing-year average price when advance payments were made. In other instances, such as for wheat in the 2005 marketing year, producers received small advance payments that they later repaid to USDA. Based on our analysis, the probability of full repayment is inversely related to the size of the advance payment. These probabilities should be taken into account when farmers decide how to use their advance payments. From a program perspective, it may not be cost effective for USDA to make small advance payments, especially in view of the significant chance of repayment by producers and associated administrative costs.

Counter-cyclical payments are intended to provide a form of price protection for producers of the designated commodity. However, not all recipients of counter-cyclical payments continue to grow the designated commodity. Others do grow the commodity but avail themselves of other forms of price protection (by using futures or options, for example). In these cases, producers are likely to regard counter-cyclical payments as a kind of financial asset, characterized by risk and return, rather than as an instrument of risk management for their current production. For recipients who view payments this way, the risk is that counter-cyclical payments will fall below expectations. Our analysis indicates that this risk can be reduced—but only moderately—by hedging the expected payments with call options. Given the low effectiveness of this hedging strategy, producers may be more inclined to simply hold their advance payments in conservative investments.

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Glossary

Base acreage—A farm's crop-specific acreage of wheat, feed grains, upland cotton, rice, oilseeds, or peanuts eligible to participate in commodity programs under the 2002 Farm Act.

Call option—A contract that gives the buyer the right, but not the obligation, to buy a specified quantity of a commodity, a futures contract, or other financial instrument (regardless of its market price) at a price called the strike price.

Contract market—A board of trade or exchange designated by the Commodity Futures Trading Commission to trade futures contracts and option contracts under the Commodity Exchange Act.

Decoupled payments—Government program payments to producers that are not linked to the current levels of production, prices, or resource use. When payments are decoupled, producers make production decisions based on expected market returns rather than expected government payments.

Deficiency payments—Government payments to producers who prior to the 1996 Farm Bill, participated in an annual commodity program for wheat, feed grains, rice, or cotton. The crop-specific payment rate for a particular crop year was based on the difference between an established target price and the higher of the commodity loan rate or the national average market price for the commodity during a specified time period. A deficiency payment to a producer was calculated as the product of the payment rate, the farm's eligible payment base acreage, and the farm's established program payment yield.

Futures contract—A contract traded on a contract market to purchase or sell a commodity or financial asset in the future at a market price that is determined at initiation of the contract. All terms of a futures contract, except price, are specified by the contract market.

Hedge—A transaction intended to reduce or eliminate an existing risk.

Hedge ratio—Ratio of hedging instrument quantity to the quantity of the financial asset or commodity being hedged.

Intrinsic value—The amount by which the market price for the underlying commodity or futures contract is above the strike price of a call option or below the strike price of a put option.

Market loss assistance payments—Producer payments authorized by emergency legislation in 1998-2001.

Marketing year—The 12-month period starting with the month when the harvest of a specific crop typically begins. The 1998 wheat crop year, for example, is June 1, 1998, through May 31, 1999. The amount harvested during this time is then considered the "1998 crop."

Option premium or price—The market price of an option.

Payment yield—Farm commodity per acre yield (as determined by legislation) used in calculating direct and counter-cyclical payments.

Put option—A contract that gives the buyer the right, but not the obligation, to sell a specified quantity of a commodity, futures contract, or other financial instrument (regardless its market price) at a price called the strike price.

Strike price—The price, specified in an option contract, at which the underlying commodity, futures contract, or other financial instrument can be purchased or sold.

Target price—Prices established in the 2002 Farm Act used for calculating counter-cyclical payments for wheat, corn, grain sorghum, barley, oats, rice, upland cotton, oilseeds, and peanuts. Target prices are fixed for 2002-03 and then raised to fixed levels for 2004-07, except for soybeans and rice, which remain at the 2002-03 levels. Prior to 1996, target prices were used to calculate deficiency payments.

Time value—That portion of an option's premium or price that exceeds the intrinsic value.

Volatility—Standard deviation of the rate of price change of a futures contract or other financial instrument.

