Robust Live Hog Pricing Strategies under Uncertain Prices and Risk Preferences

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Producers of agricultural commodities are faced with numerous and complex pricing decisions. The number of pricing alternatives has been greatly expanded with the introduction of options on agricultural futures. The choice of appropriate marketing strategies is further complicated by the uncertain and changing nature of agricultural prices and differences in producers' risk preferences. The best pricing alternative is often sensitive to the producer's expectation of prices and preference for risk.

In this context, it is useful to consider the "robustness" of alternative marketing strategies to the changing distribution of ending prices and to the level of risk that producers are willing to accept. Identifying strategies which provide favorable returns over a range of final distributions of cash and futures prices across different risk preferences can provide producers simpler, more effective marketing alternatives. Similarly, it may permit insight into the development of more general producer marketing strategies that will be effective even under changing market conditions [Babb et al. (1985)].

The objective of this article is to determine the importance of producer price expectations and risk preferences in selecting optimal marketing strategies, and to identify strategies that are relatively robust to differences in producer's attitudes toward risk and expectations about prices. Using a two-period simulation model with parameters appropriate for a hog producer, the choice of marketing strategies is analyzed. Changes in ex ante utility are used to assess the sensitivity of marketing strategies to different scenarios of the distribution of prices and to producer risk preferences.

An emphasis of the analysis is to identify "near-optimal" hedging strategies. Sets of strategies that achieve near-optimal utility—a measure of utility in a neighborhood around the utility maximizing point—for a range of price scenarios are identified as robust marketing strategies. In addition, strategies that are robust to differences in producers' levels of risk aversion are identified. Robust strategies are compared to strategies commonly recommended by market advisors.

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This study expands on previous research by directly focusing on the robustness question—measuring the attractiveness of marketing strategies under alternative price expectations and utility specifications—and by allowing only discrete contract units in order to reflect realistic hedging positions on a fixed quantity. The large set of discrete cash, futures, and options marketing strategies considered permits a useful and practical assessment of risk management strategies available to the producer. Several futures/options strategies are identified which provide reasonable levels of utility even when the producer's price expectations and risk preferences are not precisely identified.

THE THEORETICAL MODEL

A two-period model is used to simulate a producer's choice of pricing strategies for varying levels of risk. Given an expectation in period 1 of the distribution of period 2 cash and futures prices and an initial cash-market position, the producer maximizes expected utility by buying or selling puts, and futures contracts. These contracts are offset in period 2, at the time the cash commodity is sold. No trades take place between period 1 and period 2.[1]

Specifically, the producer maximizes the expected utility of profit by taking positions in the futures and options markets, given an initial cash position. Return (R) is represented as the sum of the transactions made in futures, options, and cash markets. Formally,

$$R = Qh + \sum_j \left[p_j^2 - rp_j^1 \right] P_j + \sum_i \left[c_i^2 - rc_i^1 \right] C_i + \left[f^2 - f^1 \right] F \tag{1}$$

where:

R = return
Q = quantity of cash commodity to be sold in period 2
h = cash price of the commodity sold in period 2
r = risk-free rate of return + unity
p_j^t = price of put option at jth strike price in period t, $t = 1, 2$
c_i^t = price of call option at ith strike price in period t
f^t = price of futures contract in period t

F, P_j, C_i are the number of long positions in futures contracts, puts at the jth strike price and calls at the ith strike price (negative values of F, P_j, and C_i indicate short positions). Commission costs are included in the prices of each of the contracts.

In this framework, the producer's problem is to maximize expected utility of returns,

$$\begin{aligned} &\max_{P_j, C_i, F} \quad EU(R) \\ &\text{s.t.} \quad F, P_j, C_i \text{ are integers} \end{aligned} \tag{2}$$

or

$$\begin{aligned} &\max_{P_j, C_i, F} \quad \int U(R) L'(R)\, dR \\ &\text{s.t.} \quad F, P_j, C_i \text{ are integers} \end{aligned} \tag{3}$$

[1]The theoretical model and its specification are described in more depth in Adam (1990). The model does not allow storage, so the analysis is more appropriate for nonstorable commodities such as livestock.

where $L'(R)$ is the probability density function of R. The producer's subjective expectations enter the model through the parameters of $L'(R)$. The nature of the producer's utility function enters the model through the specification of $U(R)$.

