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THREE ARTICLES CONCERNING RISK MANAGEMENT IN THE MEAT INDUSTRY

Iowa State University PH.D. 1986

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Three articles concerning risk management

in the meat industry

by

Dennis Duane DiPietre

A Dissertation Submitted to the

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GENERAL INTRODUCTION

Perhaps one of the most pervasive desires of humanity throughout history has been to know the future with certainty. The instrumentality of prediction has evolved from such things as prophecy, star charts and crystal balls to include modern mathematical forecasting models. Statistical probability and technique form the fundamental methods upon which most, if not all of modern decision analysis and forecasting are based.

The need to know the future pervades present economic decision-making. This need arises from a problem which occurs when two or more choices with different possible outcomes are available and the economic consequences of the decision are judged important.

The growth of futures markets and their use are examples of efforts to mitigate the consequences of future price changes. On exchanges where meat-related futures are traded, contracts for pork bellies, live hogs, live cattle and feeder cattle are trading heavily. Although contracts for boneless beef have been withdrawn at both the New York and Chicago Merchantile Exchanges, their reintroduction is likely as soon as research indicates the characteristics of contract design which will attract hedging and speculative interest.

In the 1983 annual report of the Commodity Futures Trading Commission (CFTC), the use of meat-related futures markets by commercial interests holding large contract commitments was examined. Beef processors were found to carry predominantly long futures positions in live cattle contracts as a hedge against widely fluctuating cattle prices. Cattle costs represent about 85 to 90 percent of the basic cost of production of fresh beef carcasses and fabricated cuts. Both beef and pork processors indicated to the CFTC that the demand for forward pricing meat cuts to hotels, restaurants and institutions was increasing. Because the dollar risk of these forward price commitments is so large to meat processors, they have made bids and accepted orders only when they could hedge or cross-hedge the sales in a livestock future. Cattle processors were found to preprice as much as 80 percent of their anticipated cattle needs by using futures markets.

Pork processors were also found to be predominantly long hedgers for the same reason as cattle processors. These positions were normally held in live hog futures, but the use of pork belly futures to hedge bacon sales and preprice raw materials was not uncommon.

Nine of the ten large hedgers interviewed indicated that selective hedging as opposed to routine hedging was the most prevalent practice employed by their firm. Furthermore, the size of the selective hedge was typically larger than the routine hedge position. Managers revealed that their selective hedging criteria was a function of their "risk/opportunity" probability in a given situation which was determined both objectively and subjectively.

Explanation of Thesis/Dissertation Format

This dissertation consists of three articles in applied risk management. All three involve meat industry applications addressing techniques for price risk management.

The first two articles attempt to describe a rational model for cross-hedging. Cross-hedging is a relatively new phenomenon involving the hedging of one product in the futures contract of a related product. At the time this research was begun, very little literature was available on the subject, although the practice was becoming widespread among larger firms as an agricultural risk management tool.

The first article concerns cross-hedging beef products using live cattle futures. The second article is a similar attempt describing cross-hedging pork products in live hog futures. Both articles represent an early attempt in the economics literature to apply cross-hedging to price risk problems in the meat industry. Both articles examine the feasibility of cross-hedging several products in the corresponding live animal future by calculating the hedging relationships between various commercial cuts of meat and the live animal contracts and examining the basis risk involved when such a practice is employed.

The first two articles have been published in the Journal of Futures Markets and the American Journal of Agricultural Economics, respectively. As a result, numerous inquiries from meat industry managers have been received regarding specific applications of the technique to their products and hedging practices. The first article is journal paper J-10525 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa, Project No. 2437. The copyright is held by John Wiley and Sons, Inc. The second article is journal paper J-10429 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa, Project No. 2437. The copyright is held by the American Association of

Agricultural Economics. A complete bibliographical citation for each is contained in the bibliography of Section III. The candidate co-authored both articles with Marvin L. Hayenga, Professor of Economics, Iowa State University.

The third article represents an attempt to apply the latest theory of risk management to meat industry purchasing decisions. It incorporates target motives and the feelings regarding results different from target into the purchase and inventory strategies of meat buyers. It is widely observed that many purchasing agents formulate their strategies with specific price or profit targets in mind. The consequences of results achieved when deviations from target occur are not necessarily symmetric above and below the specified target. If this is the case, current economic theory possesses only a beginning understanding of how to describe and model this behavior in a purchasing context where several risk management strategies such as hedging and cross-hedging are available. Funding for this article was granted by the Columbia Center for the Study of Futures Markets, Columbia University, New York, New York.

SECTION I. HEDGING WHOLESALE MEAT PRICES: AN ANALYSIS OF THE BASIS RISK

INTRODUCTION

Hedging has long been recognized as a means by which the risks of price variability can be reduced. In the classic case, equal and opposite price risks for a given commodity are assumed in the cash and futures market so that the value of the gains in one market perfectly offset the losses in the other. Assuming equal and opposite price risks in two markets is made possible by the development of organized markets in the trading of futures contracts. A commodity futures contract is the instrument by which the transfer of price risk from hedgers to speculators is facilitated. The contract is most specific as to commodity quantity whereas other characteristics such as quality or grade, location and time of delivery are allowed to vary within limits, with appropriate discounts or premiums associated with variations from the basic contract specifications. These specifications establish enough standardization to facilitate the trading of contracts on the basis of the product specifications, but also provide enough flexibility in quality, location and time of delivery to minimize concern regarding squeezes or artificial shortages of a standard grade (1).

Virtually all of the literature regarding the transfer of price risk using futures markets is concerned with trading the same commodity in both spot and futures markets (3). Indeed, the principle upon which such a transfer of risk is made possible is the threat of making or requiring delivery. This threat normally forces a convergence of spot and futures during the delivery period, which is necessary to provide the predictable basis (futures-cash price difference) essential for effective hedging. The question arises for many commodity producers or merchandisers whether commodities which do not meet futures contract specifications, and are therefore nondeliverable because of time, space, or form differences, can still be successfully hedged in an established related futures contract.

Many potential hedgers in commodity or financial futures markets trade commodities which differ from the contract specifications in the futures market in a variety of ways including sex, grade, weight, location, maturity, etc. If the price relationship between their commodity and the commodity specified in the contract is known with a reasonable level of assurance, then the potential hedger may be able to use the related futures contract as a risk management tool.

Wholesale meat processors and merchandisers have long had to weather volatile markets when dealing with large physical inventories or contractual commitments for perishable meat products, without directly comparable futures markets contracts to offset these price risks (with the exception of pork bellies and the limited volume boneless beef contract). In today's environment of high interest rates, using futures markets to establish prices or margins on forward raw material purchases or product sales could frequently be more desirable than carrying costly physical inventories.

While there are viable live hog and live cattle contracts, seldom do many wholesale cut prices seem to move in parallel with these futures prices. However, prices do not have to move in parallel for a futures contract to serve as a useful hedging mechanism for another commodity. If prices of the two commodities move in a predictable proportional pattern, the futures market could serve as a useful hedging mechanism for the related commodity.

In this study, we analyze the technical feasibility of hedging wholesale beef products (carcasses, primal cuts, fabricated (boxed) cuts, and lean trimmings) using live cattle futures. Because these products are further processed components of the live animal, many of the carcass and component prices are sharply higher due to the value added in processing. Frequently, wholesale beef prices exhibit different seasonal demand patterns in comparison to the composite demand for all beef products reflected in live cattle prices. Accommodating this, we break down the year into six two-month segments and determine to what degree there has been an historically consistent, proportional correspondence between cash and futures price movements within each period. If this correspondence or basis relationship between the meat product price and the live cattle futures price is quite predictable within each time period, then a hedge (or cross-hedge) would appear to be technically feasible for meat processors and merchandisers with moderate or small basis risk.

Miller (4) analyzed the hedging relationship for a few wholesale beef products, without considering the seasonal differences on hedging relationships that appear potentially appropriate for many products. Hayenga and DiPietre (2) used the approach presented in this paper to analyze the relationship between wholesale pork products and live hog futures, and found that live hog futures could be a useful hedging tool for many firms merchandising wholesale pork products.

THE MODEL AND ESTIMATION PROCEDURE

Using 1970-1980 data[1] on wholesale beef product prices from *The National Provisioner* and live cattle futures closing prices from the Chicago Mercantile Exchange, we estimated the relationship between average cash prices and futures prices for each selected time period using ordinary least squares. The basic model is:

$$CP_{ij} = a_{ij} + b_{ij}\ FP_i + u_{ij}$$

where: CP_{ij} = the average of the daily cash prices for the jth wholesale beef product during contracting period i each year (cents per pound).

FP_i = the average of the daily prices for the nearby live cattle futures contract during contracting period i each year (cents per pound).

u_{ij} = error term.

The six selected time periods were defined as the two-month period when a particular contract month would be the nearby contract used for hedging. The last two weeks prior to a contract's expiration were omitted to minimize the risk of making or taking delivery. Thus, the data were the average prices for the two-month periods: Feb.: Dec. 7-Feb. 6; Apr.: Feb. 7-Apr. 6; June: Apr. 7-June 6; Aug: June 7-Aug. 6; Oct.: Aug. 7-Oct. 6; Dec.: Oct. 7-Dec. 6. Typically, 11 observations on cash and futures prices were used to estimate the model parameters.

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[1] 1975-80 for 50% lean trim and the boxed beef products; these prices weren't reported in *The National Provisioner* magazine prior to 1975.

FP is treated as the independent variable since the initial futures market price would be predetermined in a hedging operation, and the corresponding beef product price would have to be estimated.

This model allows both the intercept and the slope coefficients to vary seasonally for each wholesale cut, reflecting the seasonal demand variations for many beef cuts (Hacklander). The estimated equation reflects the typical basis which varies as the level of futures and the wholesale product prices rise or fall.

The potential hedger's critical concern would be the difference in the wholesale product cash price and the live cattle futures price during the time period when the hedge would be liquidated. The initial futures price in a hedging transaction would be the current price quotation in the relevant contract month. If the futures and cash price relationship has generally behaved in a consistent proportional fashion during the period of anticipated cash market transactions, then a hedger should feel reasonably confident that, absent any changes in the structure of the market, estimates of that relationship could be used to develop a reasonable hedging mechanism for their wholesale beef product purchases or inventories.

In this model, the estimated slope coefficients (b_{ij}'s) reflect the typical change during the last 11 years in the average wholesale beef product price associated with a one dollar change in the average futures price during each two-month contracting period. If the product price typically rose $1.60 when the futures price increased by one dollar, the hedger clearly wouldn't be able to assure a purchase price or protect an inventory value by hedging on a pound-for-pound basis during a volatile market. If the price changes on a 1.6:1 ratio, the hedger would have to take a larger position (1.6 times larger) in the futures market than in the cash market to have the gains and losses from the cash market and futures market balance out.

By using the estimated intercept term (a_{ij}) in conjunction with the estimated slope coefficient (b_{ij}), the hedger can take the current futures price quotation (say, 60 for December), and calculate the wholesale product cash price equivalent of that futures price (example: CP = 10 + 1.6FP = \$1.06). The potential hedger could then elect to take a position in live cattle futures to establish that approximate cash price for that beef product up to 12 months in advance of the actual cash market transaction. However, this would only be considered if the prices did move together and the basis behaved in a predictable manner.

