Cross Hedging Wholesale Beef and Pork Products

by

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Meat processors and merchandisers utilize firm priced forward contracts for wholesale meat products for a variety of reasons. Such contracts can improve sales volume and capacity utilization for meat processors, and assure quantity and price for meat merchandisers and customers who want to reduce the risk of higher prices. Frequently, processors and merchandisers in the meat industry request or offer firm priced forward contracts for delivery two to twelve months in the future.

For pork and beef products, cross hedging (hedging cash commodities in different but related futures markets) procedures have been employed to set up firm priced forward contracts because there are no futures markets for wholesale products (with the exception of pork bellies). Many pork and beef merchandisers are offering fixed price contracts for meat products based on the prevailing futures prices for live hog and cattle futures contracts which are traded on the Chicago Mercantile Exchange. Typically, the historical cash price-futures price ratio which prevailed during the same part of the year serves as the base for determining a cash price quotation for future delivery. In order to cover the cost of hedging and reduce the risk that the contracted sales return less than spot market sales, a cost and risk adjustment is typically added to the expected spot price (based on the current futures price) in determining the forward contract price offer. However, some meat merchandisers have found that their cross hedging and forward contracting programs are not performing well.

The objectives of this study are (i) to examine the changes in the live hog and cattle futures and wholesale pork and beef products price relationships in recent years, (ii) to diagnose some possible causes for poor hedge and forward contract performance, and (iii) to evaluate alternative methods of managing price risk for meat merchandisers. We estimate cross hedging relationships for selected products which may provide improvements in price risk minimizing forward pricing arrangements or inventory risk management for meat processors or their customers. Both the current meat industry procedure and alternative models are estimated and evaluated for several wholesale pork and beef products using data for the period 1987-1992.

Previous Studies

The traditional minimum variance hedge ratio (i.e., the hedge ratio that minimizes price risk of the hedged position) is the Ordinary Least Squares (OLS) estimate of the slope in a simple regression of cash prices on futures prices. Anderson and Danthine (1981) showed that cross hedging is possible whenever the covariance between futures prices and cash prices is significantly different from zero. Ederington (1979) elaborated the price risk minimizing methodology from earlier work on futures portfolio theory by Johnson (1960) and Stein (1961). Hayenga and DiPietre (1982a, 1982b) used this methodology to analyze the price

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relationship between wholesale pork products and live hog futures, and wholesale beef products and live cattle futures.

Among the various model specifications utilized to estimate minimum variance hedge ratios, a simple regression of spot price levels on futures price levels, spot price changes on futures price changes, and spot market returns on futures market returns are the most commonly used approaches. Witt, Schroeder, and Hayenga (1987) contrasted the optimum hedge ratios from the price level regression, price change regression, and percentage change regression frameworks, and suggested that the price level regression method is most appropriate for nonstorable commodities. Myers and Thompson (1989) argue that the hedge ratios obtained by these traditional approaches (price level, price change and market return models) are not appropriate, because the estimated slope coefficients are the ratio of the unconditional covariance between spot price and futures price to the unconditional variance of the futures price. They suggest a generalized conditional approach which uses fundamental market information available at the time of placing the hedge to improve the performance of the estimated hedge relationships. The traditional approaches are found to be special cases of the generalized conditional approach. Using Myers and Thompson's model, Viswanath (1993) argue that the current basis should have power to predict changes in the spot and futures prices. Viswanath's basis-corrected model is also consistent with convergence of spot and futures prices at the maturity of the futures contract.

Models

In the meat industry, meat processors typically use the historical cash/futures price ratio to estimate likely future cash prices based on the prevailing futures prices, and determine a forward contract price offer. If their offer is accepted, they use the same ratio to open a corresponding position in the futures market. For example, if ham prices are usually 50 percent higher than the live hog futures prices, ham would have a fixed contract price ratio of 1.5:1. In addition, many managers add a premium to the expected cash prices for a forward contract price offer to adjust for hedging costs and reduce their risk of adverse results.

Typically, the fixed price contracts for a pork product are based on historical price ratios which vary seasonally, reflecting sometimes strong seasonal influences which change relative prices of various products with respect to the live hog or fed steer and their related futures prices. However, meat industry managers report several problems in using these cross hedging and forward contracting procedures. Too often, the actual cash prices of pork and beef products prevailing at the time of delivery are significantly higher than the expected wholesale prices of these cuts based on current futures prices and historical cash/futures price ratios. Consequently, products sold at spot market prices bring substantially more revenue than the net contract prices, after adjusting for futures gains and losses. Even though cross hedging operations may not be expected to be major profit centers, frequent low returns or large losses from contracting are undesirable.

