Swine -
Marketing
6

AAEA   1981

Economic Report Series

Department of Economics

Iowa State University

Ames, Iowa 50011

HEDGING PORK PRODUCTS USING
LIVE HOG FUTURES:
A FEASIBILITY ANALYSIS

by
Marvin L. Hayenga and Dennis D. DiPietre

No. 19

Presented at AAEA meetings, Clemson University, July 26-29 1981.

June 1981

Abstract

The feasibility of hedging ten wholesale pork products using the live hog futures market was analyzed, and appropriate hedging relationships were estimated using 1970-79 data. Depending upon a firm's risk aversion, the live hog futures market could be a useful risk management tool for meat processors and merchandisers dealing with pork products.

Hedging Pork Products Using Live Hog Futures:
A Feasibility Analysis

by
Marvin L. Hayenga and Dennis D. DiPietre*

The increased volatility of commodity market prices in the 1970's and early 1980's has sharply increased the risks associated with commodity procurement and inventory management in most food processing and distribution firms. Many firms dealing in commodities which have futures markets can use the futures markets as procurement or inventory management tools, but many commodities have no viable futures market. For example, most wholesale meat products (with the exception of pork bellies, boneless beef, and iced broilers) are traded only on cash markets, so hedging pork loins, hams, and most other beef and pork products cannot be done in a directly comparable futures market. However, there are futures markets for live hogs and live cattle which might potentially serve as hedging mechanisms for meat packers, processors, food retailers, restaurants and food service firms handling large volumes of these meat products (Miller).

The objective of this study is to evaluate the feasibility of using the live hog futures market as a risk management tool for hedging purchases or inventories of several wholesale pork products. We will determine how closely wholesale pork product prices are related to live hog futures, and what the appropriate hedging relationships would be using live hog futures to protect against adverse pork product price fluctuations. The methodology employed could also be used in subsequent studies to evaluate the feasibility of cross-hedging other commodities.

---

*Associate Professor of Economics, Iowa State University and Instructor of Economics, Iowa State University

For this analysis we selected the most heavily traded wholesale cuts of pork which a) were often stored in large volumes, and subject to substantial price risk, or b) sometimes were forward priced to retail, food service, or processing firms.

Several weight categories of many wholesale pork cuts are traded. To simplify the analysis, only one heavily traded weight category was selected for each cut, since it was expected that the prices of other weight categories would move in similar fashion.

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

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

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

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

u_{ij} = error term.

FP is treated as the independent variable since the initial futures market price would be predetermined in a hedging operation, and the corresponding pork 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 pork cuts (Hacklander). The estimated equation reflects the typical "basis" which varies as the level of live hog futures and the wholesale pork cut prices rise or fall.

In an ideal anticipatory (buying) hedge or inventory (selling) hedge, the difference between the initial futures price (FP_i^I) at which the firm would buy or sell, and the ending (close-out) futures price (FP_i^E), using the appropriate hedging relationship (b_{ij}), should be approximately equal to the difference between the expected pork product cash price ($\hat{CP}_{ij}$) derived from the estimated equation and the actual cash price (CP_{ij}) when the final cash and futures market transactions are completed.

$$(FP_i^I - FP_i^E)b_{ij} \stackrel{\sim}{=} \hat{CP}_{ij} - CP_{ij}$$

Since 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 (e.g., 1:1.6), reversing that ratio (e.g. 1.6:1) provides the appropriate ratio of the quantities (hog Q: pork product Q) to be hedged to assure that futures market gains or losses on the live animal approximately off-set changes in the cash market price of the processed cut. The slope coefficients reflect the relative price changes of the processed cut and the live animal futures contract.

The general decision framework for a firm making a selective hedging decision would incorporate the firm's aversion to various risks (Hayenga), 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 would be a function of:

    a. The current live hog futures price in the relevant contract month, and the expected probability distribution of that futures price (FP_i^I) during the period when the hedge could be initiated.

b. The expected probability distribution of the ending basis between live hog futures and pork product prices ($FP_i^E - CP_{ij}$) derived from our estimated equations,[1] and

c. the probability distribution of pork product prices in the cash market (CP_{ij}) during the period when cash market transactions could be made.