RESULTS

In Table I-I, the estimated hedging relationships and measures of the basis variability are presented for fifteen wholesale beef products ranging from carcasses to lean trimmings. The coefficient of determination (R^2) reflects the proportion of the variation in average cash prices associated with changes in average futures prices. The standard error of the forecast (S.E.F.) at the mean of the observed futures prices is also presented; approximately 2/3 of the variations from the expected average cash price (based on the average futures price) would be within $\pm$ 1 S.E.F. Another way of looking at this variability measure is 1/3 of the hedges would result in favorable or unfavorable basis results greater than the standard error estimated; however, only one-half of those would be unfavorable to the hedger. Over time, the favorable and unfavorable results should balance out. It should be noted that hedgers who didn't liquidate hedges evenly over the two-month contracting period would be faced with a greater standard error (more basis variability) than indicated in Table I-1.

The results for many beef products generally show good fits between average futures and cash prices over time within the six contracting periods. The equations for steer and heifer carcasses, rounds, and chucks exhibit very high R^2 statistics and relatively small standard errors of the forecast for all contract periods; however, note that the size of the error that would be considered acceptable on any particular hedge or series of hedging transactions would vary greatly among firms or managers.

Table I-1. Beef product hedging relationships[a]

Dependent Variable	Contract Period					
	Feb.	Apr.	June	Aug.	Oct.	Dec.
Choice Steer Carcasses 6/700 lbs., Yld. 3						
Intercept	6.06	5.17	3.22	3.52	2.95	2.97
Slope	1.40	1.40	1.45	1.47	1.48	1.44
R^2	.97	.99	.98	.94	.95	.98
S.E.F. (mean)	3.20	1.72	3.47	5.14	4.88	2.97
Choice Heifer Carcasses 5/600 lbs., Yld. 3						
Intercept	4.34	4.65	3.52	4.12	3.45	2.33
Slope	1.41	1.38	1.42	1.42	1.43	1.42
R^2	.97	.99	.98	.94	.96	.98
S.E.F. (mean)	3.12	1.71	3.12	4.95	4.02	2.92
Choice Steer Carcasses 6/700 lbs., Yld. 4						
Intercept	12.44	8.81	8.43	10.87	10.96	11.99
Slope	1.18	1.25	1.27	1.24	1.24	1.14
R^2	.98	.99	.96	.92	.94	.95
S.E.F. (mean)	2.52	1.96	3.90	5.03	4.90	3.84
Choice Heifer Carcasses 5/600 lbs., Yld. 4						
Intercept	11.04	8.52	8.17	9.14	8.44	9.47
Slope	1.18	1.23	1.26	1.25	1.27	1.17
R^2	.97	.99	.96	.93	.95	.95
S.E.F. (mean)	2.75	2.18	3.82	4.69	4.01	3.87
Choice Steer Round 70/90 lbs.						
Intercept	16.54	11.61	8.76	10.79	13.35	11.28
Slope	1.48	1.53	1.56	1.50	1.48	1.54
R^2	.97	.97	.95	.96	.97	.98
S.E.F. (mean)	3.35	3.79	5.25	4.19	4.02	2.80

[a]The slope coefficient for all products except livers were significantly different from zero at the 99 percent confidence level.

Table I-1. continued

Dependent Variable	Feb.	Apr.	June	Aug.	Oct.	Dec.
	Contract Period					
Choice Arm Chuck 80/110 lbs.						
Intercept	-2.97	-1.82	-1.41	-1.21	-.75	-1.90
Slope	1.42	1.35	1.24	1.28	1.30	1.32
R^2	.98	.98	.95	.95	.97	.98
S.E.F. (mean)	7.00	2.89	4.20	4.04	3.04	2.53
Choice Loin 60/70 lbs.						
Intercept	29.54	22.91	21.66	20.08	29.95	24.52
Slope	1.62	1.85	2.12	2.28	1.93	1.78
R^2	.88	.97	.93	.96	.90	.95
S.E.F. (mean)	7.86	4.72	8.40	7.02	9.18	5.80
Choice Ribs 30/35 lbs.						
Intercept	9.61	8.36	2.29	2.30	10.66	3.27
Slope	1.90	1.80	1.99	2.11	1.91	2.06
R^2	.84	.95	.95	.92	.91	.89
S.E.F. (mean)	11.30	6.42	6.37	9.49	8.63	10.35
50% Lean Trim[b]						
Intercept	5.99	4.82	5.30	.24	-12.13	-10.57
Slope	.70	.74	.82	.89	1.13	1.04
R^2	.79	.71	.59	.58	.70	.79
S.E.F. (mean)	5.78	8.77	10.17	12.12	11.50	8.00
75% Lean Trim						
Intercept	-6.70	2.47	1.68	2.47	-.35	-3.22
Slope	1.65	1.51	1.47	1.39	1.54	1.55
R^2	.91	.95	.90	.90	.87	.86
S.E.F. (mean)	6.74	4.93	7.12	6.69	8.70	9.21
85% Lean Trim						
Intercept	-15.18	-2.53	-1.86	1.69	-4.43	-5.29
Slope	2.14	1.91	1.79	1.69	1.88	1.87
R^2	.94	.96	.91	.89	.90	.88
S.E.F. (mean)	7.25	5.55	8.29	8.29	9.15	9.96

[b] 1975-80 only.

Table I-1. continued

Dependent Variable	Contract Period Feb.	Apr.	June	Aug.	Oct.	Dec.
Imported Cow Meat 85% Lean						
Intercept	-15.38	-2.01	.53	.60	-6.78	-11.57
Slope	2.20	1.90	1.74	1.69	1.96	2.08
R^2	.94	.95	.88	.90	.87	.89
S.E.F. (mean)	7.67	6.67	9.49	8.03	10.97	10.90
109 Rib Roast*** 15/25 lbs.						
Intercept	82.69	65.41	48.11	30.85	35.65	74.78
Slope	1.65	1.84	2.17	2.73	2.54	1.92
R^2	.81	.93	.90	.82	.87	.85
S.E.F. (mean)	13.35	9.52	10.78	20.22	15.32	12.46
Ribeye 2" Lip On*** 8/14 lbs.						
Intercept	146.98	123.97	102.56	76.25	62.46	122.27
Slope	2.15	2.38	2.85	3.70	3.74	2.76
R^2	.79	.93	.86	.80	.86	.83
S.E.F. (mean)	18.59	12.19	16.93	29.09	23.88	19.57
126 3-Way Chuck*** 60/110 lbs						
Intercept	-2.96	2.46	-11.14	3.36	-5.96	-4.23
Slope	1.89	1.68	1.83	1.65	1.83	1.79
R^2	.99	.98	.97	.97	.97	.97
S.E.F. (mean)	3.65	4.76	4.58	4.74	5.11	4.47
168 Inside Round*** 15/25 lbs.						
Intercept	57.83	47.52	18.40	19.11	32.11	45.88
Slope	1.61	1.63	2.30	2.34	2.03	1.77
R^2	.95	.93	.91	.97	.95	.96
S.E.F. (mean)	6.51	8.15	10.98	6.49	7.34	5.32
Gooseneck Round*** 20/30 lbs.						
Intercept	41.05	40.57	24.11	24.63	24.41	29.49
Slope	1.62	1.57	1.78	1.78	1.81	1.77
R^2	.94	.92	.86	.95	.95	.94
S.E.F. (mean)	6.79	8.49	10.52	6.65	6.74	7.12

[c] 1975-80 only, except for February, (1976-80).

Table I-1. continued

Dependent Variable	Contract Period Feb.	Apr.	June	Aug.	Oct.	Dec.
180 Boneless Strip*** 8/14 lbs.						
Intercept	97.19	96.05	128.86	78.42	85.72	78.02
Slope	2.31	2.36	2.09	3.42	3.19	2.85
R^2	.68	.89	.80	.93	.91	.88
S.E.F. (mean)	26.60	15.57	15.56	14.98	15.97	16.21
184 Top Butt*** 8/14 lbs.						
Intercept	69.58	66.88	55.14	38.36	56.75	62.15
Slope	1.61	2.04	2.56	2.66	2.26	1.94
R^2	.97	.83	.93	.87	.80	.93
S.E.F. (mean)	4.74	17.40	10.55	16.19	17.41	8.00
Livers (2 to box)						
Intercept	-.22	13.32	7.85	8.83	3.55	4.65
Slope	.60	.32	.43	.39	.57	.51
R^2	.41	.15	.23	.22	.33	.30
S.E.F. (mean)	10.13	11.46	12.01	10.76	12.06	11.84

Steer and heifer carcasses of the same yield grade exhibited very similar slope coefficients (hedging ratios), but substantial differences were observed between yield grades. Only modest seasonal differences in the hedging ratios were noted for rounds and chucks; these seasonal differences were much more pronounced for ribs, loins, and the fabricated or boxed products derived from them, reflecting the strong summer barbecue demand for steaks derived from these cuts. The seasonal demand variability for these cuts relative to the carcass and live animal probably contributed to the slightly lower, but still quite high R^2 statistics; the standard errors in these equations were much larger, partly reflecting the much higher absolute prices of these high value cuts, and partly reflecting additional sources of price variability which had different impacts on these cuts and the live cattle cash and futures prices.

Many restaurant chains interested in assuring purchase price levels in advance on their ground beef requirements would be interested in the fairly close relationships between many of the lean trimming product categories and live cattle futures. The 50% lean trim fit was weaker, probably due to the fact that only six years of data were used in that analysis, and two of those six years were during the liquidation phase of the cattle cycle when very high levels of cow slaughter pushed lean trim prices much lower than would typically be expected. The other lean trim classes exhibited similar patterns of residuals, but the greater number of observations from the more typical market environment made their results appear much better.

Beef livers were expected to serve as an example of a product which should not be hedged using live cattle futures. The results were consistent with this expectation. The very poor fits and high standard errors relative to their price levels reflect the high basis risk that a potential hedger of livers would face. However, one should not overlook the fact that even a relatively high basis risk on some beef products may appear desirable in situations when the likelihood of a large adverse change in wholesale product prices appears to be quite high.

HEDGING EXAMPLE

To provide a clearer idea of how these relationships could be used, consider the following case examples:

A major fast food chain wants a firm price quotation on its 75% lean trim needs during the next six months. A meat processor would be supplying it from ongoing processing operations, not from storage, so raw material costs aren't known in advance. How could the processor offer a price quotation (and hedge the price risk) using current live cattle futures prices?

If a million pounds are required each month (July through December), determine the quantities to hedge and the corresponding prices to quote by:

a. determining the quantity delivered in each contract period.

b. using the equations to translate current futures prices into equivalent product prices in each delivery period.

c. using the estimated hedge ratio to calculate the required futures position in each contract.

In Table I-2, the required volume to be supplied in each contracting period is calculated first. The estimated equation is then used to translate today's futures price in the relevant contract into an expected 75% lean trim cost for the processor (e.g., CP = 2.47 + 1.39(68) for July 1-August 6). This cost (97 cents/lb.) should be within $\pm$ 7 cents of the actual cost approximately 2/3 of the time and usually was closer than that during 1970-80 except when the cow herd liquidation was at its peak.

The processor could then add the desired merchandising margin. An additional "fudge factor" could be added to allow for changes in the futures price between the time of the quotation and its acceptance and to cut down on the risk of unfavorable basis results. Of course, that also could reduce the processor's chances of winning the contract. Upon acceptance of the offer, the processor would buy the number of cattle futures contracts which would establish his approximate raw material cost and margin on this forward sales contract. A slight modification of the same procedure could be used by the fast food or retail chain to establish their costs without tying them to a particular supplier.

