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by

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THE SENSITIVITY OF LIVE HOG MARKETING STRATEGIES TO UNCERTAIN PRICES

Philip Garcia and Brian Adam*

Producers of agricultural commodities often are faced with difficult to assess pricing decisions. Recently, the number of pricing alternatives has been greatly enhanced with the introduction of options that can provide a wide range of attractive risk/return possibilities (Hauser and Eales, 1987). The usefulness of particular strategies frequently is dictated by the ending distribution of prices and the willingness of the producer to assume varying levels of risk. In the hog market, previous research has suggested that it is possible to construct accurate forecasts of future prices. However, few producers have the resources to develop or use better forecasting techniques in their pricing decisions. Similarly, the use of forecasts and the active assumption of market positions may be associated with an unacceptable level of price uncertainty.

In this environment, 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. If strategies can be identified which are relatively insensitive to the final distribution of cash and futures and to producer's risk preferences, it may be possible to provide hog producers with a broader range of effective marketing alternatives. Similarly, it may permit insight into the development of more general producer marketing strategies in light of changing market conditions (Babb, et al).

The purpose of this paper is examine the sensitivity of hog producer's choice of marketing strategies in the cash, futures and options markets to alternative expectations and risk preferences. Given alternative distributions of cash and futures, strategies that provide a reasonable set of returns are identified. More specifically, the choice of marketing strategies is analyzed using a simulation framework which maximizes ex ante utility under different scenarios of the final distribution of prices. Sets of strategies that achieve a measure of utility in the neighborhood around the utility maximizing point for various price scenarios are identified as robust marketing strategies. In addition, because options have the potential of truncating the ending distribution of outcomes and their potential usefulness may be influenced by the producer's risk preferences, the sensitivity of the findings to alternative utility specifications which incorporate the higher moments of the returns distribution, and different levels of risk aversion is considered. Finally, the robustness of several standard options strategies proposed in the literature is investigated.

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The analysis here relaxes restrictive assumptions made in previous studies of marketing strategies by including commission costs and by considering only integer multiples of futures and options contracts. Also, the set of possible discrete marketing strategies is larger than those examined in previous analyses of options hedging (e.g., Hauser and Eales, 1987).

The paper is comprised of several sections which briefly identify the model and procedures and provide concise statements about the simulation. This is followed by a more detailed presentation of the results of the robustness experiments.

The Theoretical Model[1]

A two-period model is used to simulate a hog producer's choice of pricing strategies for varying levels of risk. Given an expectation of the distribution of future prices, the producer maximizes expected utility by buying or selling puts, calls and futures contracts. These contracts are offset at the time the cash commodity is sold.

Specifically, the producer maximizes the expected utility of profit by taking positions in the futures and options markets, given an initial cash position. In period 1 the producer formulates expectations of cash, futures, and options prices for period 2 and takes the positions to maximize expected utility in the futures and options markets. In period 2 the producer offsets any futures or options positions previously taken and sells the cash commodity. The producer's subjective expectations enter the model through the parameters of the joint distribution function of cash and futures prices. The producer's risk preferences enter the model through the utility specification.

Empirical Specification

The producer is assumed to farrow 125 pigs in period 1, which are sold in six months (period 2) at a weight of 240 pounds each (i.e., the total weight represented by each live hog futures and options contract), and is permitted to buy or sell only one put, call or futures contract each. The small initial cash position and the limitation of the number of contracts emphasizes the hedging component of these market activities. It also is assumed that no trades take place between period 1 and period 2. This assumption may limit the producer's potential returns, since it understates the value of options; options premiums prior to expiration are comprised of time value in addition to intrinsic value, whereas at expiration no time value remains. In addition, three strike prices for puts and three for calls are assumed: one at-the-money, and one on either side of the at-the-money strike. By permitting only integer multiples of contracts to be examined, 2187 possible strategies are evaluated in this framework.

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[1]The theoretical model, its specification and solution procedures are described in more depth in the "Hog Producer's Marketing Decisions under Alternative Utility Specifications" which appears in this publication. For further information on the model see B. Adam "Incorporating Options and Forecast Information in Producer Hog Marketing Strategies: Conceptual and Measurement Issues", Ph.D. Thesis, University of Illinois, 1990.