Empirical Specification

One approach to analyzing this type of model is to rank marketing strategies with stochastic dominance criteria or a particular specification of an expected utility model [e.g., Schroeder and Hayenga (1988)]. Most of these studies have used historical data to determine what the best strategies would have been at a particular time, given a particular production process. Often, such studies are limited by the characteristics of the time period studied.

An alternative approach examines the comparative statics of optimal solutions derived from expected utility models [e.g., Wolf (1987); Lapan, Moschini, and Hanson (1991); Hanson and Ladd (1991)]. This approach cannot be used to solve for optimal strategies since an expected utility model has no analytical solutions when options are in the choice set, and thus numerical search procedures are used to solve for global solutions; [e.g., Hanson and Ladd (1991)]. However, these solutions are usually expressed in fractions of contracts purchased or sold, and do not reflect the restriction implied by futures and options contracts of fixed sizes. This is especially important in analyzing models containing both futures and options, since options, with their selection of strike prices, can mitigate the effects of fixed futures contract sizes [Hauser and Andersen (1987)].

Here, numerical procedures are used to search for solutions of integer positions in the futures and option markets. The maximization procedure evaluates each possible combination of puts, calls, and futures contracts by numerically integrating the utility of return R achieved with each strategy over the joint probability density function of cash and futures prices. The producer is assumed to have an initial cash position which will equal the size of a futures contract in period 2. Such an assumption emphasizes the ability of options to partially alleviate the restriction of fixed contract sizes. In order to limit computing iterations to a manageable number, the model permits the producer to buy or sell one put at each strike price, one call per strike, and/or a futures contract. The small initial cash position and the limitation on the number of contracts emphasizes the hedging component of these market activities.[2]

Three strike prices for puts and three for calls are included: one at-the-money, and one on either side of the at-the-money strike. Options are offset with no time value remaining. By permitting only integer multiples of contracts to be examined, 2187 possible strategies are evaluated for each set of assumptions about the producer's expectations and utility specification.[3] These strategies include most, if not all, strategies that would be reasonably considered by a risk-averse producer.

[2] Q in eq. (1) is equal to one futures contract-sized unit of the cash commodity divided by the number of hundredweight in a contract, and R is return in \$/cwt. This one-contract restriction could theoretically limit the results. However, examination of those scenarios where multiple futures contracts or multiple options contracts of the same strike price are theoretically most likely (i.e., where producer expectations of price mean and volatility differ most from the market) indicate that the one-contract restriction is not binding.

[3] The number of strategies involving integer multiples of contracts is given by 3^{i+j+1}, where 3 is the number of instruments traded (futures, put options, and call options), i is the number of call strikes, and j is the number of put strikes (a futures contract adds an additional combination). Here, this results in 3^7 (2187) possible marketing strategies. With this general approach many of these strategies would not be considered hedges for tax purposes. However, in most cases the strategies selected by the model reduce risk, or at least are no more speculative than holding a long cash position with no offsetting futures or options positions.

Given these assumptions, eqs. (1) and (3) can be rewritten as:

$$R = h + \sum_j \left[\mathrm{Max}(x_j p - f^2, 0) - rp_j^1\right] P_j + \sum_i [\mathrm{Max}(f^2 - x_i c, 0) - rc_i 1] C_i + [f^2 - f^1] F \tag{1$'$}$$

$$\mathrm{Max}\ EU(R) = \mathrm{Max} \int_{Lf^2}^{Uf^2} \int_{Lh}^{Uh} U(R) L'(h, f^2)\, dh, df^2 \tag{3$'$}$$

where:

Uf^2 and Lf^2 are upper and lower bounds of integration for period 2 futures price,
Uh and Lh are upper and lower bounds of integration for period 2 cash price,
$x_j p$ = jth strike price for put options, and
$x_i c$ = ith strike price for call options.

Utility Specification

Many empirical analyses have evaluated hedging strategies using a mean-variance (MV) framework. The MV framework is consistent with expected utility maximization when utility is quadratic, when the possible outcomes are normally distributed, or when the choice set is made up of random variables which differ from each other only by location and scale parameters [Meyer (1987)]. Hanson and Ladd (1991) have shown that these conditions are violated when options positions can be taken, although in many cases the MV may be a good approximation. Additionally, since options positions can result in skewed outcome distributions, it may be important to examine a producer's preference for skewness as well as the first and second moments [Cox and Rubinstein (1985, p. 318)].