Table I-2. Cross-hedging example

Dates	Contract	75% Lean Q (1,000 lbs.)	Hedge Ratio	Cattle Equivalent Q (1,000 lbs.)	Number of Contracts	Current Futures Price (cents/lb.)	Cash Price Equivalent (cents/lb.)
July 1 - Aug 6	Aug	1250	1.39	1738	43	68	97
Aug. 7 - Oct 6	Oct	1970	1.54	3034	76	65	100
Oct 7 - Dec 6	Dec	1970	1.55	3054	76	66	99
Dec 7 - Dec 31	Feb	810	1.65	1337	33	66	102
	Total	6000				Wtd. ave.	99

SUMMARY AND IMPLICATIONS

Using a fairly simple econometric procedure, which could be used in other cross-hedging analyses for other commodities, the relationships between prices of live cattle futures and fifteen wholesale beef products during 1970-80 were analyzed. Typically, the wholesale product prices and live cattle futures prices have moved in a proportional fashion within selected time periods during a year, a necessary condition for the live cattle futures to be a feasible hedging tool. The futures position required to hedge a particular volume of wholesale beef varies substantially by product and by period within the year; thus, "pound-for-pound" hedging in live cattle futures definitely would not be appropriate, and even using the same hedging ratio throughout the year would not be appropriate for most wholesale beef products. Utilizing the best estimated hedging ratios still leaves the hedger with some basis risk, which varies for the wholesale beef products studied. Depending upon expectations regarding likely cash market prices in the future, prevailing futures prices, and the firm's risk aversion, live cattle futures can sometimes be a useful tool in forward selling or advance purchase programs and inventory management activities for firms dealing in the wholesale beef market.

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SECTION II. CROSS-HEDGING WHOLESALE PORK PRODUCTS USING LIVE HOG FUTURES

INTRODUCTION

The increased commodity market price volatility in the 1970s and early 1980s has sharply increased risks in commodity procurement and inventory management for food processing and distribution firms. Firms dealing in commodities which have futures contracts can use them as procurement or inventory management tools. Even though most wholesale meat products have no futures market, established futures trading in live hogs and cattle may provide hedging opportunities for firms handling large volumes of related meat products (4).

The objective of this paper is to evaluate the basis risk in using the live hog futures market as a risk management tool for hedging several wholesale pork products. Although either pork belly or live hog contracts could be considered for hedging wholesale pork products, we considered only live hog futures because (a) the seasonal demand patterns for bellies and some cuts are dissimilar (1) and (b) the pork belly futures market is more volatile than live hog futures and seen as more risky by many potential hedgers. We determine how closely wholesale pork product prices are related to live hog futures and what appropriate hedging relationships are using live hog futures to protect against adverse pork product price fluctuations.

MODEL AND ESTIMATION PROCEDURE

For this analysis we selected the most heavily traded wholesale pork cuts. These are often stored in large volumes and sometimes forward-priced to retail, food service, or processing firms.

Several weight categories of wholesale pork cuts are traded. To simplify the analysis, only one heavily traded weight category was selected for each cut, assuming that the other weight category prices would move similarly.

Utilizing 1970-79 daily price data from The National Provisioner and live hog futures closing prices from the Chicago Mercantile Exchange, the following basic model was estimated:

$$CP_{ij} = a_{ij} + b_{ij} FP_i + u_{ij} \qquad (1)$$

where CP_{ij} is the average cash price of the jth wholesale pork product during contract period i each year, FP_i is the average closing price of the nearby live hog futures contract during contract period i each year, and u_{ij} is the error term.

The seven contract periods were selected to minimize the probability of any hedger having to make or accept delivery of live hogs. In defining each contract period, the last two weeks preceding the expiration of each live hog contract were eliminated. The contracting periods considered in this analysis are listed below:

Feb.	Apr.	June	July	Aug.	Oct.	Dec.
Dec. 7-	Feb. 7-	Apr. 7-	June 7-	July 7-	Aug. 7-	Oct. 7-
Feb. 6	Apr. 6	June 6	July 6	Aug. 6	Oct. 6	Dec. 6

Thus, we typically used ten observations of average daily closing prices for each wholesale product and the nearby live hog futures contract. FP_i is the independent variable since the initial futures market price is predetermined in hedging, and the corresponding pork product price is to be estimated.

This model allows both the intercept and slope coefficients to vary seasonally for each wholesale cut, reflecting seasonal demand variations (1). The estimated equation reflects the typical "basis" which varies as the live hog futures and the wholesale prices rise or fall. The intercept reflects average live hog futures-product price differences during the contracting period that are unrelated to price level changes. The slope coefficient reflects how the cash price-futures price difference changes as price levels change. If the slope coefficient differs from +1.0, the cash-futures price difference (the basis) will differ at each futures price.

In an anticipatory (buying) hedge or inventory (selling) hedge, the difference between the initial futures price (FP^I) and the ending (close-out) futures price (FP^E), multiplied by the slope coefficient (b_{ij}), should be approximately equal to the difference between the expected pork product cash price (CP) from the estimated equation and the actual cash price (CP^E) when the final transactions are completed.

$$(FP^I - FP^E)b = (CP - CP^E) \qquad (2)$$

Because the estimated slope coefficients (b_{ij}) indicate the typical product price change associated with a one dollar change in the nearby live hog futures price at maturity (e.g., 1:1.6), reversing that ratio (e.g., 1.6:1) provides the appropriate ratio of the quantities (hog vs.

pork product) to be hedged so that futures market gains or losses approximately offset cash market changes in the processed cut.

Hedging decisions by a firm should incorporate its aversion to various risks (2) and the probability of various outcomes from hedging today, hedging at a later date, or relying solely on the cash market. The distribution of realized net product prices is a function of:

a. the current live hog futures price in the relevant contract month and the expected probability distribution of that price (FP^I) when a hedge is initiated,

b. the expected probability distribution of the ending basis between live hog futures and pork product prices ($FP^E - CP^E$).

c. the probability distribution of pork product prices in the cash market (CP^E) when cash market transactions are made, and

d. costs associated with hedging.

The manager's decision today would be based on a comparison of the likely distribution of results from hedging using live hog futures, taking into account basis size and variability and likely results from relying solely on the cash market. By examining the likelihood and magnitude of various results from hedging today, the manager can determine whether hedging today or waiting for a better opportunity is the best strategy. The same process would be repeated daily when hedging is an alternative.

The hedging relationships and associated variance in the cash-futures basis were estimated with separate equations for ten wholesale pork cuts (listed in Table II-1) in seven time periods during the year. Each of these periods coincides with a particular nearby live hog futures contract

Table II-1. Pork product hedging relationships

	Contract Period						
	Feb.	Apr.	June	July	Aug.	Oct.	Dec.
Hams (17-20 lbs.)							
Intercept	8.87	7.06	5.43	7.61	6.95	9.60	11.54
Slope	1.51	1.62	1.36	1.39	1.48	1.55	1.60
R^2	.88	.96	.98	.98	.97	.97	.90
S.E.F. (mean)	7.04	3.65	2.27	2.64	3.37	3.69	7.23
Picnics (8 lbs.-up)							
Intercept	7.69	10.57	10.76	9.77	5.94	9.15	6.12
Slope	.94	.95	.81	.89	1.05	.99	.94
R^2	.87	.88	.85	.91	.93	.91	.93
S.E.F. (mean)	4.47	3.80	4.26	3.44	3.62	4.21	3.52
Loins (14-17 lbs.)							
Intercept	7.94	5.17	3.18	11.49	18.41	17.73	10.92
Slope	1.76	1.88	1.73	1.70	1.59	1.61	1.59
R^2	.93	.98	.98	.89	.96	.92	.94
S.E.F. (mean)	6.25	2.58	2.86	7.66	4.12	6.47	5.45
Boston Butts (4-8 lbs.)							
Intercept	.94	5.68	2.71	-3.54	3.67	7.10	4.18
Slope	1.55	1.56	1.38	1.67	1.57	1.48	1.37
R^2	.91	.92	.94	.95	.96	.98	.94
S.E.F. (mean)	6.01	4.89	4.31	4.70	3.95	2.92	4.64
Boneless Butts (1.5-3 lbs.)							
Intercept	-1.19	-1.13	.20	-8.49	2.15	12.23	7.88
Slope	2.22	2.53	2.10	2.35	2.21	2.04	2.00
R^2	.88	.95	.92	.97	.87	.92	.93
S.E.F. (mean)	10.26	6.44	7.82	4.90	10.68	8.21	7.25
Spareribs (3 lbs.-down)							
Intercept	11.76	3.91	5.33	3.48	20.37	18.47	14.69
Slope	1.57	2.13	2.05	2.19	1.71	1.63	1.50
R^2	.86	.96	.96	.89	.75	.95	.93
S.E.F. (mean)	7.75	4.50	4.97	9.62	12.30	5.28	5.84
50% Lean Trim							
Intercept	2.13	.88	-2.12	-9.82	-10.94	-9.25	-3.63
Slope	.82	1.05	1.02	1.22	1.30	1.28	.95
R^2	.90	.80	.79	.85	.86	.83	.84
S.E.F. (mean)	3.51	5.73	6.62	6.48	6.64	7.86	5.58

Table II-1. continued

	Contract Period						
	Feb.	Apr.	June	July	Aug.	Oct.	Dec.
80% Lean Trim							
Intercept	11.18	12.65	10.10	9.66	9.26	11.21	12.68
Slope	1.24	1.31	1.22	1.33	1.41	1.38	1.17
R^2	.84	.58	.57	.80	.72	.66	.81
S.E.F. (mean)	6.80	12.12	13.40	8.48	11.08	13.27	7.75
Livers (100 lb. box)							
Intercept	12.42	20.36	23.19	16.62	4.74	12.38	11.10
Slope	.18	.02	-.05	.10	.43	.24	.23
R^2	.06	.00	.00	.02	.17	.10	.11
S.E.F. (mean)	9.62	10.19	10.63	12.18	12.17	9.50	8.94
Bellies (12-14 lbs.)							
Intercept	2.06	1.83	-2.24	-7.15	-10.48	-6.43	-2.50
Slope	1.29	1.41	1.36	1.50	1.73	1.70	1.35
R^2	.89	.81	.84	.83	.86	.81	.87
S.E.F. (mean)	5.81	7.36	7.43	8.59	8.95	10.99	7.13

typically considered appropriate for potential hedgers.[1] Note that our analysis focuses on the cash-futures price relationship during the period when a hedge would be closed out. This reflects the basis risk faced by a hedger even though that hedge might have been initiated several months before. The basis risk borne by the hedger is reflected in the standard error of the forecast (S.E.F.) for the particular cut and contracting period used (Table II-1). The hedger could use the estimated equation to translate the current price of the relevant futures contract into an expected cash price and then use the estimated S.E.F. to calculate the cash price confidence interval associated with that particular hedge.

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[1]For greater precision, separate equations could have been estimated for each month or bi-weekly period. Initial tests suggested that the estimates would not differ significantly, so we used the simpler procedure.

RESULTS

The estimated equations are summarized in Table II-1. The correspondence between pork product prices and live hog futures prices generally was quite high for hams, loins, butts, and picnics, with R^2 over .90 for most equations. More then 80% of the price variation for spareribs, bellies, and lean trim were explained by variations in the live hog futures prices in nearly all periods. Because the correspondence between those prices and live hog futures was lower and more variable across contracting periods, live hog futures might be a useful hedging tool in some periods.

While our analysis shows that live hog futures could be used to hedge pork bellies, using pork belly futures would be preferable. Comparable equations relating cash pork belly prices to pork belly futures provided R^2 statistics ranging from .95 to .99, slope coefficients ranging from 1.01 to 1.07, and standard errors less than 2.5 cents.