The manager's decision (D) to hedge or not hedge today would be based on a comparison of the likely distribution of results from hedging using live hog futures, taking into account the basis size and variability, and the likely results from relying solely on the cash market for buying or selling pork products.

$$D = g \left[f_1 \left[FP_i^I - (FP_i^E - CP_{ij})\right]; f_2 (CP_{ij}) \right]; \text{ where } f_1 \text{ and } f_2$$
are probability distributions.

By examining the likelihood and magnitude of favorable or unfavorable results from hedging today, the manager of the meat processing or merchandising firm can determine whether hedging today or waiting for a better futures or cash price opportunity is the best strategy. The same process would be repeated daily during the period when hedging is an alternative.

Note that the opportunity of hedging today (at a known price) and subjecting the firm only to the risk of basis fluctuations typically would cause the distribution of realized prices (illustrated in Figure 1) from hedging today or in the near future to fall within a narrower range than the corresponding distribution of cash market prices.

To determine the best hedging relationships and the associated variance in the cash-futures basis, separate equations were estimated for ten wholesale pork cuts (listed in Table 1) in seven time periods during the year. Each of these

Table 1. Pork Product Hedging Relationships

	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

Contract Period

Table 1. continued

	Feb.	Apr.	June	July	Aug.	Oct.	Dec.
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
80% Lean Trim							
Intercept	11.06	14.91	12.75	14.12	11.54	13.78	16.46
Slope	1.24	1.28	1.24	1.24	1.41	1.37	1.09
R^2	.84	.80	.80	.86	.94	.86	.76
S.E.F. (mean)	6.80	7.24	7.76	6.34	4.58	7.45	8.67
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

periods coincides with a particular nearby live hog futures contract typically considered most appropriate for potential hedgers to use.[2] Note that our analysis focuses on the cash-futures price relationship existing during the period when a buying or selling hedge would be closed out. This relationship reflects the basis risk faced by a hedger even though the hedge may be initiated several months in advance. Utilizing the estimated hedging relationships, the basis risk borne by the hedger would be reflected in the standard error of the forecast (S.E.F.) shown in Table 1 for the particular cut and contracting period used. To minimize the probability of any hedger having to make or accept delivery of live hogs because of his live hog futures position, the last two weeks prior to the expiration of each live hog futures contract were eliminated from the contracting period. As a result, the contracting periods considered in this analysis were:

Live Hog Contracts	Feb.	Apr.	June	July	Aug.	Oct.	Dec.
Contracting Period	Dec. 7–Feb. 6	Feb. 7–Apr. 6	Apr. 7–June 6	June 7–July 6	July 7–Aug. 6	Aug. 7–Oct. 6	Oct. 7–Dec. 6

The Correspondence Between Cash and Futures Prices

The estimated equations are summarized in Table 1. The degree of correspondence between pork product prices and live hog futures prices generally was quite high for hams, picnics, loins, butts, spareribs, bellies, and 50% lean trim.[3] Over 80% of the variations in these pork product prices were explained by variations in the live hog futures prices for nearly all contracting periods, and the coefficient of determination (R^2) was above .90 for most ham, loin, butt, and sparerib equations. The correspondence between 80% lean trim prices and live hog futures was lower and more variable across contracting periods; in some periods, live hog futures might be a useful hedging tool, while the unexplained variability might be too large in other contracting periods for live

hog futures to be a useful hedge for many firms.[4] The liver equation is an example where very little relationship between live hog futures and liver prices exists indicating that live hog futures would be an ineffective hedging mechanism for pork liver.

While the proportion of the variation in pork product prices explained by live hog futures was high for most cuts and contracting periods, the magnitude and the frequency of variations from the estimated relationship provide a better index of the potential risks involved in using these estimated relationships in a hedging program. The standard error of the forecast (S.E.F.) calculated for particular values of the independent variable gives an indication of the expected variance around the estimated relationship if these equations were to be used for hedging. While the S.E.F. increases slightly as the distance from the mean of the independent variable increases (illustrated in Figure 2), only the S.E.F. at the mean is shown in Table 1. At the relevant average 1970-79 live hog futures price, approximately 2/3 of the variation around the estimated relationships would be within ± 1 S.E.F. (assuming normally distributed errors) if the equation was used as a hedging or forecasting tool. For example, 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 the favorable and unfavorable variations in the futures-cash price relationships would tend to cancel out over time. The actual results for a particular hedge would 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, and slightly larger than that as you move away from the mean; only one-half of the deviations from the estimated relationship would have unfavorable consequences.[5] Whether this type of basis risk on individual transactions would be tolerable would be