Three specifications of expected utility are examined in the analysis: mean-variance (MV), and third- (CR3) and second-order (CR2) Cox Rubinstein utility functions. The MV framework is consistent with the expected utility maximization when utility is quadratic, when the probability of outcomes is normally distributed, or when the choice set is made up of random variables which differ from each only by location and scale parameters (Meyer, 1987). The form of the MV specification used in this analysis is $EU = m - (q/2)v$, when m is the mean of the outcome distribution and v is the variance of the outcome distribution. If the MV specification is assumed to be derived from a negative exponential utility function, then q (a constant) is the Arrow-Pratt measure of absolute risk aversion.

The use of options in marketing strategies raises questions about the appropriateness of the MV framework. Options positions can result in highly skewed outcome distributions suggesting that it may be important to examine a producer's preference for skewness. The CR3 utility function permits an assessment of the effect of positive skewness in the returns distribution on the selection of marketing alternatives. The form of the Cox-Rubinstein utility function used here is

$$EU(R) = (1/(1-d))m^{1-d} - (1/2)dm^{-d-1}v + (1/6)d(d+1)m^{-d-2}s$$

where R = profit, m = mean, v = variance, s = skewness, and d = the level of constant relative risk aversion. The CR3 function is a third-order Taylor series expansion of a constant elasticity utility function which implies that as the decision-maker's wealth increases, more wealth is allocated to risky assets.

A CR2 function also is used in the analysis. It differs from the CR3 form, including only terms containing mean and variance of the CR3. It differs from the traditional mean-variance specification because it is characterized by constant relative risk aversion and decreasing absolute risk aversion.

Comparison of the results from the different expected utility specifications requires that the risk parameters q and d reflect similar levels of risk aversion. Here, for each value of q, the Arrow-Pratt measure of absolute risk aversion, and a value of R, producer income, a value of d can be calculated from the equation $d = R \bullet q$. This relationship is derived by setting the Arrow-Pratt measures of absolute risk aversion from each utility specification equal to each other. Using values of q specified from the range suggested by Holt and Brandt for hog producers and setting R at the $/cwt market return, values of d are calculated: Risk Averse ($q = 0.030$, $d = 1.35$), Slightly Risk Averse ($q = 0.10$, $d = 0.44$), and Risk Neutral ($q = 0.0002$, $d = 0.0088$). To compare alternative strategies in monetary terms, certainty equivalence is used. The certainty equivalent (CE) is the difference between the expected value and the risk premium.

Given a specific utility formulation, a producer's expectations of the mean and volatility of prices are important determinants of strategy selection. Price expectations enter into the analysis through a set of price scenarios over which the model is maximized. The structure of the scenarios was formulated to reflect representative price variation and means for the 1980-88 period. For all scenarios, the current futures price for the contract expiring six months later in period 2 is $44/cwt. The market's expectation of

the volatility of prices in period 2 is 0.23, based on an annualized average of six-month volatilities for the futures close. The option premiums in period 1 are assumed to agree with calculated values from Black's model using an annualized volatility of 0.23 and a underlying price of $44/cwt. The mean and variance of the cash and futures prices are equal with a correlation between cash and futures of 0.95. Lognormality is used throughout the analysis based on statistical evaluation of the cash and futures prices.

The scenarios are built around a base scenario where the producer takes the market's expectations of mean and volatility as his own. Other scenarios vary the parameters of the density function in order to analyze the choice of marketing strategies when the producer's expectations differ from those of the market. Parameters different from the market imply that the producer's subjective probability distribution differs from the market's expectations. A higher (lower) mean for the futures price implies that the producer believes that the current futures price underestimates (overestimates) the price in period 2. A higher (lower) annualized volatility indicates that the producer believes the market is underestimating (overestimating) the dispersion of prices around the mean in period 2.

For the simulation, the cash and futures means range from $40/cwt to $48/cwt with more observations near the $44/cwt market expectations. This reflects an increase or decrease from the market's expectations of about 9%. For the bulk of the analysis, the annualized volatility varies from 0.16 to 0.30. This range reflects a difference of up to 30% between the producer's expectations of annualized volatility and the market's implied volatility.