A large variance around the estimated relationship may not preclude hedging if there is a strong likelihood of a large, adverse change in cash prices. Then, a large basis risk might look relatively tolerable. However, a large basis risk usually reduces hedging desirability. The liver equation, for example shows very little relationship between live hog futures and liver prices. This indicates that live hog futures would be an ineffective pork liver hedging mechanism in most circumstances.

Although the proportion of product price variation explained by live hog futures was high for most cuts and periods, the size and frequency of variations around the estimated relationship provide a better index of the potential risks of using these estimates in a hedging program. The S.E.F. calculated for various values of the independent variable indicates the expected variance around the estimated relationship. Although the S.E.F. increases with distance from the independent variable mean, only the S.E.F. at the mean is shown in Table II-1. A meat processor, hedging hams each year in the February live hog contract and liquidating the hedge uniformly throughout the contracting period, would find that favorable and unfavorable variations in the futures-cash price relationships tend to cancel out over time. The actual results for a particular hedge could be expected to be within ±7.04 cents of the anticipated result approximately two-thirds of the time at the mean futures price of 38 cents. The variation becomes slightly larger away from the mean. However, only half of these deviations have unfavorable consequences. Whether this basis risk on individual transactions is tolerable depends on the manager's risk aversion. For example, a retail meat buyer might be able to tolerate a 5-7 cent per pound unfavorable basis error 20% of the time on unadvertised pork products but only a 2-3 cent basis error 10% of the time on heavily advertised specials. If the probability of an unmanageable adverse basis was too great with the estimated relationships, hedging procedures could be modified to make that risk manageable. A seller could add 3 or 4 cents to the estimated offer price, or a buyer could require the expected purchase price via hedging to be 3 or 4 cents higher than the expected cash market price.

If the manager elected to liquidate the hedge within a particular week or day rather than over the entire period, the average estimated relationships would still be appropriate, because the errors would still tend to cancel over time. However, the expected basis variability for individual hedges would be larger than reflected in the table 1 S.E.F.'s.

The residuals in most equations did not display a systematic pattern (most Durbin-Watson statistics indicated that the disturbances were not autocorrelated). However, there was an unusual pattern of large negative residuals for hams, loins, and butts in several contracting periods in 1973. These were balanced by large positive residuals for picnics and lean trim in many of the same periods. The red meat price controls in 1973 and the strong surge of Japanese purchases of boneless pork and processing cuts after devaluation in 1973 may have caused these fluctuations.

The slope coefficients in each equation indicate the extent to which the pork product price typically changes in association with a $1/cwt. change in the live hog futures price. All slope coefficients (except for livers) were significantly different from zero at the 1% level. It is evident that the slope coefficients differ among cuts and differ seasonally for most cuts (see Table II-1). Since the supply of hogs and wholesale cuts generally varies proportionately (except where cold storage or imports are influential), differences in slope coefficients probably can be attributed to differences in demand elasticities or to seasonal shifts in demand for each cut relative to the composite reflected by the live hog futures price. For example, large slope coefficients for spareribs during April through August probably reflect both a very inelastic demand and strong summer barbecue demand. The large slope coefficients for boneless butts probably reflect extra trimming losses and the inelastic demand for this highly processed product in dry sausage and canned lunchmeat. In contrast, prices for 50% lean trim and picnics change on an approximate 1:1 basis with live hog futures, reflecting greater substitution possibilities and a more elastic demand for these cuts. The large coefficients for ham in April and December probably reflect the relatively large holiday ham demand. A relatively low demand in the summer also is reflected in the coefficients.

An analysis of covariance model was employed to test whether the separate slope coefficients for each period and cut were significantly different from an annual model with a single slope coefficient (5). The resulting F-statistic indicated that all slopes for each period were significantly different at the 2% level from a single annual slope for each cut.

HEDGING EXAMPLES

How might these estimated relationships be used in actual practice? Consider two examples:

In May, a sausage manufacturer makes a large sales commitment, and wants to lock in a favorable purchase price on pork trimmings for use in July. Assume that the manufacturer requires 1.1 million pounds of trimmings, and the current July hog futures price is $45. Using the July 80% lean trim equation, the sausage manufacturer can take the current July hog futures price of $45 and convert that into an expected trimmings price of $69.50 (9.66 + 1.33 (45)). Buying 50 contracts (1,500,000 pounds) of July hog futures at $45 can establish the approximate cost of $69.50 for 1,130,000 pounds of trimmings, even though the actual trimmings would not be bought until sometime in June or early July. The manufacturer would expect the actual cash price to be within ± 7 cents of the estimated price approximately two-thirds of the time. As the sausage maker purchases trimmings in the cash market, a futures contract (30,000 pounds) should be sold for each 22,600 pounds of trimmings purchased.

In February, a meat packer has 500,000 pounds of hams in cold storage in anticipation of large Easter sales but is concerned that the market price may drop before the sales are completed. Assume that the current April live hog futures price is $50 per cwt. Since the packer will sell hams before mid-April, the April contract would be selected for hedging. Using the April ham equation in Table II-1, the packer could hedge those hams by selling 810,000 pounds of live hogs via April futures contracts.

If the current April futures price is \$50, the approximate ham price that the packer would be "locking in" is \$88.06. The packer's actual net cash price from the hedge could be expected to be within a \$84-92 range approximately two-thirds of the time.

Because each live hog contract requires 30,000 pounds of hogs, the appropriate number of contracts to sell is 27. As the packer begins making sales of hams to retailers or other customers, one live hog contract should be bought each time approximately 18,500 pounds of hams are sold. This will provide reasonable assurance of the approximate net sale price during the time that the hams remain in storage.

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SECTION III. A STOCHASTIC RISK-RETURN MODEL OF PURCHASING STRATEGIES

INTRODUCTION

The variability of agricultural product prices has undergone a tremendous increase in the last decade. Managers at every level of the market channel have come under increasing pressure to formulate effective purchase and marketing strategies in order to remain profitable. The selection of effective strategies is a multi-dimensional problem involving among other things, knowledge of the cash and futures markets, the managers feelings regarding loss aversion/gain attraction, and target return motives.

Sales officers, inventory managers and trade economists in the meat industry face special difficulties in maintaining profit margins while offering intermediate-term fixed price commitments to large buyers. This is particularly risky when firms offer such commitments without having established their future costs via forward contracting or forward pricing. For instance, a wholesale meat processing firm may be asked to submit a bid offering to supply a restaurant chain, dormitory food service, or the military with a large quantity of meat over a six month period at a fixed price. If long-term storage is not available (or suitable), the processing firm exposes itself to potentially unacceptable price risk by committing to the fixed price. As another example, a supermarket chain may wish to offer a holiday special on a particular cut of meat. This decision may be made several months in advance with or without the possibility of storage. The procurement manager must decide if current prices are low enough to warrant purchasing part or all of the anticipated needs. If prices are expected to fall, the manager may elect to delay the purchase in which case he will expose the firm to price risks and the potential for loss. The same basic problem confronts restaurant managers who usually prefer to fix menu prices for an extended period but cannot purchase perishable products very far in advance. Failure to formulate and implement an effective purchasing strategy may mean loss of customers to competitors and decreased profits.

The basic question which these managers face is how to determine and implement the best cash and/or futures market position to establish a profitable and competitive purchase or sales price. The decision involves the option of purchasing now at known prices and storage costs versus delaying purchases until some future date. Frequently, available storage is not sufficient or suitable to allow purchase-plus-storage pricing in the bidding and/or cost establishment process. Other options include buying hand-to-mouth or using the futures markets to hedge, cross-hedge or establish a forward purchase or sales price. Buying hand-to-mouth generally results in the attainment of an average price over the purchasing horizon which may result in small profits or perhaps losses. Hedging and cross-hedging exposes the firm to a basis risk which can be substantial for some cross-hedges (6, 7).

OBJECTIVE

The objective of this research is to develop a generalized inventory management model applicable to meat processing firms in market situations where quantity demanded is known but price distributions are stochastic, transitory and (possibly) nonstationary. The model selects utility maximizing inventory positions in both cash and futures markets where utility is dependent on deviations from management determined target objectives.

The most interesting aspect of this model is the specific inclusion of a target parameter and an associated two part utility function. This formulation departs from traditional modeling which often measures risk and return with respect to the mean and variance of returns. In simple terms, this model measures return according to an individual's attraction for returns above a given target level whereas risk is measured according to the individual's aversion for returns below target. Further, the effect of above-target returns on manager utility need not be symetric to the effect of below-target returns. The same argument can be made with respect to a firm's cost functions without a direct reference to utility. For a firm near bankruptcy, a small return above breakeven may not have the same impact as a loss of equal magnitude. Such a formulation provides the basis for an understanding of the effects on strategy as changes occur in the target and the loss aversion/gain attraction parameters.

Several factors must be considered in the development and implementation of such a model. First, if a position in the futures market is considered, the appropriate futures contract(s) offered on relevant exchanges must be identified. Anderson and Danthine (1) have shown that because of differing contract specifications and the potential for cross-hedging and arbitrage among exchanges, it may be desirable to take positions in several contracts on different exchanges in order to achieve profit objectives. Second, the futures price today along with current cash prices and storage costs (if storage is available and feasible) must be considered. Third, the probability density functions for cash and futures prices during the time when these positions could be taken should be estimated. The distribution of cash-futures basis during the time when the futures position would be liquidated must also be considered. Fourth, the individual decision-maker's loss aversion/gain attraction and target return motives should influence the determination of the strategy. Lastly, the strategy set should include the possibility of simultaneous cash and futures positions with flexibility to change in situations where new information regarding price becomes available during the implementation horizon.

REVIEW OF LITERATURE

Within the economics and finance literature, efforts have been made to extend the theory of investment and inventory management in order to describe the optimal behavior of agents under conditions of imperfect knowledge regarding the future. These developments have proceeded along two distinct yet related lines. The first approach has its roots in the classic mean-variance models of Markowitz (12). These models have been extremely popular because they have intuitive appeal and are easily estimated. The intuitive appeal arises from the notion that portfolios are selected with respect to some expected return on assets (mean) and how likely the return is to be realized (variance).

The basic result of portfolio theory is that if expected returns to assets are not perfectly positively correlated, the utility maximizing, risk averse investor will hold a diversified group of assets rather than a single asset. Investors are assumed to choose this group of assets on the basis of a utility function defined in terms of the mean and standard deviation of the portfolio return. The most popular application of this theory has been to the problem of selecting stocks and bonds.

Within the last twenty years, an increasing application of mean-variance portfolio theory to hedging problems has occurred. In these applications, the hedger holds a portfolio of hedged and unhedged stocks of a commodity in order to maximize utility. Johnson and Burgess (9) and Stein (15) were among the first to apply portfolio theory to the problem of selecting optimal cash-futures positions by producers.

McKinnon (13) examined the problem of a grain producer who faces an uncertain harvest. Since the size of the "investment" is unknown, the willingness to hold hedged and unhedged stocks is affected. McKinnon concluded that in the case of an uncertain harvest, a producer who would normally be a short hedger, may hold a long position to maintain his income if the harvest is expected to be small. Ward and Fletcher (18) apply mean-variance portfolio theory to cattle producers and marketing firms and conclude that it may be rational for a hedger to hold contract commitments in excess of their expected cash position for speculative purposes. The notion here is that the motivations behind speculation and hedging are points along a single continuum of manager objectives.

More recently, Rolfo (14) and Anderson and Danthine (1) have applied the mean-variance approach to hedging under both price and quantity uncertainty. Rolfo examined the case of a cocoa producer, modeling both quadratic (mean-variance) and logarithmic utility functions. The result obtained was that limited or no use of futures markets may be superior to a full short hedge of expected output when production variability is high. Anderson and Danthine present a complete theoretical model which allows the hedger/speculator an opportunity to include several contracts and exchanges along with cross-hedging.