Figure 1. Estimated Regression of Ham Cash Price and February
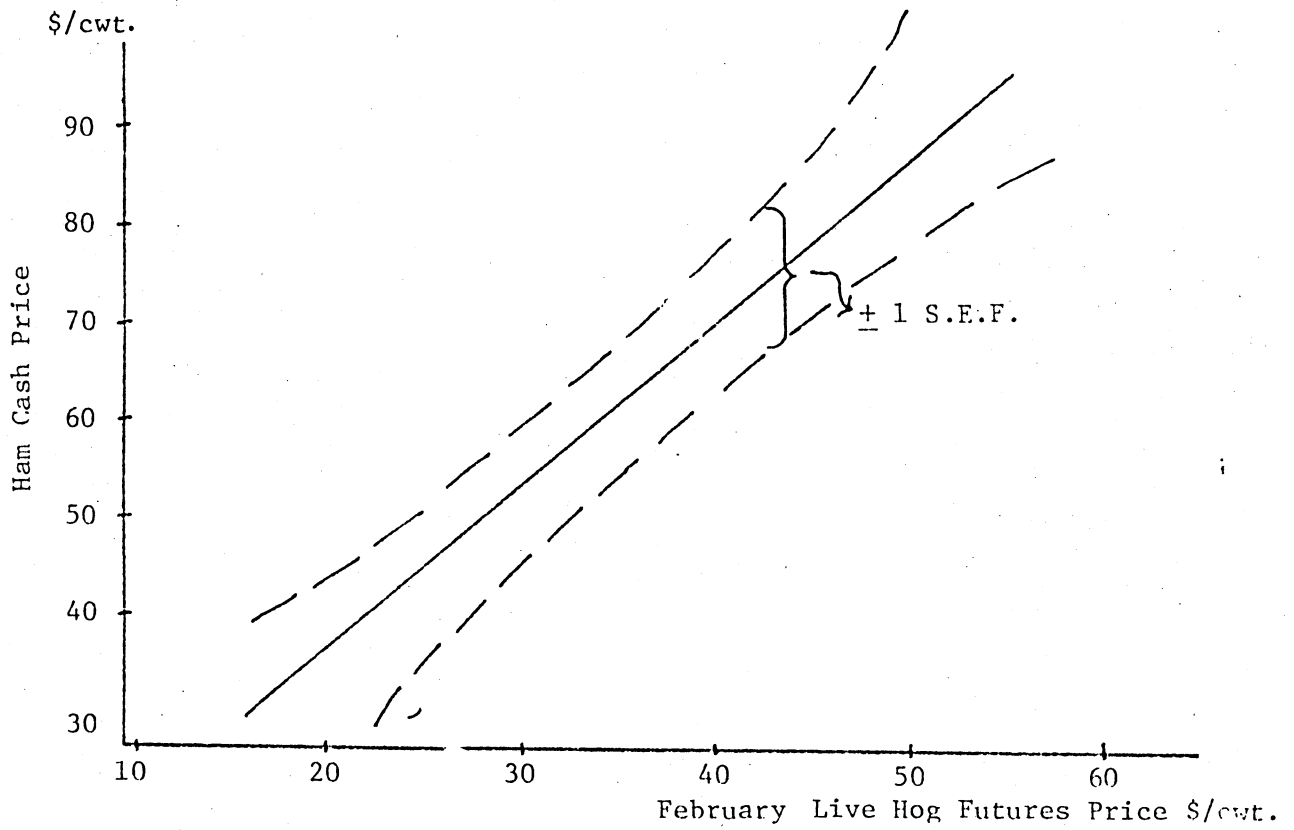