Using an actual utility function in (3)$'$, as opposed to an approximation or derivation such as the MV, makes use of the entire density function of returns, including the third and higher moments. The negative exponential utility function, $U(R) = -\exp(-qR)$, where q is the Arrow–Pratt coefficient of absolute risk aversion, is used in this analysis.[4]

Fitting the model with parameters appropriate for a hog producer, a value of q for a risk averse producer is specified from a range suggested by Holt and Brandt (1985) for hog producers. In addition, a value of q between that for a risk averse producer and 0 is specified for a "slightly risk averse" producer. The values used are: risk averse $q = 0.030$; and slightly risk averse $q = 0.010$. To express differences among strategy outcomes in risk-adjusted money terms, certainty equivalent (CE) for the negative exponential utility function is used, where

$$CE = \frac{[\ln U(R)]^{-1}}{-q} \tag{4}$$

Given a specific utility formulation, a producer's expectations of the mean and volatility of prices are important determinants of strategy selection. Price expectations are represented by alternative price scenarios under which the model is maximized. Expectations of the mean and volatility, and their range of values, are based on typical

[4]The use of the negative exponential function has been criticized because it supposes constant absolute risk aversion. The use of a decreasing absolute risk aversion utility function produced almost identical results to those reported later. The results of the negative exponential formulation are presented because of its ease of understanding and its frequent use in the literature.

variations in price mean and volatility over the period 1980–1988. Based on these historical variations, the producer's expectations of mean and volatility of the period 2 price distribution are permitted to vary 4 to 8% in either direction from the market's expectations. Producer expectations of volatility range from 21.25 to 24.75, a range of 8% on either side of the market's expectation of 23.[5] Producer expectations of mean range from $42/cwt to $46/cwt, a range of 4% on either side of the market's expectation of $44/cwt.

Statistical evaluation of daily cash and futures log-price returns using the Jarque–Bera LM test for normality could not reject lognormality for most years in this period [Jarque and Bera (1987)].[6] Thus, lognormality of prices is assumed throughout the analysis. The futures and cash price distributions have the same moments. The correlation of the joint distribution between cash and futures is set at 0.95, reflecting the correlation of daily prices in the last trading day of pre-expiration months during 1980–1988. Option premiums in period 1 are calculated with Black's (1976) model using an annualized volatility of 0.23, an underlying price of $44/cwt., and an annualized interest rate of 8%.

Commission Costs

Commission costs enter directly into the calculations of the returns. For futures, the charge is $80/contract per round turn. For options, it is 5% of the premium on each purchase or scale; i.e., 5% of the initial premium plus, if the option is offset, 5% of the period 2 premium (which here is the intrinsic value of the option since no time value remains in period 2). The commission costs assumed here are those commonly charged by a full-service broker to a producer who trades only one or a few contracts at a time. Since average commission costs usually decrease as the number of contracts traded increases, these costs may be higher than many producers would be required to pay. Also, because full-service quotes are used, discounts may be available which are not accounted for here. Thus, the commission costs used here may influence the results slightly in the direction of a cash-only marketing strategy.[7]

Robustness of Pricing Strategies

The model is used to identify optimal strategies for producers under each combination of risk preference and price expectations. Since many producers may find it difficult to identify precise expectations about future price distributions or adequately characterize their preference for risk, it may be useful to identify strategies providing "near-optimal" results under a range of price scenarios and risk preferences, even if the strategies are not "best" for any particular set of price expectation and risk preference.

A near-optimal strategy is defined here as one which yields a certainty equivalent (CE) within 2% of the CE of the best strategy for a specific scenario.[8] For example, if the best strategy yields a CE of $43.64/cwt for a given set of price expectations

[5]Volatility calculations use standard procedures as described in many references; e.g., Cox and Rubinstein, pp. 255–259.

[6]These reflect representative price variation and means for the 1980–1988 period. Daily closing futures prices from the Chicago Mercantile Exchange and daily high and low prices from Interior Iowa, Omaha, and Sioux City livestock markets are provided by Gene Futrell and Dan O'Brien, Iowa State University Economics Department.