Figure 1 depicts the historical cash/futures price ratios for pork lean trimmings calculated as arithmetic averages of price ratios. Figure 1 shows a clear downward trend in the cash/futures price ratios. Such trend is likely to be one of the reasons underlying the unsatisfactory performance of cross hedges for meat wholesale products.

Cash/futures price ratios can be calculated alternatively from a simple regression of cash prices on futures prices, i.e.,

$$(1) \quad C_{ij} = \beta_{ij} F_{ij} + e_{ij};\ i = 1, \ldots, 12;\ j = 1, \ldots, n;$$

where C_{ij} is the wholesale cash price of product j during month i, β_{ij} is hedge ratio, F_{ij} is the closing price of the corresponding nearby live hog and cattle futures contract during each contract period, e_{ij} is an error term, and n is the number of cuts. β_{ij} is the basic cross hedge ratio employed in the typical meat industry cross hedging and forward contracting.

Model (1) represents the common practice in the meat industry, but it is very restrictive in that it implicitly assumes that the intercept term is zero. Allowing for an intercept term in (1) yields

$$(2) \quad C_{ij} = \alpha_{ij} + \beta_{ij} F_{ij} + e_{ij};\ i = 1, \ldots, 12;\ j = 1, \ldots, n;$$

where α_{ij} is the intercept term. Model (2) has been used previously by Hayenga and DiPietre (1982a, 1982b).

In the case of a cross hedge where the hedging instrument differs from the product to be hedged, the relative prices of these two products are likely to vary over time. Consequently, the variation of futures prices alone may not explain satisfactorily the variation of related products' cash prices. In this instance, the conditional approach of Myers and Thompson, and Viswanath has intuitive appeal. It implies that hedgers make their decisions based on all the information available to them at the time of placing the hedge.

In the meat industry, significant changes in (i) export volumes of particular pork or beef cuts;(ii) menus in major restaurant chains; (iii) processors' offerings of new meat products; (iv) live animal basis (difference between the live animal futures and the live animal cash prices); and (v) meat processors' gross margins could affect the historical fit and cross hedge performance in forward pricing operations. Because many of these fundamental factors are not quantifiable at the time of placing a hedge but may affect price relationships and persist for several months, the most recent cash and futures price relationship (the basis or price ratio) may be the most useful and practical additional market information to employ in cross hedge ratios for wholesale meat products.

The third model analyzed here incorporates the lagged average basis as an additional factor explaining cash price changes, i.e.,

$$(3) \quad C_{ij} = \alpha_{ij} + \beta_{ij} F_{ij} + \sum_{k=0}^{11} \delta_{ijk} B_{ijk} + e_{ij};\ i = 1, \ldots, 12;\ j = 1, \ldots, n;$$

where B_{ijk} is the monthly average basis lagged k months with respect to the time of making the contract offer and placing the hedge, and δ_{ijk} is the corresponding coefficient. Employing the recent average basis (cash price minus futures price) as additional market information seemed reasonable because it should reflect recent developments affecting the relative prices of individual beef or pork cuts and the prices of the live animals. Not only would the basis be readily understood and available, but it also could be interpreted as a simple method of tracking any changes in relative price relationships. The fit of the cross-hedging equation should improve to the extent that recent changes in market relationships persist during the period of the forward contract.

Model (3) follows Myers and Thompson's idea of conditional hedge ratios, in which fundamental market information available at the time of placing the hedge is taken into account when making hedging decisions.[1] The only conditioning market information included in this model is the lagged basis. Other variables may be relevant theoretically, but have not been found empirically significant in earlier studies. In their study of hedge ratios for corn, soybeans, and wheat, Myers and Thompson found that other variables such as lagged prices and stock levels did not contribute appreciably to the explanatory power of the model.

Data and Estimation Procedures

Models (1), (2), and (3) were estimated separately for each month of the year to allow for seasonal variation in cash and futures relations.[2] Five relatively heavily traded wholesale beef cuts (chuck-2 piece boneless, ribeye-2" lip on, round-shank off, top butt, and boneless brisket[3]) and six wholesale pork cuts (pork loin, boston butt, combo 42% lean trimmings, combo 72% lean trimmings, ham selected 17-20 lbs, and ham selected 20-26 lbs) were selected for the analysis. Because of space limitations, results of only two beef cuts and three pork cuts are reported here.