Robustness and the Standard Options Strategies

Maximization procedures result in the selection of an optimal strategy for the hog producer given his expectations of prices and his utility specification. As previously indicated, if a producer is uncertain about the ending distribution of prices, he may prefer a strategy that provides "near optimal" results under a range of price scenarios, even if that particular strategy is not "best" for any particular set of prices. Strategies which are near optimal under more price scenarios than other strategies are considered robust.

Here, a near optimal strategy is defined as one which yields a certainty equivalent within 2% of the CE of the best strategy for a specific scenario.[2] For example, if the best strategy under a mean-variance specification with q = 0.03 yields a CE of $43.64/cwt for a given set of price expectations, all strategies yielding a CE greater than or equal to $42.77/cwt ($43.64 - (0.02 • $43.64)) are considered near optimal. Robust strategies are those that are near optimal for a particular set of price scenarios considered.

When evaluating possible options strategies to be used for hedging, simple strategies often are considered first. These strategies typically include only one or two options. Several of the simple strategies, referred to as standard strategies, are evaluated in this analysis. The standard

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[2]2% is chosen somewhat arbitrarily, but its value over a wide of range of scenarios is approximately $1.00/cwt.

to as standard strategies, are evaluated in this analysis. The standard strategies are commonly recommended as hedging strategies and can serve as a relatively familiar benchmark by which the model's best strategies may be evaluated.

The standard strategies analyzed by Hauser and Eales (1987) are considered here. The strategies were selected based on advisory newsletters and discussions with market advisers. They are (all include a long cash position): #1337, a long put at a strike price of $42/cwt (lp42); #1175, a long put at $44/cwt (lp44); #1121, a long put at $46/cwt (lp46); #1085, a short call at $42/cwt (sc42); #1091, a short call at $44/cwt (sc44); #1093, a short call at $46/cwt (sc46); #1112, a bear spread, consisting of a long put at $46/cwt and a short call at $42/cwt (bear); #1336, a bull spread, consisting of a long put at $42/cwt and a short call at $46/cwt; #1084, a short strangle, consisting of a short call at $42/cwt and a short call at $46/cwt (sstg); and #1364, a long strangle, consisting of a long put at $42/cwt and a long put at $46/cwt (lstg). In addition, for purposes of comparison, a cash only strategy (#1094) and a short futures position (#365) are included in the analysis. These last two strategies also are referred to as simply cash and sfut, respectively.

EMPIRICAL FINDINGS

Robustness

The sensitivity of the producer's marketing choices was examined over 56 scenarios of expected prices (means and volatilities), three expected utility representations (MV, CR3 and CR2), and three levels of risk aversion for each utility representation (Risk Averse, Slightly Risk Averse and Risk Neutral). In total, 504 combinations of utility specifications and expected price distributions are examined.

Examination of the results of the simulations revealed that none of the 2187 possible strategies was near optimal across all price expectation scenarios. Consequently, three, more refined, sets of price expectations are considered: 1) no change or small deviations in mean and volatility, on either side of the market's expectations; 2) no change or increase in the mean from the market expectation along with no change or small changes in volatility on either side of the market; and 3) no change or decrease in the mean from the market expectation along with no change or small changes in the volatility on either side of the market. Case 1 is most interesting when the producer believes that market expectations are reasonable, but is uncertain as to the exact value of the ending prices. In this situation, the producer might choose a strategy that is robust at the market expectations and for small deviations around the those expectations. Case 2 (3) is most relevant when the producer believes that prices will hold steady or increase (decrease), but is uncertain about how much they might increase (decrease) and about their volatility.

For purposes of brevity and exposition, the presentation of the empirical results focuses on Case 1, examination of the little or no change in the mean and volatility of the distribution of prices under various levels of risk aversion for the CR3 and the MV specifications. However, information from the other two cases also is presented.

Tables 1 and 2 present a listing of the robust strategies for Case 1 under the CR3 and MV specifications. Here, small changes in the mean of the price distribution include one dollar changes above and below the market expectation of $44/cwt. The range of volatilities considered is from 21.25 to 24.75 which are centered around the market's expectation of 23. Under each utility specification two sets of strategies are presented: those strategies that are robust under the largest number of price scenarios, and one less than the largest number of price scenarios. An 'X' in the table indicates that the strategy is within 2% of the maximum possible CE under the price scenario.

