U.S. Farm Price Support Programs

Analyzed as Put Options

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U. S. government-sponsored agricultural programs are frequently designed to protect the farmer from depressed market prices. Among these program, the nonrecourse loan program has been characterized as essentially taxpayer-subsidized put options [Gardner (81), Petzel (84 and 85), and Marcus and Modest]. This paper demonstrates how both nonrecourse loan and deficiency payment programs may be examined within the framework of option valuation theory by distinquishing their respective option characteristics.

To facilitate the analysis, a simplified two-period crop market and government program model will be constructed. The link between the government program and put options will then be established through a summary of option valuation theory. Finally, a hypothetical example of options analysis as applied to policy will be presented.

FARMER INCOME SUPPORT PROGRAMS AND MARKET

The connection between government programs and put options lies in the essential commitments made by the government to the farmer through legislated farm laws. Abstracting from the complicated formulas and market complexities is helpful in investigating the nature of these commitments. First, a two period -- pre and post harvest period -- model is assumed. Second, it is assumed that there is one central market with all features of perfect competition except that (a) the market price

for the future period is a random variable with normal distribution properties and a known mean and variance, and, (b) government demand for stocks of a commodity at an established "loan" value is insatiable. In effect, part (b) of the assumption truncates the portion of the price distribution below the loan rate so that all prices that would have occured in the truncated portion occur at the loan rate instead.[1] Third, the assumed interest rate reflects rates in the economy generally (no subsidized rates) and is fixed at rate r for the period. Fourth, crop yields are known with certainty. And finally, marketing transaction costs are assumed to be zero.

Suppose in period 0 that the government announces an agricultural price support program for a commodity, say, corn. The announced loan rate is L per bushel. The guaranteed target price is T. The current market price is P0. Market price is a stochastic variable P1 with variance Var(P1).

The government guarantees the farmer who signs up for the program the target price for corn. This is accomplished through a cash deficiency payment when harvest prices are less than the target price. The deficiency payment is the difference between market and target prices. A maximum deficiency payment is in effect and equals T minus L. However, the farmer has protection for market prices at or below the loan level through the ability to "default" on the loan and through the government's resolve to demand unlimited stocks at the loan level. Upon default, the farmer retains the loan proceeds and the Commodity Credit Corporation (CCC) assumes title for the commodity. To keep the

model simple it is assumed that interest costs on the loan must be repaid in period 1 even if the farmer defaults on the loan and surrenders the crop to the CCC.

The farmer can produce a potential XP bushels of corn in period 1. However, the government requires that farmers who wish to receive deficiency payments must reduce production by a "set-aside" XS bushels.[2/]

The farmer who signs up for the program receives a cash "loan" of L (XP-XS) in period 0. If prices in period 1 are greater than or equal to the target price, i.e. P1 >= T, then the farmer will sell the crop and repay the government loan. Total revenue for the farmer in this instance will be P1 (XP-XS). The out of pocket cost of the government program will be zero as there will be no default on the loan and no deficiency payment.

If prices in period 1 are less than the target price but greater than the loan rate, i.e. T < P1 < L, the farmer will sell the crop in the market, repay the loan, and receive a deficiency payment of (T-P1) (XP-XS). Total revenue will equal the sum of a deficiency payment plus marketing receipts [(T-P1) (XP-XS) + P1 (XP-XS)] or simply T (XP-XS).

Prices in period 1 are prevented from dropping below the loan rate by government stocks demand. At market prices equal to the loan rate, P1=L, the farmer is indifferent between defaulting on the loan and selling the crop to repay the loan. In either case, total farm revenue will equal loan proceeds L(XP-XS) and the maximum deficiency payment (T-L)(XP-XS), or again, T (XP-XS). The out of pocket cost to the government is the cost of

3

deficiency payments (T-L) (XP-XS).

Non-participating farmers (and, for that matter, consumers) are affected by target prices and loan levels. In the absence of aggregate production constraints, a high target price will summon forth a larger supply and have a larger price depressing effect than a low target price. With aggregate production constraints, price depressing effects of target prices are mitigated. Conversely, a high loan level will support higher market prices than a low loan level through the demand for loan default stocks by the government. Thus, the non-participating farmer would like to see large set asides, relatively low target prices but relatively high loan levels, everything else equal. The opportunity for a "free economic ride" at the expense of the participating farmer is apparent.

The farmer who does not sign up for the government program will bear the market risk that prices could drop near the loan level. But, the non-participating farmer may grow the maximum desired quantity with no opportunity cost of a set aside requirement. Thus, the revenues of the non-participating farmer are Pl (XP).