The Federal-State Livestock Market News provided daily cash prices from 1987 through 1992 for all reported wholesale pork products. Only a few products which had a relative high volume of reported trades were selected for this study. Since the forward contract prices offered on a formula basis are typically associated with the top of the price range reported, the high end of the daily cash price range was used. Daily futures closing prices for live hog and cattle contracts were provided by the Chicago Mercantile Exchange. The nearby futures price series (NBFP) was constructed as the combination of futures prices of nearby contracts over the year. For example, the NBFP for beef in January is the price of the February live cattle futures contract; the NBFP for beef in February and March is the price of the April live cattle futures contract, and so on. The NBFP for pork is constructed in the same fashion.

Unit-root tests were performed on each of the series of cash prices and futures prices. The null hypothesis of a unit root was rejected for all cash price series at the 5 percent level of significance using the standard Dickey-Fuller test. The null hypothesis of a unit root for the NBFP series for both live hog and live cattle were also rejected based on this simple unit root test (first order autoregressive model). Therefore, all series were treated as stationary for estimation purposes.

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[1]Compared to Myers and Thompson's single equation approach to generalized optimal hedge ratio estimation, model (3) assumes further that the coefficients for the lagged spot price and futures price are the same. Viswanath's model of conditional hedge ratio estimation also uses basis as the conditioning information that may be important in optimal hedge ratio estimation. His model uses current basis in regressing spot price changes on futures price changes.

[2]Only the regression estimation is discussed in the present study because the arithmetic averages of price ratios are extremely close to hedge ratio estimates from model (1).

[3]These five cuts represent five major portions of the beef carcass; each is relatively heavily traded.

OLS procedures were used to estimate the models outlined in the previous section. Individual cross hedge relationships were estimated separately for each month during the year to capture seasonal variation in the cross hedge relationships and to provide estimates of the goodness of fit for each month, which is important information to a potential hedger. The lagged basis model (equation (3)) was estimated for lags of up to 11 months, so there are twelve regressions for each cut and each month. Because of the lagged basis, model (3) was estimated for the period 1988-1992. For comparability, models (1) and (2) were also estimated for the same period as model (3).

Results

Analysis of the empirical results focus on (i) the differences between the two unconditional hedge ratio models (1) and (2), where (1) reflects current industry practices, and (ii) the conditional model (3) versus the unconditional models. The results are reported separately for beef products and pork products.

Beef: The 2-piece boneless chuck and top butt are selected to illustrate the results.[4] For model (1), R^2s are not reported because they are not comparable across regressions. The standard errors of these equations are useful to compare the unexplained variability around the expected cash prices. The standard errors of the estimates for each equations reflect the error distribution at the mean of the observed futures and cash prices used in the estimation; the standard error of the forecast at the means of the data used in the estimation is virtually identical to this figure, though it increases as the cash and futures prices move away from those means.

Tables 1 and 2 report the estimation results for equations (1) and (2), respectively. In equation (1), hedge ratios are significantly greater than zero at the 1 percent level for both chuck and top butt. In equation (2), all the hedge ratios for chuck and 10 out of 12 hedge ratios for top butt are significantly greater than zero. Table 2 also shows that 75 percent of the intercept terms are significantly different from zero. Comparison of Tables 1 and 2 reveals that the standard errors of model (2) are generally lower than standard errors of (1). The addition of the intercept term generally improved the fit for all five beef cuts studied, similar to the results by Hayenga and DiPietre.

The tables of estimated coefficients for model (3) are excluded from this report for space considerations.[5] Comparative results are summarized graphically in Figures 2 and 3. Figures 2 and 3 depict the high, low, and mean of the estimated standard errors for model (3) and the standard errors for models (1) and (2). From these figures, it is clear that the standard errors are lowest for the lagged basis model (i.e., conditional hedge ratio model), and highest for the simple regression model without intercept term. On average, the estimated standard errors of model (3) are 11 percent lower than those of model (2) for both beef cuts, and the estimated standard errors of model (2) are 8 percent and 6 percent lower than those of model (1) for chuck and top butt, respectively. About 80 (65) percent of the coefficients for lagged basis are significantly different from zero for the chuck (top butt).

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[4]Among the five beef cuts studied, three cuts have reasonably good fits and two cuts have poor fits. One cut from each group is reported here.

[5]Coefficient estimates for model (3) are available from the authors upon request.

Estimated hedge ratios are stable over the year for the most commonly used industry practice (model (1)). Cross hedge ratios from models (2) and (3) vary more during the year, as illustrated in Figure 4 for the beef chuck.