Appendix A—Equivalence of Counter-Cyclical Payment Rate and Put Option Returns

Let:
ETP = Effective target price
MYAP = Marketing-year average price
NLR = National Loan Rate

Returns to buying a put option with a strike price equal to the effective target price

(1a) (ETP – MYAP) MYAP < ETP or (1b) 0 MYAP ≥ ETP

Returns to selling a put option with a strike price equal to the national loan rate

(2a) - (NLR – MYAP) MYAP < NLR or (2b) 0 MYAP ≥ NLR

Break (1a) into 2 parts

(3a) (ETP – MYAP) NLR ≤ MYAP < ETP (3b) (ETP – MYAP) MYAP < NLR

Break 3b into 2 parts after subtracting and adding NLR

(4a) (ETP – NLR) MYAP < NLR (4b) (NLR – MYAP) MYAP < NLR

Returns to buying and selling the put options {(1b) + (3a) + (4a) + (4b)} + {(2a) + (2b)}
{(2a) and (4b) sum to zero} leaving {(1b) + (3a) + (4a)} + {(2b)}

Returns from (1b), (3a), and (2b) apply when MYAP ≥ NLR
Returns from (4a) apply when MYAP ≤ NLR

(3a) (ETP – MYAP) NLR ≤ MYAP < ETP or (1b) 0 MYAP ≥ ETP

(4a) (ETP – NLR) MYAP ≤ NLR or (2b) 0 MYAP ≥ NLR

(3a), (4a), and (2b) are combined in one term in (5) and (1b) is separate

Equation (5) below is the same as equation (1) in the text

(5) {ETP – (maximum of MYAP and NLR)} MYAP < ETP or 0 MYAP ≥ ETP

Appendix B—Option Pricing Procedure Used To Estimate Expected Counter-Cyclical Payment Rates

Equations (1) and (2) are used to estimate expected counter-cyclical payment rates.

$$(1)\quad p_{s,mya} = p_{f,mya} e^{-1/2\sigma_f^2 + \sigma_f z} \qquad s = 1, 2, 3, \ldots\ldots\ldots\ 10{,}000$$

$p_{s,mya}$ = a simulated marketing-year average price outcome

$p_{f,mya}$ = a forecasted USDA-WASDE marketing-year average price

σ_f = variability of the natural logarithm of USDA-WASDE forecast outcomes to USDA-WASDE forecasts

z = a random draw from the standard normal probability distribution

(2) Counter-cyclical payment rate =
{(Effective target price) - (larger of: a simulated marketing year average price outcome and national loan rate)} if greater than zero

Otherwise:
= 0

Equation 1 is used to simulate 10,000 marketing-year average price outcomes for a forecast of the marketing year average price. The outcomes reflect estimated forecast error variability. Equation 2 uses the 10,000 price outcomes to simulate 10,000 counter-cyclical payment rate outcomes at marketing-year end. Equation 2 differs from equation 1 in the text in that it contains a simulated marketing-year average price outcome rather than a USDA, NASS-reported or a WASDE-forecasted marketing-year average price. The 10,000 simulated price outcomes and corresponding payment rate outcomes for a forecasted marketing-year average price represent a sample from all the possible outcomes at marketing-year end as viewed from the date on which the marketing-year average price forecast was made. The average of the payment rate outcomes from the sample estimates the expected counter-cyclical payment rate. The standard deviation of the payment rate outcomes estimates the variability of the expected counter-cyclical payment rate.[1]

We estimated the expected frequency (probability) of repaying all of an advance partial payment by counting the number of simulated zero total counter-cyclical payment rates for a forecasted marketing year average price. The expected frequency of repaying all the advance partial payment is the count divided by 10,000.

We also estimated the expected frequency of repaying part or all of the advance partial payment by counting the number of less-than-zero simulated counter-cyclical payment rates. The count divided by 10,000 is the expected frequency of repaying part or all of an advance partial payment.

[1]Our procedure for estimating counter-cyclical payment rates differs from the simulation procedure used to solve option pricing models. The simulation procedures used to solve option pricing models simulate entire price paths (for example, all the daily prices) from the current date until option expiration. For example, the Kema and Vorst and the Turnbell and Wakeman simulation procedures for estimating average option prices simulate entire price paths. We did not simulate the entire price path of a time series because there are no reported time series whose average price equals the marketing-year average price.

The average of the 10,000 simulated price outcomes, $p_{s,mya}$, from equation 1 is an unbiased estimate of the forecast, $p_{f,mya}$. We specified equation (1) to produce unbiased estimates of expected marketing-year average prices.[2]

Simulation procedures similar to the procedure we used are used to solve option models with payments based on an arithmetic average price because, like our model for counter-cyclical payments, they do not have analytical solutions. Analytical approximation methods have been shown to be less accurate for estimating options with payments based on average price than the simulation procedure (James, 2003, pp. 215-216). In addition, the simulation procedure can estimate the variability of the expected counter-cyclical payment rate.