[7]Margin deposits are assumed to be made with an interest-bearing instrument such as a T-bill.

[8]Two percent of CE is approximately $1.00/cwt over a wide range of scenarios. Although this value is somewhat arbitrary, values greater than this do not substantially increase the number of near-optimal strategies while values less than this substantially reduce the number.

and risk preference, all strategies yielding a CE greater than or equal to \$42.77/cwt [\$43.64 $-(0.02 \times 43.64)$] are near optimal. "Robust" strategies are those that are near optimal across several price scenarios under consideration.

These strategies also are compared with a set of "standard" strategies. When evaluating possible option hedging strategies in practice, simple strategies often are assessed first. These standard strategies are commonly recommended as hedging strategies and can serve as a benchmark against which the robust strategies can be evaluated.

The standard strategies are defined by Hauser and Eales (1987) on the basis of advisory newsletters and discussions with market advisers, and are listed in Tables I–III. Each of these include a long cash position. In addition, for purposes of comparison, a cash only strategy (#1094) and a short futures position (#365) are included in the set of standard strategies. Strategies are denoted as follows: a *p* indicates a put, a *c* indicates a call, and *fut* indicates a futures position (all strategies include a long cash position). The two digits following a *p* or *c* indicate the strike price of the option, and a negative sign indicates a short position.

EMPIRICAL FINDINGS

The third row of Tables I and II lists the best strategy for a risk averse (Table I) or slightly risk averse (Table II) producer under each scenario of producer expectations of mean and volatility of the period 2 price distribution. Note that with the exception of strategy #365 (short futures hedge) for a Risk Averse producer and #1094 (cash-only) for both a Risk Averse and Slightly Risk Averse producer, none of these best strategies is best under more than one scenario. The remainder of each table lists strategies that are near-optimal under more scenarios than other strategies. An *X* identifies the scenarios under which each strategy is near-optimal. For example, in Table I, strategy #365, a futures hedge, is near-optimal for a Risk Averse producer who expects price mean to be \$43/cwt, \$44/cwt, or \$45/cwt and volatility to be 21.25, 23.00, or 24.75, or who expects price mean to be \$42/cwt and volatility to be 23.00 or 24.75. Strategies that are near-optimal under a wider range of price expectations than all other strategies are listed first in the table, followed by the set of standard strategies defined above.

The results indicate that none of the strategies is near-optimal under all of the price/volatility scenarios. However, several strategies are near-optimal under several scenarios. The near-optimal strategies are categorized into three groups, corresponding to the relationship between the producer's price expectations and the market's. The Group 1 strategies in each table are most appropriate if the producer believes the mean and volatility of the distribution of period 2 prices could differ somewhat in either direction from the market's expectation. The Group 2 (Group 3) strategies are appropriate if the producer believes the period 2 distribution is most likely to have the same or higher (lower) mean and either the same, higher, or lower volatility than the market's expectation. The last group of strategies is the set of standard strategies discussed above.

Risk Averse Producer

For the risk-averse producer (Table I), all of the strategies listed in the first three groups are near-optimal under at least 9 of the 15 scenarios. In the first group, all five strategies are near-optimal for producers' expectations of mean ranging from \$43/cwt to \$45/cwt. Strategy #365, a short futures hedge, is near-optimal under two additional scenarios where expected mean is \$42/cwt and expected volatility is 23.00 or 24.75. Thus, for the group 1 risk averse producer, a simple short futures hedge is more robust than