Several points are apparent from the tables. First, the more risk averse the producer, the larger the range of coverage for the robust strategies. For example, under both the CR3 and MV specifications there exist strategies which are robust across the complete range of price expectation considered. As the level of risk aversion decreases, so does the coverage of the robust strategies across the price scenarios. Second, many of the same robust strategies appear for similar levels of risk aversion across the CR3 and the MV specifications. For example, note the similarities of the more robust strategies in the Risk-Averse case for CR3 and MV representations. Conversely, for a particular utility function, the more robust strategies are less likely to appear for different levels of risk aversion. Finally, except in the Risk-Neutral case, the more robust strategies are rather straightforward, involving one or two market positions.

Results of the analysis of Case 2, no change and increasing prices (i.e., range of the mean and volatility - $44 to $46/cwt and 21.25 to 24.75, respectively) and Case 3, no change and decreasing prices (i.e., range of the mean and volatility - $44 to $42/cwt and 21.75 to 24.75, respectively) demonstrate several similarities to Case 1, although the particular strategies are different. The more risk averse the producer, the larger the range of coverage for the robust strategies. Many of the more robust strategies are similar for the same level of risk aversion regardless of the particular utility representation (e.g., CR3, CR2 and MV). Again, except for the Risk-Neutral case, the more robust strategies are straightforward, involving one or two market positions.

Examination of the results demonstrated that it is possible to identify several strategies which are robust across the three cases. Table 3 provides a listing of the most robust strategies for the three cases considered.[3] Eight strategies appear to dominate all others. Again, except for the Risk-Neutral situation, the strategies are straightforward.

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[3]Strategies were eliminated from the list if another strategy was robust under the same situation plus at least one additional situation.

Standard Strategies

Tables 4, 5, and 6 provide a summary of the distribution of near optimal results, indicating when the standard option strategies, as well as cash and futures, are within 2% of the best strategy for CR3 for alternative price scenarios. For purposes of brevity MV and CR2 results are not presented, but are discussed where relevant.[4]

For any level of risk aversion, each of the standard options strategies is near optimal under approximately the same number of scenarios, varying from about 19% to 6% of the total. Here, the near optimal standard strategies generally are concentrated in the neighborhood of the market's expectations of the mean and volatility. Under the MV and CR2 specifications, the number and distribution of the near optimal strategies differ for the Risk-Averse and Slightly-Risk-Averse producer. With the MV and CR2 representations, the standard option strategies are near optimal under considerably more price scenarios. The biggest difference lies in the upper range of the expected means and volatilities where the use of options and the characteristics of the underlying price distribution skew the returns distribution. The increased skewness under the CR3 specification leads to the selection of optimal strategies which results in levels of CE substantially different than the CE generated from the standard option strategies.

The number of scenarios under which the standard strategies are near optimal decreases with decreasing risk aversion. As the producer's expectations differ from the market's expectations, the greater the potential for increased returns from taking optimal positions. The more risk averse the producer, the greater the proportion of an increase in expected returns that is hedged. Conversely, the less risk averse the producer, the smaller the portion that is hedged. Thus, at lower levels of risk aversion, where producers are attempting to obtain a larger portion of the expected return, the hedging strategies considered here are less likely to be within 2% of the best strategy. From another perspective, the standard option strategies are not refined enough to take full advantage of differences between producer's price expectations and the market's. However, their simplicity allows them to perform well under a range of scenarios.

Although the standard options strategies considered here are fairly robust, in the sense that they are near optimal under a range of price scenarios, they do not appear to be any more robust than cash and futures strategies. However, as can be appreciated by the distribution of near optimal strategies, they are robust under somewhat different price scenarios. For example, if the producer believes that the market's volatility is correct, and that the mean will be either higher or only slightly lower than the futures price, a long put at $44/cwt may be a better choice than either cash or futures.[5]

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[4]The results of the MV and CR2 specifications are very similar to those reported for the CR3 specification. Important differences are discussed in the text.

[5]While not the specific focus of the paper, it is interesting to note that, in terms of the absolute level of CE, the cash and futures positions often are more attractive than the standard options strategies. The attractiveness of the cash and futures positions is that they do not require commission fees and payment of an initial premium with its associated interest cost, respectively.