[2]Adding g to the exponent in equation 3, as follows, $e^{(g-1/2\sigma_f^2)+\sigma z}$ produces biased simulated forecasts when g is not equal to zero. The average forecast error or bias is (e^g-1) times the forecast.

Appendix C—Procedure for Estimating Forecast Error Variability

(1) $\hat{\mu}_{fe} = (1/25)\sum_{i=1}^{25} \ln(p_{oi} / p_{fi})$

(2) $\sigma_{fe} = (1/24)\sqrt{\sum_{i=1}^{25} [\ln(p_{oi} / p_{fi}) - \hat{\mu}_{fe}]^2}$

where :

$i = 1,2, \ldots\ldots, 25$ is for marketing years 1980 through 2004

p_{fi} = marketing - year average price forecast for marketing year i

p_{oi} = marketing - year average price outcome for marketing year i

ln = the natural logarithm

$\hat{\mu}_{fe}$ = average continuous growth rate in the forecast error

σ_{fe} = standard deviation of the continuous growth rate in the forecast error

Appendix D—Determination of Time Value in the Counter-Cyclical Payment Rate

Appendix figure 1 shows the relationship between time value in the counter-cyclical payment rate and the forecasted marketing-year average price.

Time value in the figure was calculated by subtracting the line labeled "USDA method" from the line labeled "Option pricing method (October)" in figure 4. Time values in figures 2, 3, or 5 would work equally well in explaining the relationship between time value and forecasted marketing-year average price.

The time value corresponding to a forecasted marketing-year average price is determined by the potential price moves relative to the forecast. The potential price moves are the potential forecast errors—potential marketing-year average price outcomes minus the forecasted marketing-year average price.

Time value can be estimated by:

1. Averaging the effects of the potential price increases relative to a forecasted marketing-year average price on the counter-cyclical payment rate and subtracting the intrinsic value,[1]
2. Averaging the effects of the potential price decreases relative to a forecasted marketing-year average price on the counter-cyclical payment rate and subtracting the intrinsic value, and
3. Averaging time values from steps 1 and 2.[2]

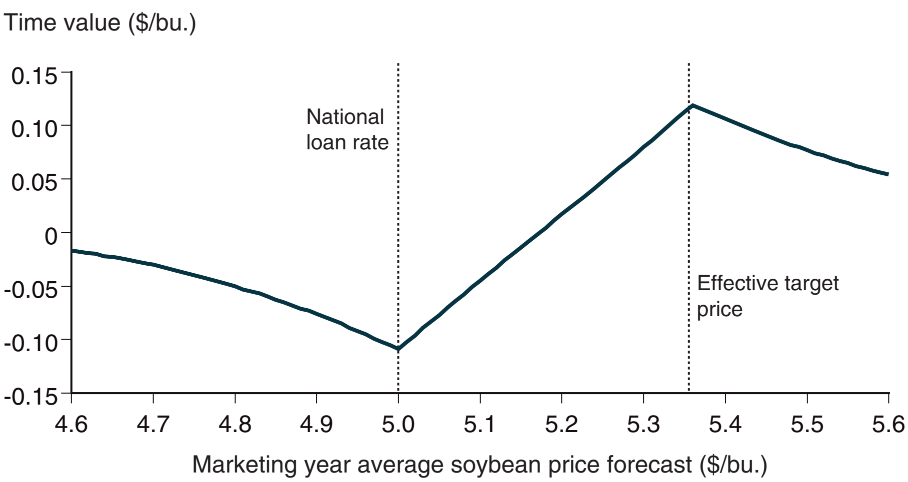
The following figure and description of estimating the effects of potential price increases and decreases relative to a forecasted price on time value are used to explain the relationship between time value and forecasted price and

[1]Intrinsic value is the counter-cyclical payment rate evaluated at the forecasted marketing-year average price level. The counter-cyclical payment rates for the curves labeled "USDA method" in figures 2 through 5 are intrinsic values.

[2]The option pricing procedure we used and described in appendix B could be programmed to separate the simulated price movements into positive and negative movements relative to each forecasted price and programmed to use the procedure described in steps 1, 2, and 3 to estimate the counter-cyclical payment rate and time value.

Appendix figure 1

Time value for USDA-WASDE October-soybean marketing year average price forecasts



Source: Compiled by USDA, Economic Research Service using the option pricing model, the USDA method, and the soybean data.

how time value is determined. The explanation uses two levels and three ranges of forecasted marketing-year average price.