It should be clear from the description of this model program that the loan level is less relevant to the participating farmer than the target price. A market price in period 1 either higher than or at the loan level but still less than the target price simply results in different methods of physically disposing of the crop, with no difference in revenue. At prices higher than the loan level, the crop will flow through marketing

4

channels while at the loan level, some supplies may go to the CCC. Revenue for the farmer in either case is guaranteed to be no lower than T (XP-XS). The relationships most important to the farmer who considers participation in the government program may be summarized as follows:

(1) T (XP-XS) = Guaranteed revenue with participation.
(2) P1 (XP-XS) = Revenue if P1 > T with participation.
(3) P1 (XS) = Ex-post cost of reducing production.
(4) L (XP) = Guaranteed revenue without participation.
(5) P1 (XP) = Revenue without participation.

OPTION THEORY

An option is a right granted by one party to another to choose to buy or sell an asset at a specific price (strike price) at some future date or within some future period. Options to buy are referred to as calls and options to sell are puts.

The financial securities market is the arena where options have had a history of active trading and about which most of the option valuation literature has been concerned. Modern option valuation theory using financial options was refined in a theoretical valuation model by Black and Scholes (B & S). Recently, however, it has become evident that option theory has broader applications. In an article which reviews and simplifies much of the basic work in option theory, Cox, Ross, and Rubinstein state:

> "... option pricing theory is relevant to almost every area of finance... Indeed, the theory applies to a very general class of economic problems -- the valuation of contracts where the outcome to each party depends on a quantifiable uncertain future event."

Gardner (77) and Petzel (84) identify the market price-

5

support activities of the government through loan defaults as, in effect, put options offered freely to all producers. The strike price on these options is the loan level. This paper makes the further claim that the deficiency payment mechanism, using a target price for many commodity programs, reflects a supplemental put option offered to those producers who participate in set aside provisions. Unlike the lower-tier loan level put option, the higher target price option has a cost represented by reduced output for the participating farmer.

These two put options -- loan level and target price -- can be described more fully by reference to the B & S model. Indeed, all of the essential variables for determining the value of put options offered by the government to farmers are contained in the B & S model and the simple two-period model. Using our notation, the values for the loan and target level puts are, respectively:

$$(6) \qquad VL = -\exp(-rt) [P0 * N(-d1) - L * N(-d2)]$$

$$(7) \qquad VT = -\exp(-rt) [P0 * N(-d3) - T * N(-d4)]$$

where:

    VL = the value of a put option per bushel of corn at the loan level.

    VT = the value of a put option per bushel of corn at the target level.

    P0 = the current price of corn.

    T = the target price (option strike price for the target put).

    L = the loan level (option strike price for the loan put).

    r = the short term interest rate.

    t = the duration on the option (=1 period in our model).

$N(d)$ = value of the cumulative normal density function for d = d1, d2, or d3.

$$d1 = [\ln(L/P0) + (r + 1/2\ Var(P1))\ t]\ /\ [SD(P1) * t^{.5}]$$

$$d2 = d1 - SD(P1) * t^{.5}$$

$$d3 = [\ln(T/P0) + (r + 1/2\ Var(P1))\ t]\ /\ [SD(P1) * t^{.5}].$$

$$d4 = d2 - SD(P1) * t^{.5}$$

$Var(P1)$ = the variance of P1.

$SD(P1)$ = the standard deviation of P1.

In the absence of traded put options for corn at the appropriate strike prices, the farmer can use option valuation formulas (6) and (7) in deciding whether to participate in the government set aside program. Recall that the loan program already provides the farmer with a cost-free option, with the loan level representing the strike price. This option has a value approximated by (6). To maximize profits/benefits from the government program, the farmer can compare the value of the target price option to the cost-free option at the loan level. The second tier of this option structure suggests that the farmer forfeits the benefits of the lower, loan level put option by accepting the higher, target price put option. It is, therefore, the marginal benefits rather than absolute benefits arising from set aside that determine program participation.

Finally, the farmer's personal preferences for risk aversion dictate whether the farmer would trade the higher degree of revenue certainty for personal opportunity costs.

AN EXAMPLE

Given the model outlined above, suppose that the government announces a corn program where, with a 5 percent reduction in output, the farmer can participate in a guaranteed target price of $2.75. A loan level of $2.00 is in place. The current interest rate is 10 percent. Market prices have a standard deviation of 20 percent of the current price level. A farmer who can grow 10,000 bushel of corn is formulating planting plans at period P0 and is trying to decide on program participation. The harvest and revenues from sales will occur 270 days later at period 1.

Table 1 presents the relevant information the farmer considers at period P0 for a range of current prices. The only place where an expectation of the price for period 1 is needed is in the calculation of the opportunity cost for setting aside a specific quantity of output. For this illustration, it is assumed that the farmer has naive expectations on the price, that is, the farmer expects that the price at harvest will be the current price.

For each possible price, the option valuation model calculates a per bushel value for the loan put (VL) and the target price put (V$\bar{P}$). The gross value of the target put to the farmer is the option value times the reduced output of 9,500 bushels. The opportunity cost of the target put is the expected price (= assumed current price) times the set aside of 500 bushels. The net value of the target put is the gross value less opportunity cost. By choosing the target put through set aside participation, however, the farmer would be giving up the free

benefit associated with the loan put. The total value of the loan put to the farmer is the per bushel value (VL) times the full 10,000 bushel potential output. The farmer could calculate the supplemental value of the target put over the loan put to arrive at a figure which appropriately accounted for the benefits or costs of set aside participation.