At least two major theoretical problems limit the usefulness of this approach. First, either a multivariate normal distribution of returns to the assets in the portfolio must be assumed or a quadratic utility function is required to insure conformity with von Neumann-Morgenstern utility theory. Secondly, it is broadly observed that managers exhibit target motives in the selection of risk management strategies. Target motives suggest that risk and return for an individual manager should be measured with respect to deviations from this target return rather than with respect to a parameter such as the mean or variance (8).

A second set of techniques commonly used in decision analysis are dominance methods. The dominance methods are sometimes considered when a quadratic representation of utility is not desirable. Stochastic dominance methods are frequently referred to as second-best methods because they describe manager behavior when very little is known regarding the underlying preference structure and thus an estimation of a strict optimum is not possible. These methods are useful when preferences of individual managers are not obtainable and an elaborate mathematical representation of preference is not desirable. The efficient set of strategies or decisions becomes those which are undominated by the criteria employed. The most popular of these methods is stochastic dominance (first, second and third degree: FSD, SSD and TSD). FSD requires only the assumption that the decision maker prefers more to less. More formally, this posits a utility function which is monotonically increasing with a strictly positive first derivative. Higher degrees of stochastic dominance can be employed as more and more restrictive assumptions are assigned to the decision-makers preference structure. This is frequently necessary because relatively few actions can be eliminated by FSD.

SSD adds the assumption that the decision-maker is risk averse. Under the SSD criteria, the decision-makers utility function is not only monotonically increasing but strictly concave. This requires the first derivative to be positive and the second derivative negative throughout. The efficient set of strategies which result are a subset of those obtained using FSD criteria.

TSD rests on the idea that as a person's wealth increases, he becomes decreasingly risk averse. This criteria requires the additional assumption of a positive third derivative of the utility function. It also suggests that there is a predisposition on the part of the decision-maker for positive skewness in the distribution of returns. TSD is relatively expensive to computationally implement. Because of this, and the fact that many empirical price distributions do not appear to possess much skewness, the TSD and SSD efficient sets are frequently found to be nearly identical leaving the added cost of TSD solutions unjustified.

Flood, McCamley and Schneeberger (4) use stochastic dominance to evaluate whether farmers select crop varieties in a rational fashion utilizing information supplied by experiment station's crop variety testing programs. The results published by experiment stations are commonly given in the form of yield/acre. Stochastic dominance was chosen as the evaluation procedure because crop yields are believed to be skewed following the Gamma distribution rather than a normal distribution. Greenhall (5) compares various corn marketing strategies using stochastic dominance techniques. Here, the appeal to stochastic dominance over mean-variance analysis is likewise proposed on the basis of an assumed skewness in corn price distributions where government policy intervention tends to mitigate downside price risk.

Johnson and Burgess (9) compare the performance of mean-variance and stochastic dominance approaches in analyzing optimal choices out of data drawn from different distributions. In samples drawn from normally distributed distributions, the two techniques were judged equally effective. However, in samples drawn from distributions which were not normally distributed there was reason to believe that stochastic dominance outperformed mean-variance techniques.

Another consideration in the modeling of manager behavior is that managers frequently choose marketing and pricing strategies with respect to a target return. In such a case, managers may not elect to maximize expected return but may wish to minimize the probability of a disastrous level of return. Among the first to recognize these motives was Telser (16), who modeled hedger behavior in a safety first setting. Developments by Turnovsky and Pyle (17) demonstrated that safety first criteria were not consistent with concave indifference curves in mean-standard deviation space when portfolios were selected in the presence of riskless assets. The departure to maximizing expected utility through safety first concepts did not provide a suitable correspondence with the well accepted mean-variance approaches.

In an effort to incorporate target return motives in the decision analysis, Fishburn (3) proposed a mean-risk dominance model which measured risk as probability weighted deviations below a specified target. Holthausen (8) extended the model to a risk-return framework where risk is measured as Fishburn suggests but returns are likewise estimated as probability weighted deviations above the target return specified. This research follows the Holthausen approach. These developments by Fishburn and Holthausen offer the possibility of combining the theoretically attractive elements of the above mentioned techniques (e.g., reasonable computational efficiency, recognition of target motives, etc.) while reconciling the unrealistic elements such as restrictive distributional properties of asset returns and nonconformity with von Neumann-Morgenstern utility theory. This class of models, referred to as α-β-τ models have reasonable computational efficiency, can be compatible with von Neumann-Morganstern utility theory, stochastic dominance and the observed appeal to target motives by investment and inventory managers.

Finally, devising a strategy and implementing it are two related functions. All of the techniques previously mentioned assume a single, stationary asset price distribution. If the distribution realized is markedly different than expected or is nonstationary, the hoped for result may be unrealized. Price distributions for meat and meat products are known to possess both seasonal and cyclical patterns. These must be accounted for in the formulation of an effective strategy. Commodity purchasing methods which are dynamic and allow for nonstationary price distributions have been developed in the operations research literature (11) but have not been widely employed in agricultural marketing contexts except with respect to government grain stock models. This research combines a purchasing model with a risk-return model of asset choice in order to formulate initial purchasing and inventory strategies and update them as the purchasing horizon is realized.

THEORETICAL MODEL

The choice between forward priced and/or purchased stocks of a commodity inventory or anticipated inventory is a function of purchase and inventory level criteria. In the case of a known demand, the problem becomes one of deciding when to purchase and how much to purchase at a current but transitory price offering. In general, the manager desires to purchase the commodity at a low price, even to the point of building inventory if prices are low enough and storage is available. At average or above average prices, the manager may buy nothing or buy only that quantity necessary to supply current needs. Deciding what price is "low" requires some knowledge of the probability density function of future prices.

Future price expectations can be generated by a variety of quantitative and qualitative procedures. However, price forecasting models which only seek to forecast average monthly prices for a few months ahead may not be sufficient to significantly lower long term buying costs. Meat prices in both cash and futures markets are subject to considerable short-run variability. Significant short term price volatility can be observed in these markets in the span of a single day. This phenomenon should be accounted for in order to effectively reduce long-run buying costs.

Along with price expectations, the purchase or sales decision may be affected by the agent's target return or cost objectives rather than simple profit maximization. It is now commonly accepted that risk managers frequently make investment decisions with respect to loss aversion or gain seeking motives. These motives may reflect perceived stock holder objectives, upper-level management objectives, or the agent's personal risk management strategies. As such, the decision to buy or sell at a given price will be a highly individualistic choice made with reference to deviations from some subjectively determined target.

While some managers may only seek to beat the average price, others may formulate targets relative to competitors, seeking to implement an input purchasing policy necessary to achieve output prices in line with competitors'. Targets may also be conceived as a fixed objective such as a margin between purchase and sales prices or as a fixed rate above or below an acceptable return or cost.

Deviations from target may be perceived with differing degrees of severity. For example, a commercial sausage manufacturer may lose all of his business if the price he offers is a single cent above competitors. On the other hand, a branded product with a loyal following may not suffer a significant loss in market share until its price is five to six cents over competition. Further, there is no reason to believe *ex ante* that the significance of deviations will be symmetric above and below target. Aversions to below-target results (for returns) may be much stronger than attractions to deviations above-target or vice versa.

The model to follow has been fashioned with a typical meat purchasing agent's situation in mind. It is assumed that over a relatively short-term purchasing horizon (say three months), the agent must purchase sufficient commodity in the cash market to supply a known demand. This demand may occur evenly, in varying amounts throughout the horizon or be due in total at the end of the horizon. Such situations are common when filling intermediate term, fixed price contract commitments to large buyers.

There are several opportunities to purchase the commodity within the purchasing horizon. Current and past prices are known, but the only information available concerning future prices is their probability distribution.

In a simple two-period purchasing horizon where no storage is allowed, the ex post profit function with respect to variable costs is:

$$\pi = r_1 d_1 + r_2 d_2 - p_1 x_1 - p_2 x_2 \qquad (1)$$

where r_t is the contractually agreed-upon sales price in each period, d_t is the demand which must be satisfied in each period, p_t is the cash price faced by the agent in each period, and x_t is the quantity purchased in period t to supply d_t or enter inventory.

When storage is allowed, the agent may choose to purchase commodity in excess of the current period's demand if prices are expected to rise in the next period by an amount greater than the cost of storage. Assuming that storage costs are a function of inventory level and that inventory is uniformly delivered over each period, the total storage cost (TSC) function can be expressed as:

$$TSC = g(s_0 + x_1 - 1/2\ d_1) + g(s_1 + x_2 - 1/2\ d_2) \qquad (2)$$

where g is the storage cost function and s_t is the amount of commodity in inventory at the beginning of the period. When storage costs are included, the profit function in the two-period model becomes:

$$\pi = r_1 d_1 + r_2 d_2 - p_1 x_1 - p_2 x_2 - g(s_0 + x_1 - 1/2\ d_1) - g(s_1 + x_2 - 1/2\ d_2) \qquad (3)$$

In the case where the agent may not be strictly interested in maximizing profits, but may have target profit motives, the problem becomes one of maximizing utility which is a function of profit outcomes with respect to a predetermined target profit. Profit outcomes above target add to total utility whereas outcomes below target subtract from total utility.

Since the impact on utility of above-target outcomes may not be symmetric to below-target results, a two-part utility function is required to translate profit results into measures of utility. Each part of the utility function can be separately specified to capture the agent's attraction for gain or aversion to loss. The utility function is

$$U(\pi) = \begin{cases} U_g(\pi) = (\pi-\tau)^\gamma \text{ for } \pi \geq \tau & (4a) \\ U_\ell(\pi) = -k(\tau-\pi)^\lambda \text{ for } \pi < \tau & (4b) \end{cases}$$

where utility is calculated in deviations from target (τ) form. The deviations are weighted by the parameters γ and λ to reflect the intensity of gain attraction and loss aversion respectively.

When $\gamma = \lambda = k = 1$, the utility function is linear. In a situation where the adverse consequences of below-target results are judged to be more severe than the favorable consequences of above-target results, the weighting parameter λ can be increased relative to γ. For instance, when $\gamma = 1$ and $\lambda = 2$, the utility function for above-target outcomes is linear, and the segment of the utility function for below-target results is quadratic.

In actual purchasing situations, future prices are unknown, but forecasts are usually available which can assign a subjective probability to each possible expected price. This information can then be used in evaluating a current price offering to determine whether and how much to purchase now versus later.

Expected prices are translated through the profit function to yield expected profits for each strategy. These are then translated into expected utility by means of the utility function. The purchase strategy offering the maximum expected utility is then selected.

Purchase and sales of commodity take place in the cash market. However, if forecasts of futures contract prices and ending bases (in the period the contracts are offset and corresponding cash market purchases are to be made) are available, the model allows pre-pricing via hedging or cross-hedging.

The purchase of futures contracts does not affect the TSC since no physical commodity is in storage. To accommodate futures contracts, the price $\underset{\sim}{P}_t$, price probability $f(\underset{\sim}{P}_t)$ and storage $\underset{\sim}{s}_t$ vectors are partitioned in the general model to separate actual physical purchase and storage from futures contract inventory. Restrictions can be placed on the storage vector to force the sale of contracts as actual purchase of commodity occurs. For example, a single restriction could be specified such that at the beginning of the period immediately following the end of the purchasing horizon (T+1), the storage vector must equal zero. This assumes the relevant contract(s) for hedging expire at or soon after the end of the purchasing horizon.