1. Forecasted Marketing-Year Average Price equals National Loan Rate (the lower kink in the curve)

   Time value is smallest and less than zero. No potential price decreases relative to the national loan rate can increase the counter-cyclical payment rate. All potential price increases relative to the national loan rate decrease the counter-cyclical payment rate.

2. Forecasted Marketing-Year Average Price equals Effective Target Price (the upper kink in the curve)

   Time value is largest and greater than zero. All potential price decreases relative to the effective target price increase the counter-cyclical payment rate. No potential price increases decrease the counter-cyclical payment rate.

3. Forecasted Marketing-Year Average Price is greater than zero and less than National Loan Rate (before the lower kink)

   As forecasted price increases, the effects of all potential negative price movements relative to forecasted price on the counter-cyclical payment rate remain constant at the maximum counter-cyclical payment rate. As forecasted price increases, the average effect of the potential positive price movements relative to forecasted price decreases the expected counter-cyclical payment rate.

4. Forecasted Marketing-Year Average Price is greater than National Loan Rate and less than Effected Target Price (between the kinks)

   As forecasted price increases, the average effect of potential negative price movements on the counter-cyclical payment rate become larger and the average effect of potential positive price movements on the counter-cyclical payment rate become smaller. The net effect is an increase in the counter-cyclical payment rate. The figure shows that as the forecasted marketing-year price increases from the level of the national loan rate, a price level is reached where the average effects of the potential price increases and potential price decreases on the counter-cyclical payment rate balance—resulting in zero time value.

5. Forecasted Marketing-Year Average Price is greater than Effective Target Price (after the upper kink)

   As forecasted price increases, the effects of all potential price increases relative to forecasted price on the counter-cyclical payment remain constant at zero while the average effects of the potential price decrease—resulting in smaller expected counter-cyclical payment.

Appendix E—Hedging the Counter-Cyclical Payment Rate With Call Options on Futures Contracts

The following equation shows the returns to hedging counter-cyclical payment rate losses with call options on futures contracts.

(1) hedging returns =

$$\sum_{i=1}^{N} \{(\text{hedge ratio}_i)(\text{futures call option return}_i)\} - \text{counter-cyclical payment loss}$$

futures call option return$_i$ = return for futures call option contract with expiration (maturity) date i

hedge ratio i = ratio of call option bushels to bushels eligible for counter-cyclical payments or call option i

N = number of futures call option contract expiration dates.

A counter-cyclical payment loss relative to price expectations occurs when the marketing-year average price outcome is larger than the forecasted marketing-year average price and also larger than the national loan rate. The size of a loss equals the smaller of the marketing-year average price outcome and the effective target price minus the larger of the forecasted marketing-year average price and the national loan rate.

Call options on futures contracts provide a payment rate equal to the futures price outcome minus the option strike price at contract maturity if the futures price outcome is larger than the strike price. They can offset counter-cyclical payment rate losses from price expectations to the extent that increases in the marketing-year average price above price expectations are matched by increases in futures price outcomes above price expectations. We assume that a hedge is formed on the day a USDA-WASDE marketing-year average price forecast is made.

Call options on futures contacts in equation 1 have a strike price equal to the current futures price or a strike price equivalent to the national loan rate. A strike price equal to the current futures price is selected if forecasted marketing-year average price is greater than or equal to the national loan rate. A strike price equivalent to the national loan rate is selected when the forecasted marketing-year average price is less than the national loan rate.

Equation 2 shows the procedure for estimating futures prices equivalent (corresponding) to national loan rates.

$$(2)\ \text{fnlr} = \text{fp} + (\text{nlr} - \text{fmyap})(\Delta\text{fp}/\ \Delta\text{myap})$$

$$= \text{fp} + (\Delta\text{myap})(\Delta\text{fp}/\ \Delta\text{myap})$$

fnlr = futures price equivalent to national loan rate

fp = current futures price

nlr = national loan rate

fmyap = forecasted marketing-year average price

Δmyap = nlr – fmyap

Δfp /Δmyap = change in futures price corresponding to a one unit change in marketing-year average price (This ratio is estimated by dividing the covariance of marketing-year average price and futures price by the variance of the marketing-year average price, appendix tables E-1, E-3, and E-5.)

We estimated hedging returns using simulated marketing-year average price and futures price outcomes about their price expectations. The price outcomes were simulated using the Cholesky decomposition of the variance-covariance- matrices for the USDA-WASDE marketing-year average price forecast errors and futures price forecast errors in appendix tables E-1, E-3, and E-5. Price expectations include USDA-WASDE marketing average price forecast and corresponding futures prices. We used the simulation procedure to estimate 10,000 sets of price outcomes that matched the correlations, variances and co-variances in appendix tables E-1 through E-6.