Table I
ROBUST STRATEGIES AND STANDARD STRATEGIES FOR RISK AVERSE PRODUCER

Expected mean	42	42	42	43	43	43	44	44	44	45	45	45	46	46	46
Expected volatility	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75
Best strategy	361	607	689	364	365	608	1093	365	365	1094	1094	1337	851	1094	1094
Expected return ($/cwt)	45.48	44.90	45.39	44.19	43.74	44.08	44.05	43.74	43.74	45.00	45.00	44.66	46.67	46.00	46.00
Certainty equivalent ($/cwt)	44.57	44.31	44.36	43.90	43.66	43.80	43.75	43.65	43.64	44.33	44.21	44.12	45.50	45.18	45.06
Robust strategies:															
Group 1															
365: -fut (futures hedge)		X	X	X	X	X	X	X	X	X	X	X			
366: -fut, c46				X	X	X	X	X	X	X	X			X	
1334: p42, -c44				X	X	X	X	X	X	X	X	X			
1174: p44, -c46				X	X	X	X	X	X	X	X	X			
1336: p42, -c46 (bull spread)				X	X	X	X	X	X	X	X	X			
Group 2															
1094: cash-only							X	X	X	X	X	X	X	X	X
1093: -c46				X	X		X	X	X	X	X	X	X	X	X
1092: -c44, c46							X	X	X	X	X	X	X	X	X
Group 3															
608: -fut, p42	X	X	X	X	X	X	X	X	X						
364: -fut, -c46	X	X	X	X	X	X	X	X	X						
446: -fut, p44	X	X	X	X	X	X	X	X	X						

(continued)

Table I (continued)

Standard strategies:														
1094: cash-only						X	X	X	X	X	X	X	X	X
365: -fut (futures hedge)	X	X	X	X	X	X	X	X	X	X	X			
1337: p42				X	X	X	X	X	X	X	X		X	X
1175: p44				X	X	X	X	X	X	X	X		X	X
1121: p46				X	X	X	X	X	X	X	X			X
1085: -c42			X	X		X	X	X	X	X	X			
1091: -c44			X	X		X	X	X	X	X	X		X	
1093: -c46			X	X		X	X	X	X	X	X	X	X	X
1112: p46, -c42 (bear spread)	X		X	X	X	X	X	X						
1336: p42, -c46 (bull spread)			X	X	X	X	X	X	X	X	X			
1084: -c42, -c46 (short strangle)			X	X		X	X		X					
1364: p42, p46 (long strangle)			X	X	X	X	X	X	X		X			

Strategies are denoted as follows: *p*, *c*, and *fut* indicate put, call, and futures positions, respectively (all strategies include a long cash position). Two digits following *p* or *c* indicates the option strike price, and a '−' indicates a short position.

Table II
ROBUST STRATEGIES AND STANDARD STRATEGIES FOR SLIGHTLY RISK AVERSE PRODUCER

Expected mean	42	42	42	43	43	43	44	44	44	45	45	45	46	46	46
Expected volatility	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75
Best strategy	676	703	713	361	607	689	1093	1094	1337	770	1094	1095	1472	1581	1824
Expected return ($/cwt)	47.44	47.99	46.87	44.67	44.13	44.45	44.05	44.00	43.98	45.82	45.00	45.41	50.19	48.86	48.63
Certainty equivalent ($/cwt)	46.15	45.64	45.64	44.33	43.91	44.13	43.94	43.74	43.81	45.06	44.73	44.74	47.69	46.85	46.70
Robust strategies:															
Group 1															
1093: -c46					X		X	X	X	X	X	X			
1175: p44					X	X	X	X	X		X	X			
1121: p46					X	X	X	X	X		X	X			
Group 2															
851: -p42							X	X	X	X	X	X		X	X
1095: c46							X	X	X	X	X	X		X	X
Group 3															
445: -fut, p44, -c46		X	X	X	X	X		X	X						

(continued)

Table II (continued)

Standard strategies:									
1094: cash-only				X	X	X	X	X	X
365: -fut (futures hedge)	X	X	X	X	X	X			
1337: p42				X	X	X		X	X
1175: p44		X	X	X	X	X		X	X
1121: p46		X	X	X	X	X		X	X
1085: -c42		X		X	X	X		X	
1091: -c44		X		X	X	X	X	X	
1093: -c46		X		X	X	X	X	X	X
1112: p46, -c42 (bear spread)		X	X	X	X	X			
1336: p42, -c46 (bull spread)		X	X	X	X	X			
1084: -c42, -c46 (short strangle)	X	X		X	X				
1364: p42, p46 (long strangle)		X	X		X	X			

Strategies are denoted as follows: *p*, *c*, and *fut* indicate put, call, and futures positions, respectively (all strategies include a long cash position). Two digits following *p* or *c* indicates the option strike price, and a '−' indicates a short position.