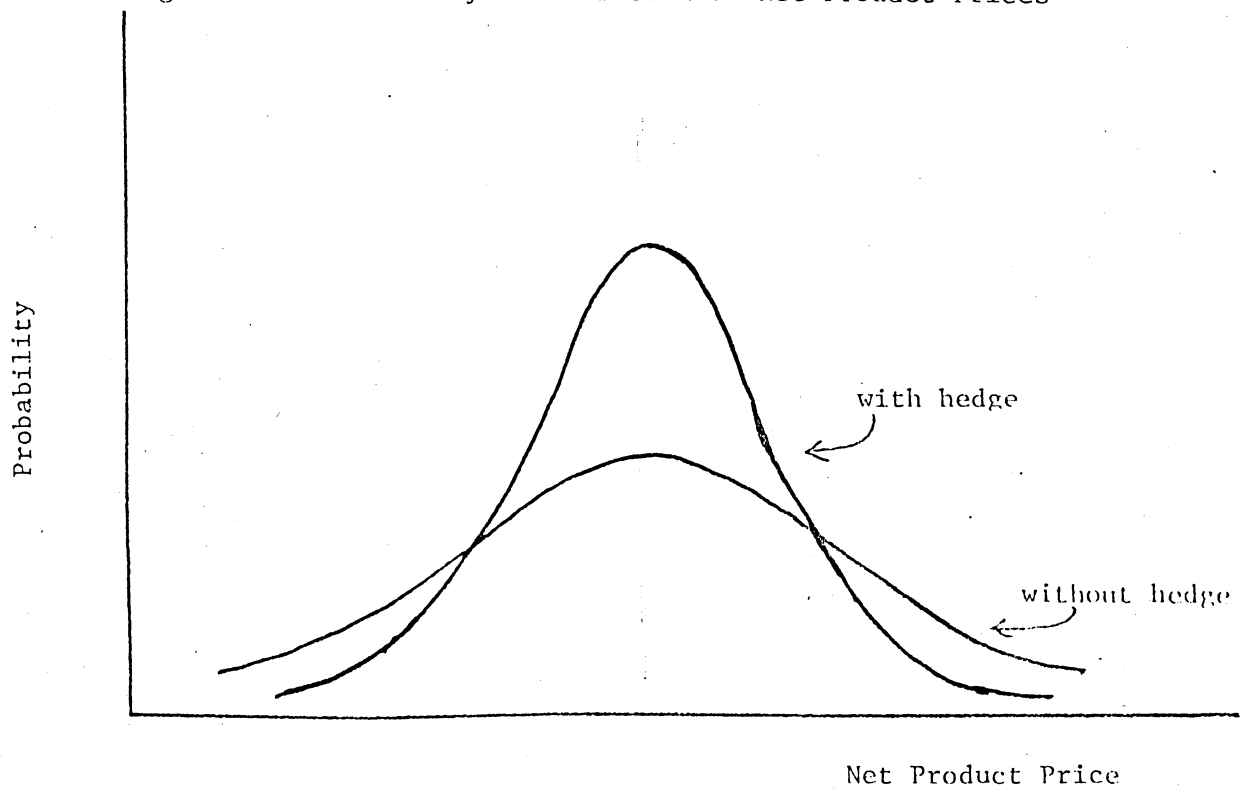Live Hog Futures Prices for the Period December 7 –
February 6, 1970-79