It is important to note that the farmer is required to form price expectations only in calculating the opportunity costs of setting aside potential output; no price expectations information is required to derive per bushel values for either the loan or target put options.

As shown in the table, the government is paying the farmer to avoid risk when current prices are between 2.00 and 2.75 per bushel. The risk averse farmer may choose to participate in the program when current prices are higher than 2.75 but can expect to pay a premium over the long run for that reduced risk. Different assumptions about volatility, interest rates, time before expiration, and government program specifications would each produce a different set of calculations.

POTENTIAL FOR EXTENDING THE MODEL

The simple model set forth in this paper will not begin to address the complex details necessary to allow option valuation to be applied to government programs. However, the critical theoretical issues are outlined. Some of the modifications important in making the model more realistic might be (a) account for yield variation and program "slippage", (b) apply to local

market conditions, and, (c) account for the numerous complexities in real world government programs.

POLICY IMPLICATIONS

Viewing government income support programs from the option valuation perspective raises several policy issues.

1. Futures market hedging behavior by producers. Government policy which offers "free" put options to farmers through the loan program and voluntary put options through the target price mechanism effectively truncate the lower tails of probability distributions of potential revenues. In using futures markets to hedge prices in such a policy environment, producers give up unlimited upside potential in prices for a relatively fixed downside risk. Thus, an unfavorable bias against the use of futures by farmers may be inherent in government policy and be a key factor in the documented reluctance of farmers to use futures markets.

2. Market alternatives. With the advent of traded options on commodity exchanges, an alternative to government income protection is available. If a farmer can obtain taxpayer-subsidized options less expensively, then this alternative will not be used. One possibility is government subsidies of market traded options thereby fostering greater market liquidity. If farmers are reluctant to use traded markets, an alternative would be to maintain current style income protection programs but allow the government to hedge these commitments by purchasing put options in the market.

3. Government program costs. Forecasts of government program costs are typically prepared from predictions of future price behavior. However, option theory along with traded market options provides alternative methods of valuing option-type commitments such as farmer income protection programs. As shown by Marcus and Modest, option valuation gives policy analysts an additional tool in assessing and forecasting program costs.

4. Arbitrage opportunities. The concurrent availability of market-traded options and government programs presents opportunities for farmers and speculators to capture some or all of the value difference between the two. To what extent can the government allow significant value differences between their programs and market option values?

5. Farm Insurance. Farm insurance schemes include most of the key requirements for applications of option valuation theory. Option theory may provide important tools to analyze these schemes?

CONCLUSION

Option valuation theory provides valuable method for analyzing commitments between parties where the outcome is uncertain. Government agricultural price support programs are particularly well suited for this type of analysis.

Viewing agricultural price support programs as put options allows the policy analyst to bring a wealth of option valuation theory to bear on the risk aspects of farmer income and government program costs. The recent advent of exchange traded

commodity futures options in key agricultural commodities adds to

the richness of this line of research inquiry.

TABLE 1

ASSUMPTIONS:

Target Price   = 2.75   Expiration Time = 270 days
Loan Level   = 2.00   Interest Rate   = 10 percent
Set Aside   = 5 percent   Price Volatility = 20 percent
Farm size   = 10,000 bushels

Current Price	VL	VT	Gross Value of Target Put	Expected Cost of Set Aside	Net Value of Target Put	Value of Loan Put	Incremental Value of Target Put
	-- per bushel --		---------------- dollars ----------------------					
2.00	.13	.75	7,125	1,000	6,125	1,300	4,825
2.25	.05	.50	4,750	1,125	3,625	500	3,125
2.50	.02	.31	2,945	1,250	1,695	200	1,495
2.75	0	.18	1,710	1,375	335	0	335
3.00	0	.09	855	1,500	(645)	0	(645)
3.25	0	.04	380	1,625	(1,245)	0	(1,245)
3.50	0	.02	190	1,750	(1,560)	0	(1,560)
3.75	0	.01	95	1,875	(1,780)	0	(1,780)
4.00	0	0	0	2,000	(2,000)	0	(2,000)

FOOTNOTES TO TEXT

1. See Petzel, 84 for a discussion of this effect. It could be argued that parts (a) and (b) are contradictory. That is, the shape of the distribution might be affected by the government actions in a way other than simple truncation through "set asides", etc. This is an interesting question but not critical for the current analysis.

2. In the "real world", policy would normally have farmers reduce acreage from historical base acreage amounts. The implicit assumption made in our simple model is that yields are known with certainty but prices are not. This is an obviously unrealistic assumption but not significant to the thrust of the current analysis if one also assumes no correlation between yields and market prices for an individual farmer.

3. For a complete description of the Put Option Valuation Model used in this paper, as originated by Black and Scholes with later modifications by Black, see Labuszewski.

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