Table III

ROBUST STRATEGIES AND STANDARD STRATEGIES FOR EITHER RISK AVERSE OR SLIGHTLY RISK AVERSE PRODUCER

Expected mean	42	42	42	43	43	43	44	44	44	45	45	45	46	46	46
Expected volatility	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75	21.25	23.00	24.75
Robust strategies:															
1093: -c46					X		X	X	X	X	X	X			
1175: p44					X	X	X	X	X		X	X			
1121: p46					X	X	X	X	X		X	X			
365: -fut (futures hedge)				X	X	X	X	X	X						
Standard strategies:															
1094: cash-only							X	X	X	X	X	X			
365: -fut (futures hedge)				X	X	X	X	X	X						
1337: p42							X	X	X		X	X			
1175: p44					X	X	X	X	X		X	X			
1121: p46					X	X	X	X	X		X	X			
1085: -c42					X		X	X	X		X				
1091: -c44					X		X	X	X	X	X				
1093: -c46					X		X	X	X	X	X	X			
1112: p46, -c42 (bear spread)					X	X	X	X	X						
1336: p42, -c46 (bull spread)					X	X	X	X							
1084: -c42, -c46 (short strangle)				X	X		X	X							
1364: p42, p46 (long strangle)					X	X		X	X						

Strategies are denoted as follows: *p*, *c*, and *fut* indicate put, call, and futures positions, respectively (all strategies include a long cash position). Two digits following *p* or *c* indicates the option strike price, and a '−' indicates a short position.

other "robust" strategies which use a combination of puts and calls. Strategy #366, -fut, c46, is near-optimal for expected mean of \$43/cwt, \$44/cwt, and \$45/cwt except when expected volatility is 24.75, and is also near-optimal for an expected mean of \$46/cwt as long as expected volatility is the same as the market's expectation. These strategies are appropriate for producers who believe the period 2 mean could be the same as the market's expectation, or could differ from it, but are uncertain of the direction in which it might differ.

There are three group 2 strategies which are appropriate for producers who expect price mean to be the same or higher and volatility to be either higher, the same, or lower than market expectations. Three strategies (cash-only, -c46, and -c44, c46) are near-optimal under at least nine scenarios for producers who expect period 2 mean to be \$44/cwt, \$45/cwt, or \$46/cwt, the same or higher than the market's expectation. In addition, strategy #1093, -c46, is near-optimal for producers who expect a mean of \$43/cwt and a volatility of 21.25 or 23.00. Thus, this strategy is the most robust group 2 strategy because it is near-optimal under 11 scenarios. The three strategies in group 3 are near-optimal for all scenarios where a producer expects the price mean to be \$42/cwt to \$44/cwt, the same or lower than the market expects.

Among the standard strategies, the results indicate that those which use only one option contract are more robust than the spread and strangle combinations which use two option contracts. The one-instrument strategies are near-optimal in 8 to 11 scenarios whereas the two-instrument strategies are near-optimal in 8 or fewer scenarios.

Thus, for a risk-averse producer who believes that the distribution of period 2 prices (both mean and volatility) could differ in either direction from the market's expectation, a short futures hedge is the most robust strategy. For a producer who believes that volatility could differ in either direction, but expects period 2 prices to be higher than the market expects, selling a call at a strike price higher than the futures price is the most robust strategy. Strategy #366 (-fut, c46) is slightly more robust for lower expected means but less for higher means. For a producer who expects period 2 prices to be lower than the market expects, three attractive strategies are available, all involving a short futures contract.

To partially illustrate why these strategies are robust, payoff diagrams for a representative strategy from each of the three groups are shown in Figure 1. The payoff diagram plots the return in \$/cwt that a strategy would yield at each price on the horizontal axis. Each diagram assumes an expected volatility of 0.23, the market's expectation, and focuses on variations in realized price.

A short futures hedge offers a constant return regardless of price (except for basis risk), so is attractive for risk averse producers who believe the mean of the period 2 price distribution is equally likely to be higher or lower than the market expects. Selling an out-of-the-money call (-c46) or maintaining a cash-only position earns a higher return for realized prices higher than the market expects, so are appropriate for producers who believe that the period 2 mean is more likely to be higher than lower. Selling a call is more attractive than a cash-only position at realized prices nearer the market's expectation because a premium is earned.

