Commodity Options for Agriculture*

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This paper considers the potential benefits of trading in options for farm commodities in three areas: risk management by individuals, the functioning of commodity markets, and the management of public policy with respect to farm products.[1/]

Individual Risk Management Using Options

To review the terminology used, a "commodity option" is a contract to buy or sell a given quantity at an exercise price stated in the contract at the option of the purchaser of the contract. A contract conveying the right to buy is a "call" option. A contract conveying the right to sell is a "put" option. While an option confers the right to buy or sell, there is no obligation to do so. The right is not a free lunch, however, because the option must be paid for, whether it is exercised or not.

The person who receives payment, the other party to the contract, is said to "write" the option. He has a responsibility but no rights, for which he is paid. For a call (put) option, if the commodity price rises above (falls below) the exercise price by more than the "premium" paid (number of bushels in the contract divided by amount paid for the contract), the buyer of the option comes out ahead. If market prices does not rise this high (fall this low), the option writer comes out ahead. The gains of one party equal the losses of the other.[2/]

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CONTRACTS

There are four roles an individual may play in options contracting: one can buy a call option, write a call option, buy a put option, or write a put option. Any of these actions may either increase or decrease an individual's exposure to price risk depending on his position in the underlying commodity, in futures, or in other options.

Hedging in futures provides a standard to which risk management by means of commodity options may be compared. The essential difference is that while futures ideally determine a price in advance for a hedger, an option fixes price over a range of market outcomes while confronting the individual with the market price over a different range. The results of a put option hedge by a producer are shown in Figure 1. An option to sell at price P*, for which the premium paid is V per bushel, guarantees returns of (P*-V) per bushel for market price below P*, but permits revenues to increase at higher prices. Numerical examples are presented below.

Whether hedging with put options is preferred to a forward sale would depend on the producer's utility function. The option would have appeal, for example, to a farmer having a utility function of the form suggested by Friedman and Savage to account for simultaneous insurance and gambling -- risk aversion in the face of large losses, but risk preference in choice between average and unusually large gains.

Even if a producer is uniformly averse to risk, options are promising in risk management when we move away from the idealized circumstances in which a futures sale determines returns per bushel in advance. In more realistic cases in which output is stochastic, or when basis risk exists, futures are

of course less effective in reducing risk. The variance of receipts in some such cases has been analyzed by McKinnon and by Peck. In the circumstances which McKinnon analyzes, where a farmer's output is negatively correlated with price, options can duplicate and even improve upon the stabilization of receipts attained by a forward sale.

To illustrate, suppose a producer faces the following situation: expected crop price is $3.00 per bushel, at which price it pays to commit $20,000 in contractually-paid inputs together with owned resources normally sufficient to produce 9,000 bushels. Let there be five possibilities for market demand and the individual's yield, each with a probability of 1/5, as shown in Table 1.

There are only three quantity outcomes but price may vary for a given crop size because of demand shifts and because other farmers will sometimes have good crops when a particular farmer has a poor crop. Nonethless, when poor weather reduces yields and increases prices for the market, it will tend to do so also for a representative producer. Thus a typical producer will tend to observe negative correlation between yields and prices.

If the producer sells forward his entire normal crop of 9,000 bushels, he does poorly in outcomes (i) and (ii) because he must buy to cover part of the forward sale at increased prices. The income results are shown in the sixth line of Table 1.

McKinnon's formula for the optimal forward sale as a fraction of expected production works out in this example to about 2/3, implying a forward sale of 6,000 bushels.[3/] With a futures sale of 6,000 bushels, receipts are $18,000