In summary, the problem is to select purchase quantities and/or pre-price a commodity for eventual purchase so as to maximize the agent's utility. Total expected utility is the sum of the price-weighted utility of profit integrated over the gain space (G) and the loss space (L). The gain space is comprised of all price outcomes that give profit greater than target, and the loss space comprises all expected price outcomes yielding profit less than target. The dimensions of the gain and loss space vary depending on the number of cash and futures positions considered relevant to the purchasing decision.

$$\text{Max } E[U(\pi)] = \int_G U_g(\pi) f(\underset{\sim}{p}_t) dG + \int_L U_\ell(\pi) f(\underset{\sim}{p}_t) dL \tag{5}$$

$$\text{where: } \pi = \Sigma_{t=1}^{T} r_t d_t - \underset{\sim}{p}_t' \underset{\sim}{x}_t - g(s_{0t} + x_{0t} - 1/2\, d_t) \tag{6}$$

$$U_g(\pi) = (\pi - \tau)^\gamma \text{ for } \pi \geq \tau \tag{7}$$

$$U_\ell(\pi) = -k(\tau - \pi)^\lambda \text{ for } \pi < \tau \tag{8}$$

subject to:

$$s_{n1} = \bar{s}_{n1} \qquad n = 0, 1, 2, \ldots, N \tag{9}$$

$$s_{n,T+1} = \bar{s}_{n,T+1} \qquad n = 0, 1, 2, \ldots, N \tag{10}$$

$$s_{0t} \geq 0 \qquad t = 1, 2, \ldots, T+1 \tag{11}$$

$$s_{0,t+1} = s_{0t} + x_{0t} - d_t \qquad t = 1, 2, \ldots, T \tag{12}$$

$$s_{n,t+1} = s_{nt} + x_{nt} \qquad t = 1, 2, \ldots, T;\ n = 0, 1, 2, \ldots, N \tag{13}$$

$$x_{0t} \geq 0 \qquad t = 1, 2, \ldots, T \tag{14}$$

where the variables and parameters are defined as:

s_{01} = beginning stocks of commodity

$\bar{s}_{01}$ = stocks of commodity from previous purchasing horizon

s_{0t} = beginning stocks of commodity in period t

s_{nt} = beginning futures inventory of contract n in period t

$$\underset{\sim}{s}_t = \begin{bmatrix} s_{0t} \\ \cdot\cdot \\ s_{1t} \\ \cdot \\ \cdot \\ \cdot \\ s_{Nt} \end{bmatrix}$$

d_t = known demand for product in period t

x_{0t} = commodity purchased in period t

x_{nt} = futures positions in contract n purchased (if > 0) or sold (if < 0) in period t

$$\underset{\sim}{x}_t = \begin{bmatrix} x_{0t} \\ \cdot\cdot \\ x_{1t} \\ \cdot \\ \cdot \\ \cdot \\ x_{Nt} \end{bmatrix}$$

p_{0t} = cash price of commodity in period t

p_{nt} = futures price in period t

$$\underset{\sim}{p}_t = \begin{bmatrix} p_{0t} \\ \cdot\cdot \\ p_{1t} \\ \cdot \\ \cdot \\ \cdot \\ p_{Nt} \end{bmatrix}$$

r_t = sales price of product in period t

g = commodity storage cost function

τ = target return

π = profit

γ = weighting factor for returns > target

λ = weighting factor for returns < target

k = additional weighting parameter for returns < target

$f(\underset{\sim}{p}_t)$ = vector of probability density functions corresponding to $\underset{\sim}{p}_t$

The first order conditions (FOCs) can be obtained by forming the Lagrange function:

$$
\begin{aligned}
LG = {} & \int_G U_g(\pi) f(\underset{\sim}{p}_t)\,dG + \int_L U_\ell(\pi) f(\underset{\sim}{p}_t)\,dL + \theta_0(s_{01} - \bar{s}_{01}) \\
& + \Sigma_{t=1}^{T} \theta_t(s_{0,t+1} - s_{ot} - x_{0t} + d_t) + \theta_{T+1}(s_{0,T+1} - \bar{s}_{0,T+1}) \\
& + \Sigma_{t=1}^{T} \Phi_t(s_{1,t+1} - s_{1t} - x_{1t}) + \Phi_{T+1}(s_{1,T+1} - \bar{s}_{1,T+1}) \qquad (15) \\
& \quad \vdots \\
& + \Sigma_{t=1}^{T} \Phi_t(s_{N,t+1} - s_{Nt} - x_{Nt}) + \Phi_{T+1}(s_{N,T+1} - \bar{s}_{N,T+1})
\end{aligned}
$$

Solving yields the following FOCs.

$$
\frac{\int_G U_g'(\pi)(p_{0t} - p_{0,t-1}) f(\underset{\sim}{p}_t)\,dG + \int_L U_\ell'(\pi)(p_{0t} - p_{0,t-1}) f(\underset{\sim}{p}_t)\,dL}{\int_G U_g'(\pi) f(\underset{\sim}{p}_t)\,dG + \int_L U_\ell'(\pi) f(\underset{\sim}{p}_t)\,dL} = g' \qquad (16)
$$

$$
\frac{\int_G U_g'(\pi)(p_{1t} - p_{1,t-1}) f(\underset{\sim}{p}_t)\,dG + \int_L U_\ell'(\pi)(p_{1t} - p_{1,t-1}) f(\underset{\sim}{p}_t)\,dL}{\int_G U_g'(\pi) f(\underset{\sim}{p}_t)\,dG + \int_L U_\ell'(\pi) f(\underset{\sim}{p}_t)\,dL} = 0
$$

$$
\vdots \qquad (17)
$$

$$
\frac{\int_G U_g'(\pi)(p_{Nt} - p_{N,t-1}) f(\underset{\sim}{p}_t)\,dG + \int_L U_\ell'(\pi)(p_{Nt} - p_{N,t-1}) f(\underset{\sim}{p}_t)\,dL}{\int_G U_g'(\pi) f(\underset{\sim}{p}_t)\,dG + \int_L U_\ell'(\pi) f(\underset{\sim}{p}_t)\,dL} = 0
$$

Equation 16 is the FOC governing choices in the cash market, while 17 is the set of FOCs governing choices in the futures market. g' has been moved to the right-hand side of equation 16 and represents the marginal cost of holding one unit of commodity in inventory for one additional period. The left-hand side is the marginal-utility-weighted proximate-period-price-difference expectation $(p_t - p_{t-1})$. When the left-hand side of equation 16 is greater than g', utility can be increased by purchasing now and storing. When the left-hand side is less than g' utility can be increased by postponing purchases to the next period.

The set of futures equations (17) is similar in interpretation, however, there is no storage cost associated with holding futures contracts. When any of these equations is not equal to zero, utility can be increased through either a purchase, when the equation is greater than zero, or a sale, when the equation is less than zero, of futures contracts.

In the simplest case where prices are known and the utility function is linear ($\gamma=\lambda=k=1$), the comparison becomes

$$g' \text{ with } p_t - p_{t-1}, \text{ or}$$

$$p_{t-1} + g' \text{ with } p_t$$

the marginal cost of holding inventory, plus the previous period's price compared with the current price. Alternatively, when the difference in proximate period prices exceeds the cost of holding one unit in inventory, the purchase of commodity is delayed until the next period. This, of course, assumes that sufficient quantity already exists in inventory to meet current demand, or purchases may be required so that a shortage does not occur. This is a standard dynamic programming problem.

With stochastic prices and a linear utility function, the comparison becomes

$$g' \text{ with } E(p_t) - E(p_{t-1}), \text{ or}$$

$$E(p_{t-1}) + g' \text{ with } E(p_t)$$

with the same decision rules applying as with the determinant situation just described. Some method must be employed to estimate $E(p_t)$ and $E(p_{t-1})$. Kingsman (11) has thoroughly outlined the solution procedures to this kind of problem in a stochastic dynamic programming format.

The situation can be further complicated by adding a utility criterion along with stochastic prices. In the case where the utility function is continuously differentiable, the objective and comparison become

$$\text{Max } E[U(\pi)], \text{ and } g' \text{ with } \frac{E[U'(\pi)(p_t - p_{t-1})]}{E[U'(\pi)]} .$$

The most common application of this model is the mean-variance case common to portfolio theory where the utility function is quadratic and $\tau = E[\pi]$.

The model presented in this paper generalizes the mean-variance approach by allowing τ to take on values different from the expected value of profit and the utility function to be different above and below τ (the target). Expected price outcomes which lead to below-target profit situations can be considered "risk", while outcomes which lead to above-target profit are "returns".

The numerator of 16 is the sum of the marginal-utility-weighted proximate-period-price-difference expectations over the risk and return spaces. The denominator is identical to the numerator with the exception of the multiplication by price differences. The set of equations in 17 has a similar interpretation.

The units of the numerator are dollars multiplied by marginal utility. The unit of the denominator is marginal utility. The marginal utilities cancel yielding a final unit measure in dollars. This is then compared to g' (measured in dollars) with the prevailing decision rules previously described. Second order conditions are indeterminant. For practical purposes, this requires a search procedure to identify an optimal or near optimal solution.

MODEL SIMULATION AND RESULTS

In order to gain insight into the purchasing and storage decision under a variety of manager attitudes regarding target profit and the impacts of deviations from target, a simplified two-period purchasing horizon was simulated. A micro-computer spread sheet formulation was used to calculate the results. In the two-period case, the solution is available by inspection of all possible outcomes.

In order to utilize this model, the following information must be available: the sales price of the product in each period (if sales are to occur in each period), the quantity demanded in each period (if any), a current price offering, the probability density function of future prices, a known cost of storage, the availability and limits of storage facilities, a target profit objective and the specification of a utility function including the gain attraction (γ), loss aversion (λ) and k parameters for weighting deviations from target. The assumptions regarding each of these in the two-period simulation follow.

It was assumed that a wholesaler had entered into a contract with a retail merchant to provide ten units of a product during the second period of the purchasing horizon. A sales price of $10 per unit was agreed upon in the contract.

At the beginning of period one, a price offer was made to the wholesaler. He could choose to purchase all ten units at that price and store them until the second period or choose to purchase some amount less than the total required (including none) and make the remaining purchases at the beginning of period two. Purchases were only allowed at the beginning of the periods and, any commodity purchased entered inventory immediately. At the beginning of period two, inventory was required to contain all ten units. If period one purchases were less than ten, the remaining units were automatically purchased at the beginning of period two (no shortages allowed). Purchases could only be made in whole units. A cost of $1 per unit was incurred for storing commodity one period.

At the beginning of period one, period two's price was unknown to the wholesaler; however, a subjective probability estimate was available for each possible period-two price. The prices in each period could range from $1 to $10 per unit in whole dollar amounts. In Situation 1, the period-two prices followed a discrete uniform distribution. In Situation 2, period-two prices followed a discrete approximation of the normal distribution.

Purchasing strategies were determined by maximizing expected utility which was calculated according to the profit and utility functions specified in the general model (equations 3, 4a and 4b) and weighted by the price probabilities. In each case, $k = 1$, while λ and γ were allowed to take on values of .33, .5, 1, 2 and 3. Figure III-1 illustrates some utility functions consistent with these values.