Counter-cyclical returns, futures call option returns, and hedging returns were estimated from the simulated prices. About half of the 10,000 counter-cyclical returns are losses from price expectations when forecasted price is above the national loan rate. The fraction decreases as forecasted price decreases below the national loan rate.

Hedging effectiveness was estimated by regressing the counter-cyclical losses on the corresponding futures call option returns. The regression coefficients are optimal hedging ratios—ratio of call option bushels to eligible counter-cyclical bushels that minimize hedging variance in equation 1. Regression R-square is the percent reduction in counter-cyclical payment loss variance.[1,2]

Hedging effectiveness can also be estimated using the variance of hedging returns and the variance of counter-cyclical losses from equation 1. The optimal hedge ratios are used to calculate the futures call option returns in equation 1. Hedging effectiveness as measured by the percent reduction in counter-cyclical payment loss variance equals:

(1 – (hedging return variance/counter-cyclical payment loss variance)) times 100.

Hedging effectiveness using this procedure equals the regression R-square discussed previously.

Hedging effectiveness was also measured by the ratio of average call option gain to average counter-cyclical payment rate loss. Call option gain and counter-cyclical payment loss are taken from equation 1.

[1]Ederington used regression to estimate hedge ratios that maximize variance reduction from hedging with futures contracts. Stoll and Whaley show how to use regression to estimate hedge ratios that maximize variance reduction for two or more futures contracts in a hedge. The hedge ratios are the regression coefficients.

[2]Tompkins uses simulation to estimate hedging outcomes for options with payment based on average price outcome. However, Tompkins did not estimate hedge ratios that maximize variance reduction from hedging.

Appendix table E-1

Soybean variance-covariance matrix USDA-WASDE and corresponding futures contract forecast errors, 1977-2003 marketing years

	WASDE	Nov.	Jan.	March	May	July
WASDE	0.38940					
November	0.25686	0.39058				
January	0.35182	0.35813	0.50641			
March	0.53329	0.42797	0.60745	0.97514		
May	0.65858	0.51575	0.73467	1.18115	1.58836	
July	0.69509	0.45071	0.75477	1.12810	1.42190	1.85630

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors and futures price forecast errors.

Appendix table E-2

Soybean correlation matrix for USDA-WASDE and futures contract forecast errors, 1977-2003 marketing years

	WASDE	Nov.	Jan.	March	May	July
WASDE	1.00					
November	0.66	1.00				
January	0.79	0.81	1.00			
March	0.87	0.69	0.86	1.00		
May	0.84	0.65	0.82	0.95	1.00	
July	0.82	0.53	0.78	0.84	0.83	1.00

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors and futures price forecast errors.

Appendix table E-3

Corn variance-covariance matrix for USDA-WASDE and corresponding futures contract forecast errors, 1977-2003 marketing years

	WASDE	Dec.	March	May	July
WASDE	0.05348				
December	0.03327	0.06687			
March	0.05898	0.06322	0.11238		
May	0.08002	0.07291	0.13972	0.20665	
July	0.11416	0.08506	0.15935	0.23792	0.39440

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors and futures price forecast errors.

Appendix table E-4

Corn correlation matrix for USDA-WASDE and futures contract forecast errors, 1977-2003 marketing years

	WASDE	Dec.	March	May	July
WASDE	1.00				
December	0.56	1.00			
March	0.76	0.73	1.00		
May	0.76	0.62	0.92	1.00	
July	0.79	0.52	0.76	0.83	1.00

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors and futures price forecast errors.

Appendix table E-5

Wheat variance-covariance matrix for USDA-WASDE and corresponding futures contract forecast errors, 1977-2003 marketing years

	WASDE	Sept.	Dec.	March	May
WASDE	0.15388				
September	0.10425	0.12850			
December	0.16549	0.12243	0.26359		
March	0.18227	0.11711	0.26915	0.34885	
May	0.20784	0.11686	0.25289	0.33718	0.48623

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors and futures price forecast errors.

Appendix table E-6

Wheat correlation matrix for all USDA-WASDE and futures contact forecast errors, 1977-2003 marketing years

	WASDE	Sept.	Dec.	March	May
WASDE	1.00				
September	0.74	1.00			
December	0.82	0.67	1.00		
March	0.79	0.55	0.89	1.00	
May	0.76	0.47	0.71	0.82	1.00

Source: Prepared by USDA, Economic Research Service using WASDE forecast errors and futures price forecast errors.