Table 1. Producer Outcomes Under Futures and Option Hedging

Market Situation	(i)	(ii)	(iii)	(iv)	(v)	mean	standard deviation
probability	.2	.2	.2	.2	.2		
quantity (th. bu.)	8	8	9	10	10	9	
price ($/bu.)	$4.00	3.50	3.00	2.50	2.00	3.00	
			$ in thousands				
market revenue	32	28	27	25	20	26.4	3.93
income *	12	8	7	5	0	6.4	3.93
Forward sales							
income, 9000 bu. sold forward	3	3.5	7	9.5	9	6.4	2.71
income, optimal forward sale	6	5	7	8	6	6.4	1.02
Optimal forward sale plus option							
Cost of option	.3	.3	.3	.3	.3	.3	
returns from option	1.0	.5	.0	.0	.0	.3	
income	6.7	5.2	6.7	7.7	5.7	6.4	0.87
Two-option hedge, no forward sale							
net gain on writing call	-3.6	-1.6	.4	2.4	2.4	0	
net gain on buying put	-1.0	-1.0	-1.0	-1.0	4.0	0	
income	7.4	5.4	6.4	6.4	6.4	6.4	0.63

* Revenue minus contractual costs of $20,000.

from the forward sale plus the market value of additional production. The income results are presented in the seventh row of Table 1. This strategy yields the same average income as selling forward the entire average crop of 9,000 bushels, but it gives more stability in returns.

Now consider the use of options. In the optimally hedged position, income is lower in the high-price outcomes. Therefore, an option will stabilize returns if it will make money when prices are high and lose money when prices are low. Let the farmer buy a call option for 1,000 bushels at $3.00. The expected value of the option when exercised is .2 (4.00-3.00) + .2 (3.50 - 3.00) = $.30 per bushel. In a competitive options market, this is about what the farmer will have to pay for the option.[4/] The results are shown in lines eight through ten of Table 1. The option transaction enables a reduction in income variability in addition to that attainable by the optimal futures sale. Mean income is the same in all cases because the expected return to options trading is zero. However, there is a real cost to the stabilization attained, namely the brokerage fees which are left out of these calculations. The producer's choice is whether the stabilization of income attainable is worth these fees and other transaction costs that will be incurred.

Returning to the original unhedged position, it may be asked whether futures might not be dispensed with altogether. Since stabilization is achieved by reducing incomes in high-price years, it is natural to consider writing a call as a substitute for the futures sale. Indeed, in this example simply writing a call option for 6,000 bushels at $2.00 duplicates the income results of the optimal futures sale of 6,000 bushels.

Finally, consider the following example in which futures transactions are replaced by <u>two</u> option hedges -- writing a call option on 4,000 bushels at $2.50 (to reduce income under high prices) and simultaneously buying a put option to sell 10,000 bushels at $2.50. The payment to the farmer for writing the call option is .2 (2.50 - 2.00) + .2 (3.50 - 2.50) + .2 (3.00 - 2.50) = $.60 per bushel, and the cost of the put is .2 (2.50 -2.00) = $.10 per bushel. The income results are shown in lines eleven through fourteen of Table 1.

This strategy yields a standard deviation of income lower than any yet considered.

Generally, a strategy of writing calls and buying puts would be expected to compare favorably with an optimal forward sale. However, it is much more difficult to use options when the set of possible outcomes is unknown or is more complicated than in this simple example. Generally applicable optimal strategies for using options in hedging have not yet been developed. The point here is to show that options have promise for limiting price risk with more flexibility than futures allow.[5/]

Options and Commodity Markets

The effect of options on the market for the underlying commodity should be similar to the effect of an improved form of insurance in any risky activity. More risk-averse participants should be drawn into the activity, and should require smaller risk-premia in their non-contractual returns. The introduction of commodity options should therefore tend to increase output and reduce prices. It might be expected, however, that any reduction in price would be quite small

because fairly good substitutes as instruments for reducing risk already exist.

Baumol argues, as an instance of the general argument that speculative activity tends to be stabilizing, that options tend to reduce instability in the price of the underlying commodity because they increase the supply of speculative services. Apart from this effect, there is no a priori reason to expect an options market to affect price fluctuations in the underlying commodity, even though market participants can use options to control the risk they face as a result of these fluctuations.

A possibly more important result of options trading is the public information which can inferred from the selling price of an option. Just as futures prices generate information about expectations of commodity prices, an option's price generates information about expectations of the variability of commodity prices.