Finally, selling a futures contract and buying an out-of-the-money put earns a higher return for realized prices which are lower than market expectations. Thus, it is more robust for producers who believe that prices are more likely to be lower, rather than higher, than the market expects.

Two of these strategies, #365 (-fut) and #1093 (-c46), are standard strategies, listed in the lower part of the table. In addition, some of the other standard strategies are

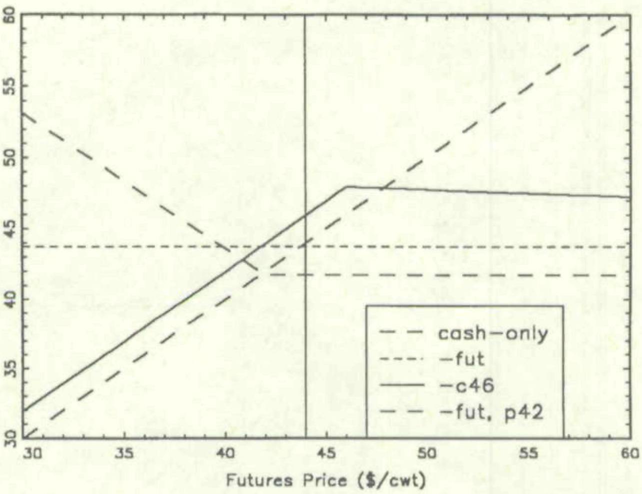

Figure 1
Payoff functions for robust strategies for risk averse producer (all strategies include long cash position).

near-optimal under a wide range of scenarios, although most are not as robust as the strategies mentioned. If a producer expects price mean to be anywhere from $43/cwt to $46/cwt, but believes that volatility will not decrease, strategies #1337 and #1174 (p42 and p44) would be appropriate. However, none of the standard strategies, with the possible exception of #365 (-fut), are appropriate for a producer who expects prices in period 2 to be the same or lower than the futures price, in contrast to three attractive strategies identified by considering the entire set of 2187 strategies.

In general, the standard strategies appear to be more sensitive to changes in volatility. Most are near-optimal under a range of expected means, but do worse when both expected mean and expected volatility differ from the market's expectation. For example, selling a call at a strike price equal to the futures price (-c44) is near-optimal for expected means ranging from $43/cwt to $46/cwt, but is near-optimal for $43/cwt only if expected volatility is 21.25 or 23.00, and is near-optimal for $46/cwt only if expected volatility is equal to the market's expectation.

Slightly Risk Averse Producer

Results for a slightly risk averse producer are presented in Table II. A noticeable characteristic of the robust strategies for a slightly risk averse producer is that they are near-optimal under fewer scenarios than are the robust strategies for a risk averse producer. A less risk-averse producer puts relatively more weight on expected gain than on risk reduction. As expected mean and volatility differ from the market's expectation, the expected gain from choosing the best strategy increases, so fewer strategies can achieve risk-adjusted gains within 2% of the best strategy.

Figure 2 shows payoff diagrams for representative strategies from the robust strategies. A diagram for a short futures hedge is included for comparison. Interpretation of Figure 2 is similar to that for Figure 1, except that the strategies in Figure 2 for a slightly risk averse producer differ more from a futures hedge as realized prices differ from the market's expectation. Again, it is clear that lower levels of risk aversion cause the producer to place relatively more weight on expected return than on risk reduction.

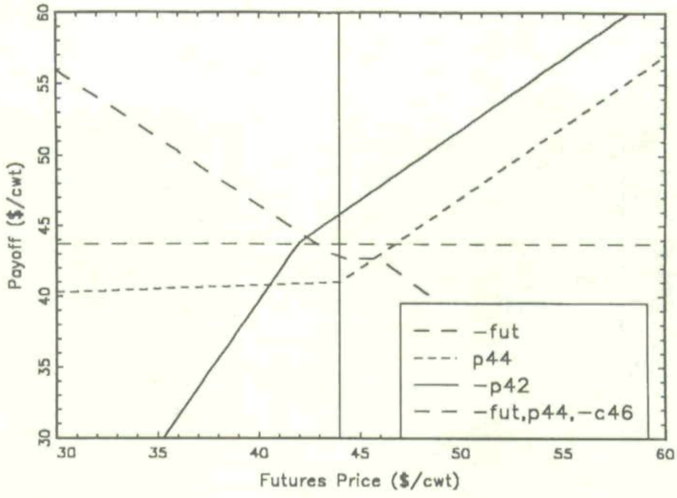

Figure 2
Payoff functions for robust strategies for slightly risk averse producer (all strategies include long cash position).