$/cwt.

Ham Cash Price

90 –

80 –

70 –

60 –

50 –

40 –

30 –

$\pm$ 1 S.E.F.

10   20   30   40   50   60

February Live Hog Futures Price $/cwt.

Figure 2. Probability Distribution of Net Product Prices

Probability

with hedge

without hedge

Net Product Price

dependent 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 percent of the time on unadvertised pork products, but only a 2-3 cent unfavorable basis error 10 percent of the time on heavily advertised specials. If a manager felt that the probability of an unmanageable adverse basis was too great using the estimated average relationships, the hedging procedure could be modified to reduce that risk to manageable levels.[6]

If the meat processor or merchandiser elected to liquidate the meat product hedge within a particular week or day rather than over the entire contracting period, the average relationships which were estimated would still be appropriate to use, and errors would still tend to cancel out over time if structural changes do not occur. However, the expected basis variability for individual hedges would be larger, increasing the standard errors of the forecast from those shown in Table 1. The prudent hedger would have to build a greater basis risk into his calculations in those situations.

While the residuals in most equations did not appear to have any systematic pattern (most Durbin-Watson statistics indicated the disturbances were not auto-correlated), there did appear to be an unusual pattern of large negative residuals for hams, loins, and butts in several contracting periods in 1973, balanced by some large positive residuals for picnics and lean trim during many of the same periods. This may be related to the red meat price controls in effect during part of 1973, or the strong surge of Japanese purchases of boneless pork and processing cuts like heavy picnics after the dollar was devalued by 10% in 1973.

As previously mentioned, 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 one percent level of probability. In Table 1, it is evident that the slope coefficients differ among cuts, and differ seasonally for most cuts. Since the supply of hogs and each wholesale cut generally varies proportionately (except where cold storage supplies or imports are influential), the differences in the slope coefficients probably can be attributed to differences in the elasticities of demand or seasonal shifts in the level of demand for each cut relative to the composite value of all cuts reflected in 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, while 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 processing. In contrast, prices for fifty percent lean trim and picnics change approximately on a 1:1 ratio with live hog futures prices, reflecting greater substitution possibilities and more elastic demand for these cuts used in further processing. The large coefficients for ham in April and December probably reflect the relatively large holiday ham demands during those contracting periods. The relatively low demand in the summer months is also reflected in the coefficients.

Slope coefficient patterns for some other cuts vary less seasonally, yet the differences are large enough (a few differ by 50% or more) to cause an important difference in financial results for a hedger if a single hedging relationship was used throughout the year rather than the separate hedging relationships which were estimated for each contracting period.

Some Practical Applications

How would these relationships be used in actual practice? Consider two case examples.

Situation 1: 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 his requirement is 1.1 million pounds of trimmings, and the current July hog futures price is $45.

Hedging Procedure: 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 $69.92 (14.12 + 1.24 (45)). Buying 45 contracts (1,350,000 pounds) of July hog futures at $45 can establish the approximate cost of $69.92 for 1,090,000 pounds of trimmings, even though the actual trimmings won't be bought until sometime in June or early July. As the sausage maker makes his trimmings purchases in the cash market, a futures contract should be sold for each 24,200 pounds of trimmings purchased in the cash market.

Situation 2: In February, a meat packer has 500,000 pounds of hams in cold storage in anticipation of large Easter sales, but is quite concerned that the market price may drop before the sale is completed. Assume the current April hog futures price is $50 per cwt.

Hedging Procedure: Since the packer will sell his hams before mid-April, he should select the April contract for hedging. Using the April ham equation in Table 1, the packer could hedge those hams by selling 810,000 pounds of live hogs via April futures contracts (1.62:1 quantity ratio). If the current April futures price is $50, the approximate ham price which the packer would be "locking in" would be $88.06 (7.06 + 1.62 (50)). Since each live hog contract

requires 30,000 pounds of hogs, the appropriate number of contracts to sell is 27. As the packer begins making his sales of hams to retailers or other customers, he should buy back one live hog contract each time that he sells approximately 18,500 pounds of hams. This should provide the packer with reasonable assurance of his approximate net sale price during the weeks or months the hams remain unsold in storage.

Situation 3: In mid-June, a food retailer enters into a purchase agreement for a million pounds of pork loins (he plans to feature pork chops on the week-end just prior to July 4), but is worried that his formula-priced pork loins may increase in price and make this feature attraction appear unattractive to customers.

Hedging Procedure: Since the retailer's purchase price will be based on the market price on the day prior to shipment from the meat packer, the buyer could elect to take a "long" position in live hog futures for the two weeks prior to the shipment date to sharply reduce the risk of the price increase which frequently occurs during that time of year. If the "feature" purchase volume was one million pounds, the buyer could purchase July live hog futures at a 1.70:1 ratio (1.7 million pounds of live hogs = 57 contracts) as insurance that his loin price wouldn't sharply increase from current levels. The buyer could examine the normal live hog futures-loin price relationship estimated in Table 1, and determine that today's July hog futures price of $50 typically would translate into a 14-17 lb. loin price of $96.50 per cwt. Purchasing 57 live hog futures contracts could establish his loin cost at approximately $96.50; he would liquidate his futures position on the day prior to shipment when the cash price for his loins was determined.