Summary and Conclusions

The search for the "ideal" marketing strategy likely will always continue. Here, we provide information on near optimal and robust strategies for a hog producer. Using a simulation framework, based on recent price patterns, strategies that are within 2% of the maximum CE are identified for different utility specifications 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 that no one strategy is near optimal under all scenarios. Nevertheless, it is possible to identify near optimal strategies for selected price expectations. It also is possible to identify strategies which are near optimal across a diverse of set of price expectations. In terms of selecting robust strategies, when prices are near the market expectations of mean and volatility, it appears to be more important to identify the level of risk aversion, as opposed to the particular form of the utility representation. That is, for expectations near the market, often similar risk preferences lead to the selection of similar if not identical strategies. As price expectations deviate substantially from those of the market, the form of the utility representation takes on added importance.

In a similar vein, the standard options strategies are most likely to be near optimal when the expected prices are near the market's expectations of mean and volatility. Differences in the number and distribution of near optimal strategies materialize as the skewness of the returns distribution increases and producer's preferences for positive skewness is permitted to influence the selection of strategies. The degree of risk aversion also influences the number of standard strategies that are near optimal; the number of near optimal strategies decreases with decreasing risk aversion. At lower levels of risk aversion, where producers are more concerned about expected return, the standard options strategies do not perform as well. Finally, often the standard options strategies do not outperform cash and futures positions. However, they are near optimal under different sets of price expectations.

The findings highlight the importance of appropriate specification of the producer's price expectations and risk preferences. Under certain circumstances, it is possible to identify rather robust strategies which permit the producer to achieve "acceptable" ex ante CE. The degree of consistency between these ex ante findings and ex post returns is the subject of future interesting research.

Table 1

Robust Strategies for Small Changes in Mean and Volatility
from Market Expectations, CR3 Utility

Risk Averse

strategy		AV mean	23 44	23 43	23 45	21.25 44	21.25 43	21.25 45	24.75 44	24.75 43	24.75 45
365	(sfut)		X	X	X	X	X	X	X	X	X
1336	(bull)		X	X	X	X	X	X	X	X	X
1174	p44,-c46		X	X	X	X	X	X	X	X	X
1334	p42,-c44		X	X	X	X	X	X	X	X	X
1093	(sc46)		X	X	X	X	X	X	X	---	X
1091	(sc44)		X	X	X	X	X	X	X	---	X
1085	(sc42)		X	X	X	X	X	X	X	---	X
1175	(lp44)		X	X	X	X	---	X	X	X	X
1121	(lp46)		X	X	X	X	---	X	X	X	X
122	-fut,-p42		X	X	X	X	X	X	X	---	X
366	-fut,c46		X	X	X	X	---	X	X	X	X

Slightly Risk Averse

strategy		AV mean	23 44	23 43	23 45	21.25 44	21.25 43	21.25 45	24.75 44	24.75 43	24.75 45
1093	(sc46)		X	X	X	X	---	X	X	---	X
1337	(lp42)		X	X	X	X	---	X	X	---	X
1091	(sc44)		X	X	X	X	X	X	X	---	---

Risk Neutral

strategy		AV mean	23 44	23 43	23 45	21.25 44	21.25 43	21.25 45	24.75 44	24.75 43	24.75 45
1581	fut,-p42,c46		X	---	X	X	---	X	X	---	X
1583	fut,-p42,c44		X	---	X	X	---	X	X	---	X
1743	fut,-p44,c46		X	---	X	X	---	X	X	---	X
1824	fut,c46		X	---	X	X	---	---	X	---	X
607	-fut,p42, -c46		X	X	---	X	---	---	X	X	---
605	-fut,p42, -c44		X	X	---	X	---	---	X	X	---
445	-fut,p44, -c46		X	X	---	X	---	---	X	X	---

An "X" indicates that the strategy at the left yields a CE within 2% of the maximum possible CE under the scenario at the top of the table.