Because the utility function is constructed in two parts, the effect of expected deviations above and below target are independent. In the standard mean-variance case, the utility function describes risk-averse behavior throughout the entire range of outcomes. In terms of the simulation, this utility function would be consistent with a manager who was

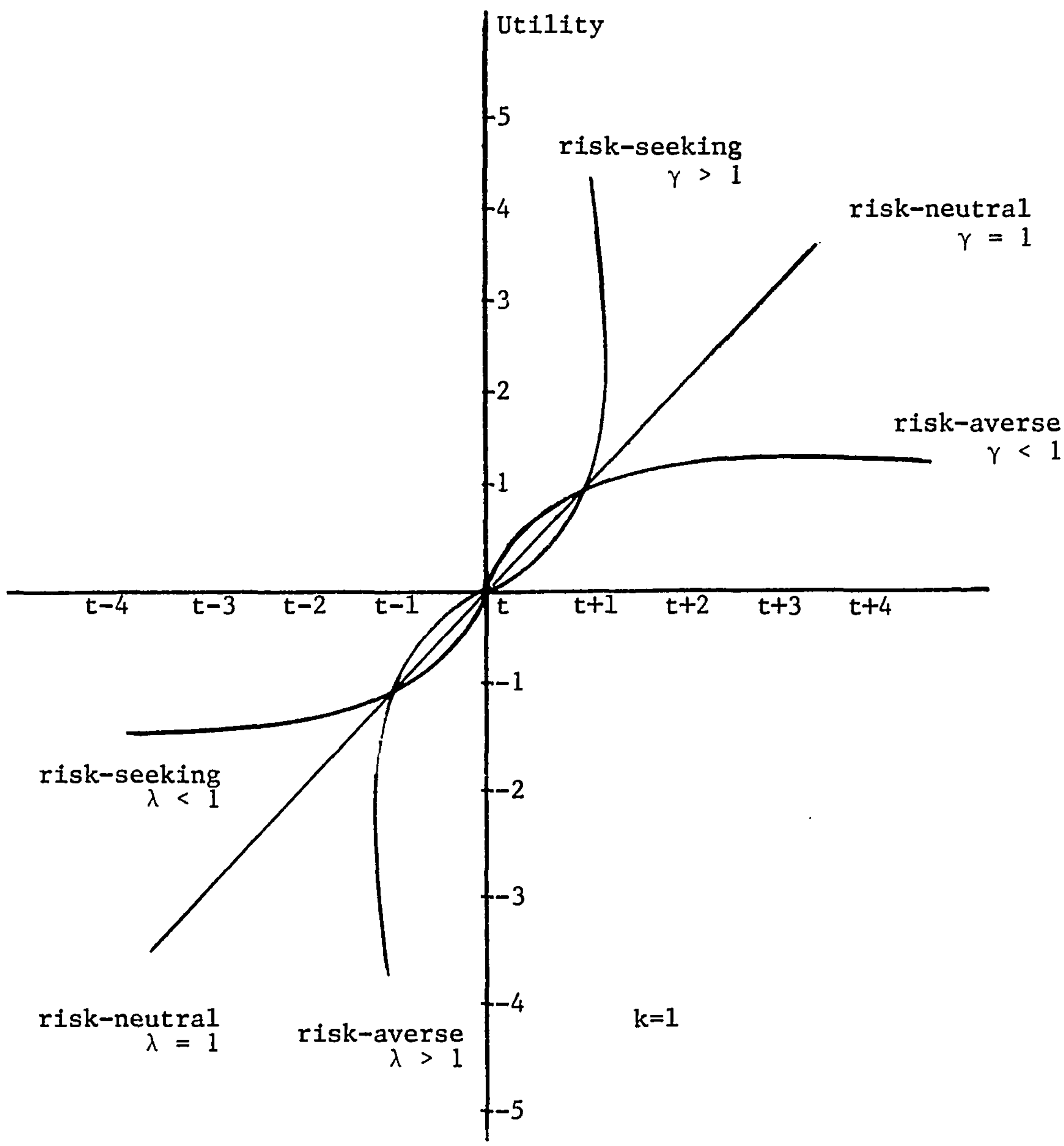


Figure III-1. Utility curves corresponding to various values of the weighting parameters relatively indifferent to expected above-target returns but strongly loss averse with respect to expected below-target outcomes. This situation corresponds to the following values of the weighting parameters: $\lambda = 2$, $\gamma = .5$, and $k = 1$.

By specifying the utility function in two independent pieces, a greater degree of flexibility is allowed in modeling different attitudes toward risk and return. For purposes of illustration, four different combinations of above-target and below-target attitudes regarding profit results are discussed following the simulation results.

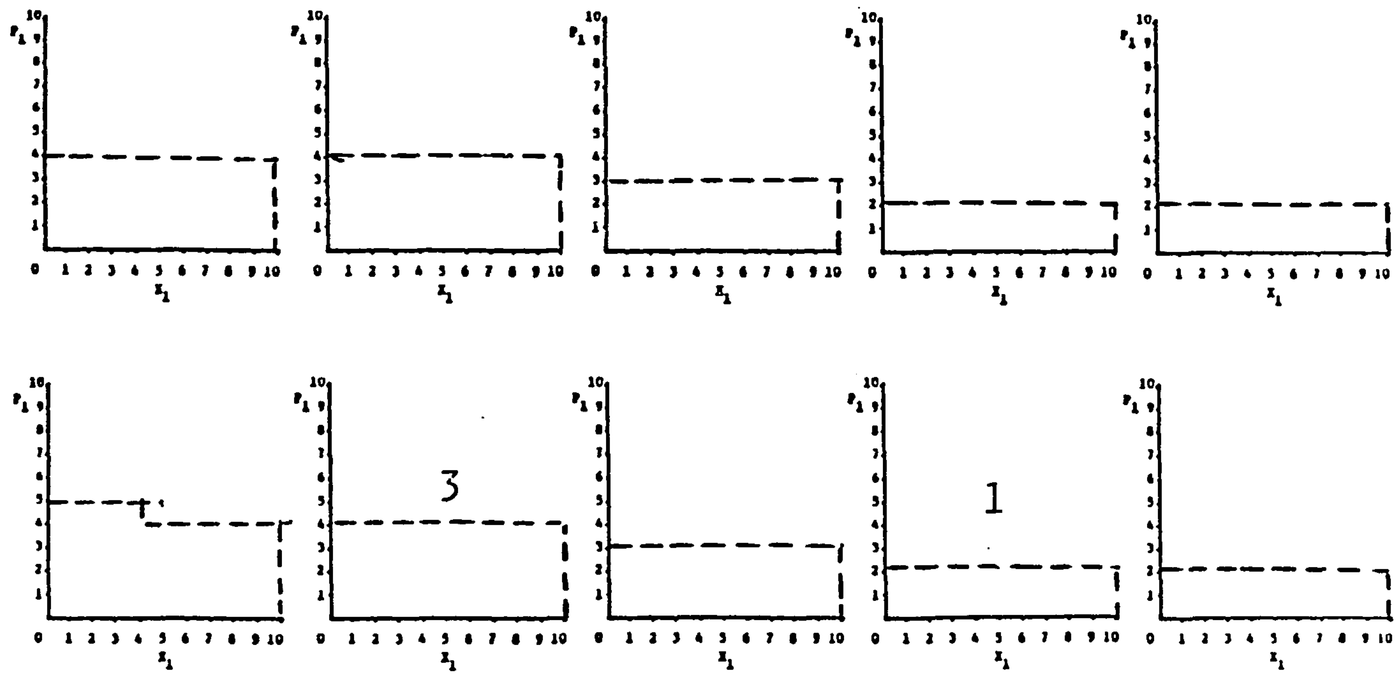
Table III-1 contains the results of the simulation where the profit target was set equal to the expected value of profit ($40), and period-two prices were assumed to come from a discrete uniform distribution. It can be noted from Table III-1 that the more risk-averse the manager was with respect to both above- and below-target outcomes, the more commodity was purchased in period one, even at prices well above the expected price ($5.50). At a price of $7 per unit and an additional storage cost of $1 per unit, the most risk-averse manager ($\lambda = 3$, $\gamma = .33$) still purchased 7 units of commodity in period one. Conversely, the most risk-seeking manager ($\lambda = .33$, $\gamma = 3$) refused to purchase any commodity until the period one offer was reduced to $2 per unit. Combinations of risk-seeking behavior in one-half of the utility function and risk-averse behavior in the other generally resulted in purchasing commodity only when the sum of the offered price and the storage cost were less than the average or expected price of $5.50.

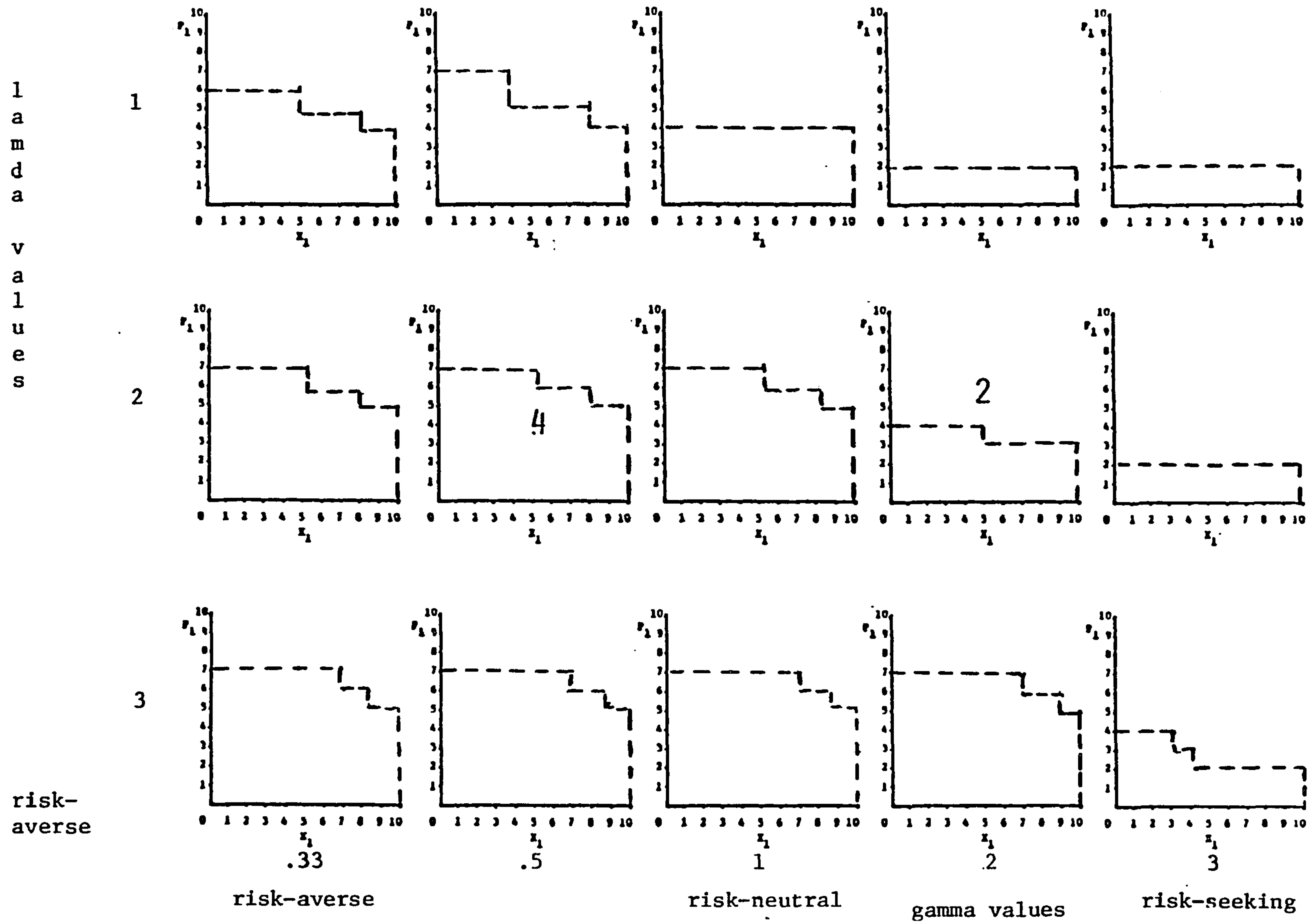
Table III-1. Quantities of X_1 purchased in period one at various price levels and attitudes regarding risk and return

---

risk-
seeking
.33

.50





lamda values
1
2
3
risk-averse
.33
.5
1
.2
3
risk-averse
risk-neutral
gamma values
risk-seeking

To examine the effect of changes in target from the expected value of profit, the profit target was increased to $50 (Case 2 of Situation 1) and the simulation repeated. The results were that the most risk-averse manager (as described above) tended to buy slightly fewer units at greater-than-average period-one prices. This pattern was repeated through most of the other cells in a table similar to Table III-1 where risk aversion was strong in either half of the utility function. In the upper right portion of the table, most values were unaffected by raising the target profit objective.