The present value of a call option to be exercised at time t, [6/] is

$$(1)\quad V = e^{-rt} \int_{P^*}^{\infty} Pr\,(P_t)\,(P_t - P^*)\,dP_t,$$

where P* is the exercise price, Pr (P) represents the probability density function of price at t, and r is the appropriate interest rate. If the probability distribution of price takes a form which can be represented by the mean, $\bar{P}_t$, and variance, σ^2, an estimate of $\bar{P}_t$ is consistent with only one value of σ^2, given the values of r and V. An estimate of $\bar{P}_t$ is available, for some commodities, from the appropriate futures price. An estimate of V is available from observation of the premium in the options market. Therefore, σ^2 can be estimated if an options market exists. The following

discussion shows how.

Under lognormality,[7] equation (1) becomes

$$(2)\quad V = \frac{e^{-rt}}{\sigma\sqrt{2\pi}} \int_{P^*}^{\infty} \frac{1}{\bar{P}_t} \exp - \left(\frac{\ln P - \overline{\ln P}}{\sigma} \right)^2 /2 \; (P_t - P^*)\, dP.$$

Let $z = (\ln p_t - \overline{\ln P}) / \sigma$, where σ is the standard deviation of the log of price. Then expanding to a P_t and P* term, completing the square on $w = z - \sigma$ to integrate the P_t term, and using the fact that $\ln\bar{P} = \overline{\ln P} + \sigma^2/2$, where $\ln\bar{P}$ is the log of the mean and $\overline{\ln P}$ is the mean of the logs, the result is

$$(3)\quad V = e^{-rt} \{ \bar{P}_t N \left(\sigma + \frac{\overline{\ln P} - \ln P^*}{\sigma} \right) - P^* N \left(\frac{\overline{\ln P} - \ln P^*}{\sigma} \right) \},$$

where N is the cumulative normal distribution.

Since $\ln\bar{P} - \ln P^* = \ln (\bar{P}/P^*)$, dividing through by $\bar{P}$ yields

$$(4)\quad V/\bar{P}_t = e^{-rt} \{ N \left[\frac{\sigma}{2} - \frac{\ln (P^*/\bar{P}_t)}{\sigma} \right] - P^*/\bar{P}_t \, N \left[-\frac{\sigma}{2} - \frac{\ln (P^*/\bar{P}_t)}{\sigma} \right] \}.$$

Given the values of r and t, equation (4) contains three unknown quantities: $P^*/\bar{P}_t$, the exercise price relative to the expected price; $V/\bar{P}_t$, the value of the option relative to the futures price; and σ, the log standard deviation of expected price. With $\bar{P}_t$, from a futures market and an options market to generate P* and V, we can calculate the implied σ.[8]

A test for the robustness of the estimated σ can be done easily if call options at different exercise prices are available. Each should yield the same estimate of σ. Even more useful as a check is the estimate of σ from the premium on a put option, which gives an estimate of σ based on the distribution of expected price in the low end of the price range.

Given the estimate of σ, it is possible to estimate the probability that price at t will be below or above any particular value. As with futures prices, it is unlikely that one will find any better estimate than the market's. This information could be helpful to a farmer in making production choices, or to policymakers considering alternative price support levels. It would be a valuable by-product of a market in farm commodity options. Since it would probably not pay for a producer to develope this information for himself, and since the information would be difficult to market by specialized firms owing to its public-good character, there may be reason actively to encourage and even subsidize options markets for their positive externalities.

Options and Farm Commodity Programs

The existence of an options market would clarify discussion of some aspects of farm policy and could facilitate the operation of some commodity programs.

Support prices as established by nonrecourse loans are equivalent to a put option. The producer has the right but not the responsibility to deliver the commodity to pay off the CCC loan. The farmer has the same protection as if he had purchased a put option on a commodity market with an exercise price at the loan level. The difference is that the farmer does not pay for the CCC put option. Indeed, the economic value of the transfer from taxpayers to farmers each year is roughly the price that would have to be paid for put options to sell each year's crop at the loan level. This formulation makes clear that support prices have real economic

value to farmers (and costs to taxpayers) even in years when market prices turn out to exceed support prices.