Table 2

Robust Strategies for Small Changes in Mean and Volatility from Market Expectations, Mean-Variance

Risk Averse

strategy		AV mean	23 44	23 43	23 45	21.25 44	21.25 43	21.25 45	24.75 44	24.75 43	24.75 45
365	(sfut)		X	X	X	X	X	X	X	X	X
1336	(bull)		X	X	X	X	X	X	X	X	X
1174	p44,-c46		X	X	X	X	X	X	X	X	X
1334	p42,-c44		X	X	X	X	X	X	X	X	X
1172	p44,-c44		X	X	X	X	X	X	X	X	X
1328	p42,-c42		X	X	X	X	X	X	X	X	X
1120	p46,-c46		X	X	X	X	X	X	X	X	X
527	-fut,p42, -p44		X	X	X	X	X	X	X	X	X
1085	(sc42)		X	X	X	X	X	X	X	---	X
1091	(sc44)		X	X	X	X	X	X	X	---	X
1166	p44,-c42		X	X	X	X	X	---	X	X	X
367	-fut,c44, -c46		X	X	X	X	X	---	X	X	X
1118	p46,-c44		X	X	X	X	X	---	X	X	X
203	-fut,-p42 p44		X	X	X	X	X	---	X	X	X
373	-fut,c42, -c46		X	X	X	X	X	---	X	X	X
371	-fut,c42, -c44		X	X	X	X	X	---	X	X	X

Slightly Risk Averse

strategy		AV mean	23 44	23 43	23 45	21.25 44	21.25 43	21.25 45	24.75 44	24.75 43	24.75 45
1093	(sc46)		X	X	X	X	---	X	X	---	X
1091	(sc44)		X	X	X	X	---	X	X	---	X
1121	(lp46)		X	X	X	X	---	---	X	X	X
366	-fut,c46		X	X	X	X	---	---	X	X	X
1094	(cash)		X	---	X	X	---	X	X	---	X
365	(sfut)		X	X	---	X	X	---	X	X	---
1337	(lp42)		X	X	X	X	---	---	X	---	X
1175	(lp44)		X	X	X	X	---	---	X	---	X
1085	(sc42)		X	X	X	X	X	---	X	---	---
608	-fut,p42		X	X	---	X	X	---	X	X	---
364	-fut,-c46		X	X	---	X	X	---	X	X	---
446	-fut,p44		X	X	---	X	X	---	X	X	---
1092	-c44,c46		X	---	X	X	---	X	X	---	X
851	-p42		X	---	X	X	---	X	X	---	X
932	-p42,p44		X	---	X	X	---	X	X	---	X
362	-fut,-c44		X	X	---	X	X	---	X	X	---
1096	c44,-c46		X	---	X	X	---	X	X	---	X
1095	c46		X	---	X	X	---	X	X	---	X
1256	p42,-p44		X	---	X	X	---	X	X	---	X

Risk Neutral

strategy		AV mean	23 44	23 43	23 45	21.25 44	21.25 43	21.25 45	24.75 44	24.75 43	24.75 45
1743	fut,-p44 c46		X	---	X	X	---	X	X	---	X
1824	fut,c46		X	---	X	X	---	---	X	---	X
607	-fut,p42, -c46		X	X	---	X	---	---	X	X	---

An "X" indicates that the strategy at the left yields a CE within 2% of the maximum possible CE under the scenario at the top of the table.

Table 3

Strategies Robust Under Several Possible Price Expectations, Levels of Risk Aversion, and Utility Specifications

		cash	sfut	sc46	-fut,p42	-p42	c46	fut, -p44,c46	-fut, p42,-c46	-fut -c44,-c46
Producer Expects Small Changes in Mean and Volatility										
CR3	RA		X							
	SR			X						
	RN							X		
MV	RA		X							
	SR			X						
	RN							X		
CR2	RA		X							
	SR			X						
	RN							X		
Producer Expects Increase or No Change in Mean, Small Changes in Volatility										
CR3	RA	X		X						
	SR	X		X		X	X			
	RN							X		
MV	RA	X		X						
	SR					X	X			
	RN							X		
CR2	RA	X		X						
	SR					X	X			
	RN							X		
Producer Expects Decrease or No Change in Mean, Small Changes in Volatility										
CR3	RA		X		X				X	
	SR									X
	RN									
MV	RA				X				X	
	SR								X	
	RN									
CR2	RA				X				X	
	SR								X	
	RN									

Table 4.