Situation 4:   A restaurant chain wants to establish its raw material cost and its menu prices for the next six months, but cannot get long-term price commitments from suppliers without paying exorbitant premiums.

Hedging Procedure: If the restaurant chain wants to establish an approximate purchase price for hams to be used in their ham and cheese sandwiches during January through June, the manager of procurement could examine the current live hog futures prices for the contracts maturing during that time period, and use the equations in Table 1 to translate those prices into expected ham purchase prices. For example, a $50 April hog futures price would translate into an $88 per cwt. price for 17-20 hams. If the ham prices equivalent to current live hog futures prices in each relevant contracting period appear attractive to the procurement manager, those forecast costs could be built into the financial plan, and live hog futures could be purchased to "lock-in" those approximate costs and the related menu prices. Later when the ham was purchased in the cash market, the futures market positions would be liquidated (for example, each 100,000 lbs. of ham purchased for January use would require selling 5 February contracts).

In this situation, the processing manager could put together the following summary of the hedging program:

Time Period	17-20 lb. Ham Requirements (1,000 lbs)	Current Futures Price ($/cwt.)	Equivalent Ham Price	Required No. of Futures Contracts	Relevant Contract Month
Jan. 1 - Feb. 6	400	48	81.35	20	February
Feb. 7 - Apr. 6	800	50	88.00	43	April
Apr. 7 - June 6	800	49	72.07	36	June
June 7 - July 1	300	52	79.90	14	July

If the manager wanted more insurance that his actual cost would not exceed his cost estimate, he could add a few cents to the forecast equivalent ham price,

which is based upon average relationships to reduce the probability of an unfavorable ham-live hog futures relationship when he would be making his cash market purchases. Adding an amount equal to one standard error (which range from 2.3-7.2¢/lb. in these particular equations) would cut down the odds of an unfavorable result to approximately 1 in 6 based upon 1970-79 price relationship (if purchases were fairly uniform during each contracting period).

Summary and Conclusions

Based upon an analysis of 1970-79 relationships between live hog futures and wholesale pork product prices, live hog futures can be a useful hedging tool for many firms dealing in producing, processing, or merchandising many wholesale pork products. The appropriate hedging relationships differ by cut and by period of the year. Adverse pork product price fluctuations can often be hedged using live hog futures, though some basis risk remains which varies by product. Depending on the likelihood and size of potential adverse price changes and the ability of the firm to handle various levels of price risk, live hog futures may be a useful tool in reducing the risk of adverse price fluctuations in pork product procurement and inventory management for many firms.

Footnotes

[1] The futures price and the basis, plus associated hedging costs determine the expected price to be realized from hedging.

[2] For greater refinement and precision, separate equations could have been estimated for each month or biweekly period. Initial tests suggested the estimated results would not differ significantly, so we elected the less costly procedure.

[3] 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.

[4] In situations where the fit is poor due to one or two outlying observations, but otherwise within acceptable ranges, the researcher can attempt to identify the particular causes of the large errors. Subsequently, the presumed causal variable could be incorporated into the equation as an interaction term with the futures price, and the more complex model estimated and used in hedging. Alternatively, the simpler model could be retained, but great caution in using it could be urged when the particular causes (perhaps cyclical herd liquidation) seemed likely to reoccur.

[5] Note that a large variance around the estimated relationship may not preclude hedging, particularly if there is a strong likelihood of a large, adverse change in cash prices which makes a large basis risk look relatively

tolerable. However, in most situations, a large basis risk reduces the desirability of hedging.

[6] For example, a seller could add 3 or 4 cents to the projected offer price based upon current futures prices, or a buyer could require the expected purchase price via hedging to be 3 or 4 cents better than the expected cash market price.

References

Hacklander, D. D., Price Relationships Among Selected Wholesale Beef and Pork Cuts. Ph.D. Dissertation, Michigan State Univerity, 1971.

Hayenga, Marvin L., "Risk Management in Imperfect Markets: Commodity Procurement Strategy in the Food Manufacturing Sector," American Journal of Agricultural Economics, May 1979, pp. 351-57.

Miller, Steve, "Beef Price Hedging Opportunities for Food Service Institutions," Paper presented at the American Agricultural Economics Association meetings, July 1980.