For Situation 2, the simulation was repeated using price expectations consistent with a discrete approximation of the normal distribution. The same basic pattern was observed as in Table III-1 (therefore, an additional table is not presented). The differences were largely in the lower left-hand portion (risk-averse) where purchases at prices above the mean were one or two units less than in the case of the uniform distribution. This would be expected since the extreme values of price are less likely to occur and therefore, the consistently risk-averse manager would be expected to wait for more favorable prices in period two.

Four combinations of attitudes toward risk and return are singled out for closer analysis. These four are: above-target risk-seeking/below-target risk-seeking, above-target risk-seeking/below-target risk-averse, above-target risk-averse/below-target risk-seeking, and above-target risk-averse/below-target risk-averse. For consistency in the descriptions to follow, it is assumed that target is set at the expected value of profit.

The first case describes a situation in which the manager experiences greater-than-proportional increases in utility for deviations above target and less-than-proportional decreases in utility for deviations below target. There are several factors which might contribute to this attitude which generally describes a manager who is going for big wins and can handle losses well. Such a situation is plausible in a firm that is not highly leveraged so that less than target results do not financially jeopardize the firm. This behavior could also be expected when a stable firm situation is combined with a bonus structure for favorable outcomes that increases as the profit performance attributable to manager decisions increases. It is probably more likely in a multi-product firm where losses in one business unit can be cushioned by gains in other units. This scenario is indicated in Table III-1 by the cell $\lambda = .5$, $\gamma = 2$. The results suggest that a manager with attitudes consistent with this environment would need prices well below average in order to induce purchases which would go into inventory for later use.

The second case describes a manager who experiences greater-than-proportional increases in utility for above-target results and greater-than-proportional decreases in utility for below-target results. This situation is plausible in a firm that is highly leveraged such that greater-than-average profits result in cash which can be allocated to debt payment or possibly additional venture capital. It may also describe the attitude of managers in a firm that is experiencing the threat of hostile takeover, where greater-than-average profit in a quarter could increase the value of the firm and slow down buyers, while less-than-average profit may result in lower stock value and increased vulnerability to takeover. The purchasing strategy consistent with this attitude is labeled 2 in the cell $\lambda = 2$, $\gamma = 2$. This cell indicates a reluctance to purchase commodity in period one when cost-plus-storage is greater than or equal to the expected price. At a price of $4, which results in an effective period-two price of $5 (50¢ below the expected price), the manager purchases half of the total purchase requirement.

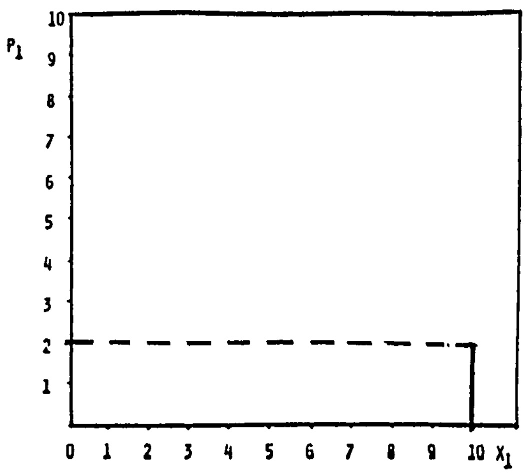
The third case describes a manager who gains less-than-proportional utility for above-target results and less-than-proportional decreases in utility for below-target results. This attitude is consistent with a purchase strategy involving a relatively minor commodity in a processing firm. The commodity may be an ingredient which is relatively low priced, does not experience much price volatility,and comprises a small portion of the total cost of the finished product. In such cases, relatively little manager effort would be expected in devising a purchasing strategy since there is little pay-off for better-than-average results and small to negligible effects on output price for less-than-average performance in purchasing. This situation is labeled 3 in the cell where $\gamma = .5$, $\lambda = .5$. Table III-1 reveals that a purchasing policy similar to Case 2 results. There is little pressure to purchase the commodity at prices at or above average, although slightly more is purchased at near average prices.

Case 4 describes the manager who experiences less-than-proportional increases in utility for above-average results and greater-than-proportional decreases in utility for below-average profits. This attitude would be expected in a business environment where the attainment of target profit is emphasized and less-than-target results could mean the manager's job. A single bonus for target with no additional reward for greater-than-target results is relatively typical in business situations. Salary, promotion and bonus may be dependent on consistent achievement of target or slightly above-target results with a short memory for spectacular one-time profit performance. In such a case, the manager would be quick to lock in prices through purchase which yield target results. If the consequences of below-target results are severe enough, the manager tends to purchase more than half of the total product requirements even at period-one prices which are greater than the expected price. This situation is demonstrated in the cell where $\lambda = 2$, $\gamma = .5$. A step function of purchases at various prices is presented in Figure III-2 for the four cases illustrated.

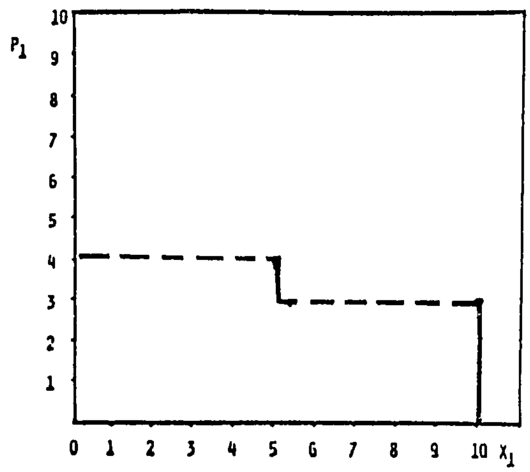
In summary, depending on the firm's financial situation, manager incentives and other factors, the purchasing agent may respond quite differently to a given market price. In the two-period model, risk aversion in both parts of the utility function generally leads to purchases even at prices above the average in period one; whereas, the risk-seeking manager requires very low period-one prices in order to induce purchasing. Combinations of risk-averse and risk-seeking in the utility function leads to period-one purchases only at prices below the expected price.

All of this raises some interesting questions for further study. For instance, depending on the firm's objectives, bonus, salary and promotion incentives might be structured in such a way as to induce different purchasing strategies from agents consistent with those objectives. The structure of the incentive package could be formulated with information regarding how the agent is likely to perform under different attitudes regarding deviations from target indicated by the model. As such, upper-management may be able to shape strategy via shaping the agent's attitudes regarding performance with respect to targets.

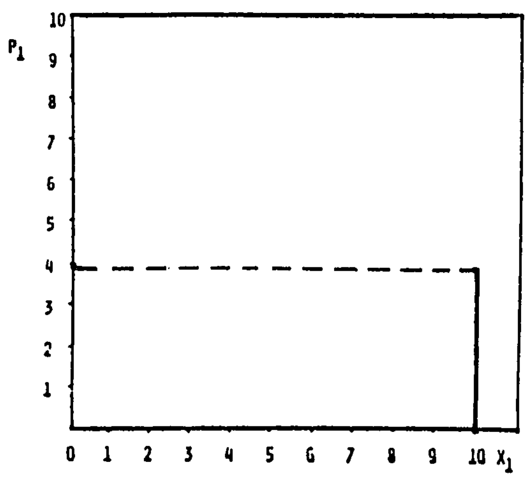
Beyond purchasing strategies, a firm may be able to induce technological innovation (for instance) by structuring incentives such that deviations above a target level of invention are highly rewarded and the consequences of failure mitigated.



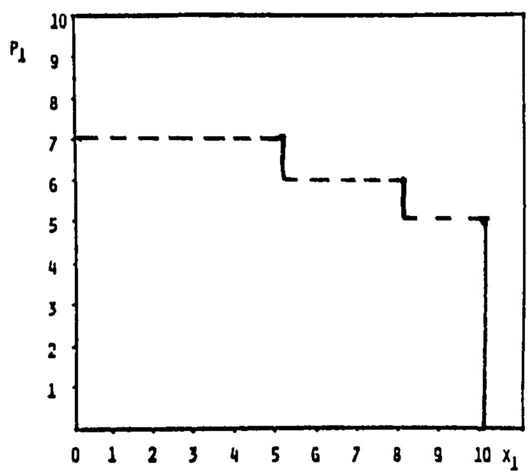
Case 1
above-target:risk-seeking
below-target:risk-seeking



Case 2
above-target:risk-seeking
below-target:risk-averse



Case 3
above-target:risk-averse
below-target:risk-seeking



Case 4
above-target:risk-averse
below-target:risk-averse

Figure III-2. Quantities of X_1 purchased at various price levels under four different attitudes regarding risk and return

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SUMMARY

In Section I, hedging relationships and an estimate of the basis risk was calculated for fifteen wholesale cuts of beef cross-hedged in the live cattle futures contract. The results show that many wholesale cuts of beef can be successfully hedged in the live animal contract. Carcasses, rounds and chucks exhibit the greatest potential as evaluated by their high degree of price correlation with the live animal contract and their relatively small variance of relationship over all periods of the year.

Several cuts of beef exhibit strong seasonal changes with respect to the appropriate hedging ratio. Ribs, loins and boxed beef cuts derived from them show substantial differences in hedging relationship reflecting their seasonal demand patterns. Lean trim and livers show the weakest relationship with the live cattle futures and would probably be candidates for cross-hedging only when extreme price volatility for these cuts is expected.

In Section II, hedging relationships and an estimate of the basis risk was determined for ten wholesale cuts of pork. After initial tests with pork belly futures, it was determined that the greatest potential contract for cross-hedging was the live hog contract. With the exception of livers, each of the pork cuts exhibited a high degree of price correlation with the live hog futures contract. Hams, loins and butts show great potential for a successful cross-hedge over all periods of the year. As with some beef cuts, pork ribs show a strong seasonal demand during the summer barbeque season and, as such, require a different hedging

relationship during this period than during the rest of the year. An analysis of covariance model was used to determine if the separate slope coefficients (hedging relationships) were significantly different from a model with a single annual slope. The results indicated that for all cuts, separate models for the six hedging periods were significantly different from a single annual model.

Section III presented a purchasing model applicable to the meat industry which selects inventory levels on the basis of predetermined manager profit targets. Further, the impact of deviations from target on manager utility was allowed to influence the strategy differently on the basis of anticipated above target versus below-target results. The model developed was a stochastic risk/return model where risk was measured with respect to expected below-target results and return was measured with respect to expected above-target results. A simulation of the theoretical model was presented utilizing a two-period purchasing horizon. Four combinations of manager attitudes regarding above- and below-target outcomes were examined, and a plausible management and/or firm situation for each combination was discussed. Purchasing strategies under each case were presented.

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