Scenarios Where Particular Standard Strategy has CE Within 2% of Best Strategy

Risk Averse Producer with CR3 Utility

Scen	Vol	Mean	Best	CE	cash	fut	lp42	lp44	lp46	sc42	sc44	sc46	bear	bull	sstg	lstg
11	9	40	460	53.55												
12	9	42	28	51.31												
13	9	43	1	51.79												
14	9	44	730	52.28												
15	9	45	1459	53.50												
16	9	46	1468	54.88												
17	9	48	1484	60.22												
21	16	40	703	51.37												
22	16	42	109	47.28												
23	16	43	28	46.31												
24	16	44	757	46.20												
25	16	45	739	47.09												
26	16	46	1468	49.01												
27	16	48	1484	55.36												
31	19.5	40	703	49.78												
32	19.5	42	361	45.05												
33	19.5	43	1081	44.12		1				1	1	1	1	1	1	
34	19.5	44	1090	44.13	1	1				1	1	1		1	1	
35	19.5	45	850	44.80	1					1	1	1				
36	19.5	46	770	46.13	1											
37	19.5	48	1485	52.69												
41	21.25	40	703	48.86												
42	21.25	42	361	44.41		1							1		1	
43	21.25	43	364	43.83		1				1	1	1	1	1	1	
44	21.25	44	1093	43.76	1	1	1	1	1	1	1	1	1	1	1	
45	21.25	45	1094	44.36	1	1	1	1	1	1	1	1		1		
46	21.25	46	851	45.53	1							1				
47	21.25	48	1512	51.68												
51	23	40	712	47.87									1			
52	23	42	607	44.17		1							1	1	1	1
53	23	43	365	43.65		1	1	1	1	1	1	1	1	1	1	1
54	23	44	365	43.64	1	1	1	1	1	1	1	1				
55	23	45	1094	44.23	1	1	1	1	1	1	1	1		1		
56	23	46	1863	45.34	1		1	1				1				
57	23	48	1836	51.56												
61	24.75	40	713	47.52												
62	24.75	42	689	44.32		1							1	1		1
63	24.75	43	608	43.76		1		1	1				1	1		1
64	24.75	44	365	43.63	1	1	1	1	1	1	1	1		1		1
65	24.75	45	1944	44.25	1	1	1	1	1	1	1	1				
66	24.75	46	2160	46.38												
67	24.75	48	1836	51.95												
71	26.5	40	715	47.47												1
72	26.5	42	689	44.58									1	1		1
73	26.5	43	608	43.89		1	1	1	1					1		1
74	26.5	44	2187	44.03		1	1	1	1							
75	26.5	45	2187	45.80												
76	26.5	46	1944	47.78												
77	26.5	48	2079	52.69												
81	30	40	716	48.08												
82	30	42	717	45.61												
83	30	43	2187	46.73												
84	30	44	2187	48.47												
85	30	45	2187	50.25												
86	30	46	2187	52.07												
87	30	48	2160	56.07												
# of times strategy is within 2% of maximum possible CE					11	16	10	11	10	11	11	13	10	13	7	8

Table 5.