A major rationale for price support programs would disappear if a well-functioning market in put options existed. Each farmer could choose the degree of price insurance he wanted by purchase of a put option at the appropriate exercise price. Of course, the higher the insured price, the more the farmer would have to pay for his put option. If a farmer wanted a complete forward sale, he could sell futures or some other form of forward contract. The key feature of the put option is that it duplicates the kind of protection farm programs give -- a price floor but no limit on profits from high prices -- yet put options have neither the income redistribution nor resource allocation effects that price support programs do.[9/]

Even if one believes that farm commodity programs should have income redistribution and resource allocation effects, options are potentially valuable in administering commodity policy. Although the existence of an options market may not have significiant price effects, government intervention in this market can be used to change commodity prices just as intervention in futures or spot markets can. For example, call options could be a useful tool to government in management of grain reserves under an international agreement. Such an agreement would probably require the United States supply grain to the world market under some specific conditions. While most countries would meet such obligations by sales of government-owned stocks, it appears likely that the United States would prefer to rely on its well-developed private storage industry. Then delivery of grain under

the international agreement could be guaranteed by acquiring call options from farmers or commerical sources.

An alternative to purchase of call options would be to extract a price from farmers for the CCC put option that current law establishes, the price taking the form of farmers giving the government a call option to buy grain at, say, twice the loan level in exchange for the farmer's option to sell at the loan level. The farmers, as owner of the put option and writer of the call, have effective control of the commodity at prices above the loan level but below twice the loan rate. The government, as owner of the call option and writer of the put, would have effective control of grain at prices below the loan and above twice the loan level. This seems a very natural arrangement for stabilization policy.

Some Objections to Options Markets

The objections to legalizing options trading seem to center on the difficulty of policing this activity and on alleged undesirable effects on competing financial markets, particularly futures markets.

The idea that any activity should be prohibited because of the difficulty of policing or regulating it seems to me a weak one. Options trading is a voluntary capitalist act between consenting adults, in Robert Nozick's phase. People ought to have the right do these things unless it can be shown that serious external harm results. The regulatory view is that people ought to be forbidden from doing these things unless it can be shown that external good results. The regulatory view gains acceptance in the case of options because of the aura of disrepute about options trading.

While options have the reputation of being inherently more purely speculative than futures trading, this reputation is undeserved. Options can be used either to increase or decrease risk of loss, just as futures or other wagers can. Options, however, are more flexible than futures, as illustrated above. Even for pure speculators, options can offer better controlled gambles than futures. In buying a call option the purchaser's maximum loss is limited by what is paid for the option. In futures trading or holding the commodity, losses are not so easily limited.

It is sometimes suggested that because the supply of speculative services is limited, the proliferation of options markets would reduce the viability of futures markets. This is an empirical issue which the Commodity Futures Trading Commission's proposed experimental program in options trading may help answer. Even if futures and options markets turned out to be such close substitutes that they couldn't coexist, can we be certain that the contest should be decided in advance in favor of futures?

It must be admitted, however, that there are many difficulties in establishing and facilitating trading in an options market, and in keeping the public's trust in the integrity of such markets.

Summary and Conclusion

The effects of options trading in farm commodities cannot be established other than hypothetically since there is so little empirical evidence. Nonetheless, there are good reasons to expect that commodity options for farm products would be useful financial instruments. They can be used by producers and users of commodities for risk management purposes more flexibly than

futures or other forward sales. They also present advantages to speculators. Their use could improve efficiency in the market for the underlying commodities. An organized options market would yield information about the distribution of expected market price that cannot be obtained from futures prices. This information would be useful for decision-making in the private sector and for such purposes as setting support prices in the public sector. Finally, over the long term options could permit a further movement toward less reliance on the general taxpayer for farm income and greater market determination of prices and resource allocation in agriculture, while still permitting farmers to obtain a degree of insurance against the income consequences of low prices (without locking themselves out of the benefits of high prices as a forward sale does).