Many of the strategies in Table II, and especially the standard strategies, are sensitive to differences in expected volatility from the market's expectation. For a given volatility, the strategies are somewhat robust to differences in expected mean, but if both volatility and mean are expected to differ from the market, the strategies are less likely to be near-optimal.

Table III lists strategies that are robust across both price expectations and risk preferences. An *X* for a strategy indicates that the strategy achieves a CE within 2% of the best strategy for that scenario for both Risk Averse and Slightly Risk Averse producers. All of the robust strategies listed here are standard strategies. Note that these strategies are more difficult to categorize in groups as in Tables I and II since they are near-optimal under a smaller range of scenarios.

These results indicate that some (but not all) of the commonly recommended strategies are likely to do reasonably well when neither the producer's risk preferences or price expectations can be precisely identified. However, if the producer's risk preferences can be more precisely characterized, robust strategies can be identified which are less sensitive to errors in price expectation. Alternatively, if the producer has a better expectation of mean and volatility of the period 2 price distribution, a precise specification of the producer's level of risk aversion is not as critical.

SUMMARY

The "ideal" marketing strategy will never be found because producers have different expectations and risk preferences. This study considers near-optimal and robust strategies for a hog producer with a given cash-market position. Using a simulation framework based on historical price patterns, strategies that are within 2% of the maximum CE are identified for different risk preferences and price scenarios. The results provide insight into the potential attractiveness of alternative strategies and into important factors to consider in establishing producer marketing plans.

The findings indicate the importance of identifying producer price expectations and risk preferences for selecting optimal market strategies. No single strategy is near optimal under all scenarios. However, several near-optimal strategies for selected ranges of price expectations are identified. At times these strategies are commonly recommended "standard strategies" but often they are not, especially when the producer's risk preferences can be characterized more precisely. In most instances, the robust strategies are rather straightforward, involving only one or two new market positions. Commonly recommended standard options strategies are likely to be near optimal when expected prices are near the market's expectations of mean and volatility.

When the producer can be characterized as risk averse, several strategies are quite robust across varying price mean and volatility expectations. A futures hedge is especially appropriate when a risk averse producer believes mean and volatility of the period 2 price distribution could differ in either direction from the market's expectation. Selling a call at a strike price higher than the futures price (out-of-the-money) performs well if the producer believes the mean will be the same as or higher than the futures price, or even somewhat lower. Three strategies, all involving selling a futures contract together with an options position, are appropriate if the producer expects price mean to be the same as or lower than the futures price. Eales et al. (1990) found that corn and soybean producers tend to agree with the market's price mean expectations, although the producers' expectations of price volatility tend to be lower than the market. Given these types of expectations, the futures hedge alone or in combination with a single options position may be practical (near-optimal) in many hedging situations.

The robust strategies are near-optimal under a smaller range of price of scenarios for a slightly risk averse producer than for a risk averse producer. However, the near-optimal strategies for slightly risk averse producers cover more scenarios than if the producer cannot specify precisely the level of risk aversion. This is especially true if the producer believes prices are more likely to move in one direction than the other, either higher or lower.

Finally, some strategies, primarily standard strategies, are reasonably robust even when neither a producer's price expectations nor risk preferences are known precisely. The findings highlight the importance of appropriate specification of the producer's price expectations and risk preferences. Under many circumstances, however, even whese are not known precisely, it is possible to identify rather robust strategies which permit the producer to achieve "acceptable" ex ante CE.

This analysis focuses on robustness of pricing strategies for hog producers considering futures and options strategies. Although the model used is general, its application requires specific assumptions which may vary for different producers and market situations. For example, the producer is assumed to have a quantity of the cash commodity equal to the size of futures and options contracts, with no other enterprises. The assumptions here emphasize the effect of integer restrictions and potential role of options in hedging strategies. Further research needs to be performed to assess the appropriateness of these robust strategies to other market situations. Also, additional work is required to identify the sensitivity of the findings to other utility specifications and to objectives other than expected utility maximization, such as safety first.

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