Scenarios Where Particular Standard Strategy has CE Within 2% of Best Strategy

Slightly Risk Averse Producer with CR3 Utility

Scen	Vol	Mean	Best	CE	cash	fut	lp42	lp44	lp46	sc42	sc44	sc46	bear	bull	sstg	lstg
11	9	40	703	53.97												
12	9	42	28	51.43												
13	9	43	1	51.99												
14	9	44	730	52.53												
15	9	45	1459	53.78												
16	9	46	1468	55.18												
17	9	48	1484	61.43												
21	16	40	703	53.20												
22	16	42	352	48.03												
23	16	43	28	47.13												
24	16	44	730	47.17												
25	16	45	1468	48.37												
26	16	46	1471	50.88												
27	16	48	1485	59.53												
31	19.5	40	703	52.60												
32	19.5	42	379	46.57											1	
33	19.5	43	352	44.94											1	
34	19.5	44	847	44.52	1	1				1	1	1		1		
35	19.5	45	742	45.76												
36	19.5	46	1472	48.79												
37	19.5	48	1485	58.31												
41	21.25	40	703	52.26												
42	21.25	42	676	45.94						1	1		1	1	1	
43	21.25	43	361	44.25		1				1	1		1	1	1	
44	21.25	44	1093	43.96	1	1	1	1	1	1	1	1	1	1	1	
45	21.25	45	770	45.04	1		1				1	1				
46	21.25	46	1472	47.73												
47	21.25	48	1485	57.67												
51	23	40	703	51.81												
52	23	42	712	45.50						1	1	1	1	1	1	1
53	23	43	607	43.86		1	1	1	1	1	1	1	1	1	1	1
54	23	44	1094	43.74	1	1	1	1	1	1	1	1				
55	23	45	1094	44.73	1		1	1	1	1	1	1				
56	23	46	1836	47.45												
57	23	48	1485	56.91												
61	24.75	40	703	51.43												
62	24.75	42	715	45.58									1	1		1
63	24.75	43	689	44.12		1							1	1		1
64	24.75	44	1337	43.82	1	1	1	1	1	1	1	1				
65	24.75	45	1095	44.80	1		1	1	1			1				
66	24.75	46	1836	47.79												
67	24.75	48	1485	56.30												
71	26.5	40	703	50.96												
72	26.5	42	716	45.97												1
73	26.5	43	716	44.52		1								1		1
74	26.5	44	1418	44.13	1	1	1	1	1							
75	26.5	45	2160	45.21	1		1	1	1							
76	26.5	46	2079	48.19												
77	26.5	48	1728	55.78												
81	30	40	707	50.58												
82	30	42	717	47.13												
83	30	43	720	46.18												
84	30	44	1458	46.11												
85	30	45	2187	47.76												
86	30	46	2160	50.10												
87	30	48	1836	56.38												
# of times strategy is within 2% of maximum possible CE					9	9	9	8	8	7	8	8	6	8	6	6

Table 6.

Scenarios Where Particular Standard Strategy has CE Within 2% of Best Strategy

Risk Neutral Producer with CR3 Utility

Scen	Vol	Mean	Best	CE	cash	fut	lp42	lp44	lp46	sc42	sc44	sc46	bear	bull	sstg	lstg
11	9	40	703	54.23												
12	9	42	28	51.49												
13	9	43	1	52.08												
14	9	44	730	52.64												
15	9	45	1459	53.91												
16	9	46	1468	55.31												
17	9	48	1485	62.21												
21	16	40	703	54.08												
22	16	42	379	48.49												
23	16	43	28	47.49												
24	16	44	730	47.66												
25	16	45	1468	49.27												
26	16	46	1484	52.32												
27	16	48	1485	62.00												
31	19.5	40	703	53.98												
32	19.5	42	703	48.07												
33	19.5	43	352	45.80												
34	19.5	44	730	45.02							1	1			1	
35	19.5	45	1472	47.59												
36	19.5	46	1485	51.98												
37	19.5	48	1485	61.87												
41	21.25	40	703	53.93												
42	21.25	42	703	48.01												
43	21.25	43	352	45.17												
44	21.25	44	850	44.10	1	1	1	1	1	1	1	1	1	1	1	
45	21.25	45	1484	46.96												
46	21.25	46	1485	51.91												
47	21.25	48	1485	61.80												
51	23	40	703	53.86												
52	23	42	703	47.93												
53	23	43	703	44.93												
54	23	44	1094	43.99	1	1	1	1	1	1	1	1	1	1	1	1
55	23	45	1485	46.85												
56	23	46	1485	51.82												
57	23	48	1485	61.72												
61	24.75	40	703	53.81												
62	24.75	42	703	47.86												
63	24.75	43	704	44.85												1
64	24.75	44	1094	43.99	1	1	1	1	1	1	1	1	1	1		
65	24.75	45	1836	46.93												
66	24.75	46	1485	51.75												
67	24.75	48	1485	61.65												
71	26.5	40	703	53.75												
72	26.5	42	703	47.80												
73	26.5	43	716	45.36												1
74	26.5	44	1422	44.54	1	1	1	1	1							
75	26.5	45	1836	47.51												
76	26.5	46	1485	51.67												
77	26.5	48	1485	61.58												
81	30	40	703	53.60												
82	30	42	716	48.18												
83	30	43	720	47.00												
84	30	44	1458	47.23												
85	30	45	2160	49.33												
86	30	46	1836	52.59												
87	30	48	1485	61.40												
# of times strategy is within 2% of maximum possible CE					4	4	4	4	4	3	4	4	3	3	3	3

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