It could be, however, that the private benefits of centralized option trading are not sufficient to cover the costs of maintaining and transacting in such a market. If so, viable options markets will not develop. Nonetheless, there is no justification for stacking the deck against options by means of legislation. Indeed, the public good aspect of information generated by quoted option prices suggests that options trading on organized exchanges should be encouraged.

FOOTNOTES

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1. Trading in commodity option for most domestic farm products (notable exceptions being sugar and tobacco) is currently prohibited by the Commodity Exchange Act. The occasion is appropriate to consider the economics of options because of the Commodity Futures Trading Commission's proposed pilot program in options trading for some nonprohibited commodities, which could open the door to a general relaxation of restrictions on options.

2. Brokerage or other transactions costs are the most part ignored in this paper, so that the premium paid by an option buyer equals the receipts of the option writer. The analysis also is oversimplified in not considering the destinctions between "American" and "European" options (defined below) or between options written on a commodity and options written on a futures contract. The basic economics of options is not affected by these complications, although they involve important practical issues.

3. The formula is:

$$\frac{\text{forward sale}}{\text{expected output}} = \frac{\rho\ \sigma_x/x}{\sigma_p/p} + 1,$$

where ρ is the correlation coefficient between price and output (about - .8 in the example, which is much greater than one would typically expect), and σ_x/x and σ_p/p are the coefficients of variation of output and price, respectively (McKinnon, p. 848).

4. Not including brokerage fees. This assertion depends on there being no risk premium to speculators, or else that speculators (individuals who increase their risk as a result of the transaction) are equally prevalent on the buying and selling side.

5. Although this discussion has dealt with producers who want to reduce risk, it should be noted that options also provide more flexibility for commodity purchasers and for speculators.

6. This discussion considers only "European" options (exercised at the expiration date). Merton's discussion of options on securities indicates that it would typically pay to hold an "American" option (which may be exercised at any date until the expiration date) until expiration, so that the two types would have roughly equal values. Black derives an equation equivalent to equation (4) under a time series of random changes in the commodity price, with changes distributed log-normally. However, the time series of agricultural commodity prices is not random in the same way as security prices because of seasonal factors. For example, an American call option for November soybeans, purchased in May, should be worth more than the corresponding European option because one would often wish

to exercise the American option at the seasonal price peak in Agugust. Therefore, hedging producers who are concerned with the November price would find European more efficent than American commodity options. Note, however, that an option to buy or sell a futures contract does not involve these problems, since there should be no seasonal in a particular futures contract's price.

7. The lognormal distribution probably gives the best simple representation of the distribution of expected price. It is preferable to the normal distribution because negative prices are ruled out and equal percentage moves up and down, e.g., doubling and halving, are equally likely.

8. Example: Suppose $\bar{P}_t$ = \$3.00 and an option to buy at P* = \$3.30 sells for V = \$.30, for a six-month option with r= .05. The value of σ which equation (4) holds is o.36. If the option sold for less, say \$.15, then the implied σ is smaller, 0.22. Note that when we observe the premium on an option whose exercise price equals the futures price, equation (4) is greatly simplified, and $V/\bar{P}$ depends only on σ. Note also that observation of an option premium does not allow an estimate of expected price. If an option to buy at \$3.30 sells for \$.30 per bushel, this does not imply a market expectation of a December price of \$3.60. However, observation of the market value of two options simultaneously allows inferences to be made about both the mean and standard deviation of expected price even without a futures market. The simplest case occurs when we observe the exercise price P* at which a put and call option have the same value. Then we have:

Value of put = value of call

$$\int_0^{P^*} \Pr(P)\,(P-P^*)\,dP = \int_{P^*}^{\infty} \Pr(P)\,(P^*-P)\,dP$$

Rearranging terms,

$$\int_0^{\infty} Pr\ (P)\ PdP = \int_0^{\infty} Pr\ (P)\ P^*dp$$

i.e., E (P) = P*, expected price is the exercise price.

9. There is an important difference in that a put option would probably expire within a year or so, while government programs ostensibly provide a price floor for longer periods. However, the permanence of government forward price guarantees should not be overstated. In the past when market prices have rested on support levels, support levels have tended subsequently to decline, despite attemps to avoid this necessity by means of production controls, export subsidies, etc.

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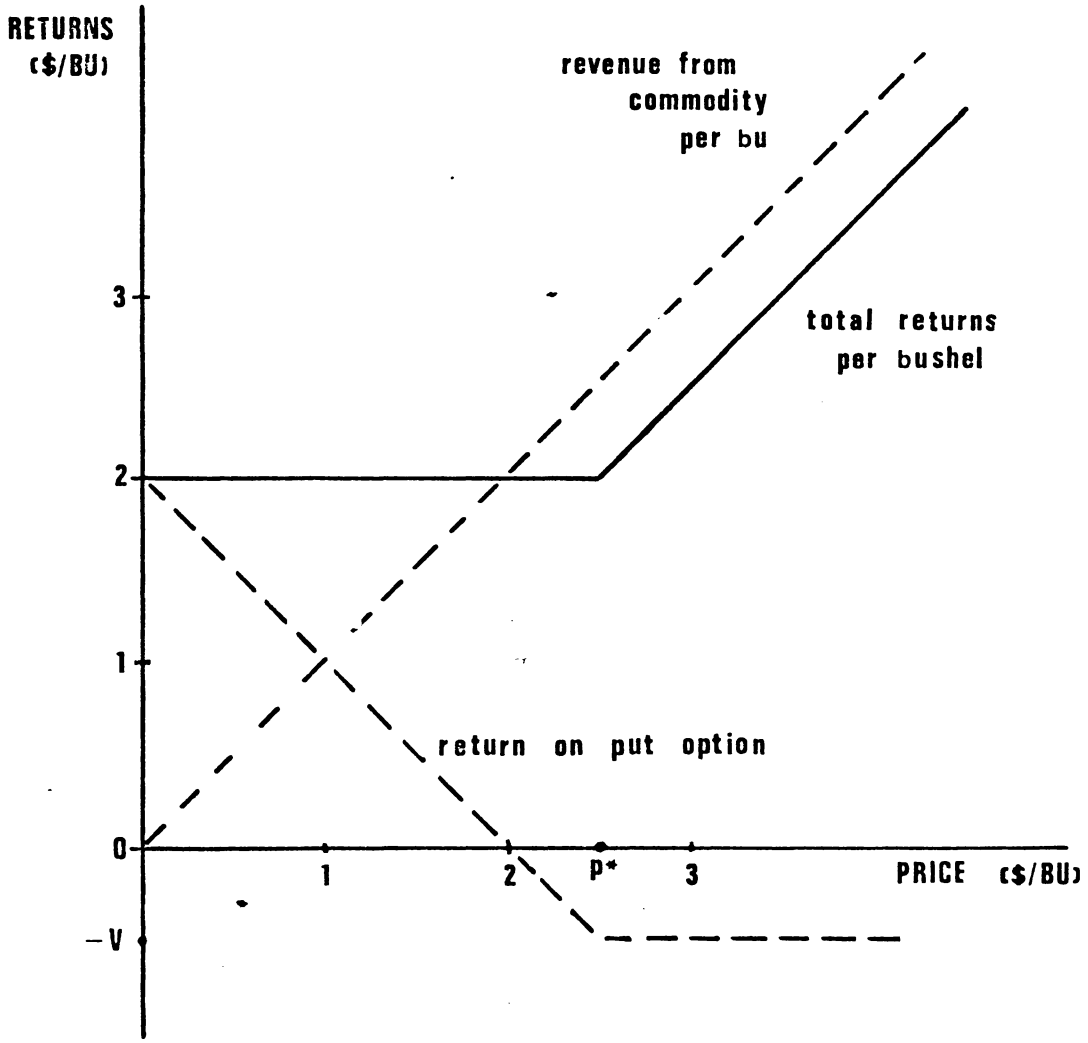

FIGURE 1. Returns per bushel for a hedging purchaser of a put option.