Pork: The results for equations (1) and (2) are summarized in Tables 3 and 4 for three of the six cuts studied: combo 72% lean pork trimmings, ham selected (17-20 lbs), and loin (14-18 lbs). Results for equation (3) are summarized graphically in Figures 5, 6, and 7.[6] Equation (1) frequently does not give a good fit throughout the year; relatively large standard errors are found for pork trimmings and pork loin, though the pork loin is relatively high priced and the percentage error may be low enough for some managers. The ham equation exhibits relatively low standard errors in most months except December, the month with the highest volume for ham. Cross hedge ratios for pork loin and pork trimmings peak in late summer, whereas cross hedge ratios for ham peak in October and November.

The results from equation (2) are similar to the results from equation (1), but the performance of the estimated equations is generally improved by the addition of an intercept term. Large differences from equation (1) are found for pork trimmings and loin, for which model (2) has standard errors averaging 20 percent and 24 percent less, respectively, than for model (1). The ham equation exhibits the smallest decrease in standard errors relative to model (1). The ham equation also has generally good fits with the exception of December.

In general, as in the beef cuts, model (2) shows more seasonal variation in estimated hedge ratios than model (1) does. The large shifts in the cross hedge ratios from adding an intercept term implies that futures gains and losses from the standard price ratio cross hedging approach used in the meat industry may not offset cash price changes well enough when price levels are quite high or low.

The relative fits of equations (1) through (3) are illustrated graphically in Figures 5, 6, and 7 for trimmings, ham, and pork loin, respectively. The addition of past average basis generally improved the fits of the regressions; equation (3) exhibited the smaller standard errors through most contracting periods. Almost all of the estimated slope coefficients from equation (3) are also significantly different from zero at the 1 percent level for all wholesale pork cuts, contracting periods, and basis lags. The majority of the estimated coefficients of the lagged basis variables are significantly different from zero at the 5 percent level. This finding implies that the lagged basis is helpful in providing a better explanation of cash and futures price relationships. Compared to model (2), model (3) reduces the estimated standard errors by 14 percent, 8 percent and 5 percent for trimmings, loin, and ham, respectively. The greatest reduction in standard error occurs when the price relationships have gradually changed, suggesting that the lagged basis does capture some of the pattern of change.

One problem with the conditional approach (3) is that it generates negative hedge ratios for pork loin and trimmings in two or three lagged basis equations. These negative hedge ratios may be associated with opposite movements in cash and futures prices during those months, given the conditioning basis information employed. Alternatively, the negative hedge ratios may be aberrations which may prove unreliable for cross hedging in the future. Since the explanation for the negative hedge ratios is unclear, it seems wise to disregard those ratios

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[6]Coefficient estimates for model (3) are available from the authors upon request.

in cross hedging and forward contracting programs until they are analyzed in more depth and tested with out-of-sample data.

Summary and Conclusions

The cross hedging model employed by meat packers and merchandisers has not been performing satisfactorily for some major products. This study analyzes the historical performance of the price ratio model (equation (1)) employed in the industry, and contrasts it with an earlier model developed by Hayenga and DiPietre (equation (2)), and with a conditional hedge model advocated by Myers and Thompson and by Viswanath (equation (3)).

The standard price ratio cross hedging model used by the industry generated poor fits for most pork cuts. Two out of the five beef products analyzed and two out of six pork products have small standard errors relative to their prices. They are beef chuck (2 pieces, boneless, 50-80 lbs) and round (shank off, 50-85 lbs), and ham selected 17-20 lbs and 20-26 lbs.

Adding an intercept term (equation (2)) generally improved the fits of the regressions, resulting in lower standard errors, especially for combo 72% pork trimmings. Pork loin showed only partial improvement in Summer and Fall (June through September). However, for ham selected 17-20 lbs, adding an intercept term didn't improve the fit much during the year. Similar results were found for the beef products analyzed.

The conditional cross hedge models (equation (3)) utilized information about the basis level available at the time of placing the hedge. This model formulation often improved the fit of the regressions for pork cuts. Most of the coefficients of lagged basis were significant at the 1 percent confidence level. The lagged basis model resulted in considerable improvement in the fits of the cross hedge model for pork trimmings and beef chuck and top butt throughout the year. For pork loin, noticeable improvements in the fits were found in November, January, February, and March. Ham selected 17-20 lbs exhibited slightly better fits in July through November, but not in December, where the standard errors remained very high.

Although most pork and beef products studied here are good candidates for cross hedging and forward contracting programs, top butt, beef ribeye, pork loins, and pork trimmings cross hedges might be problematic unless recent basis information is used. Live cattle futures might be useful for a top butt cross hedge in the late Fall and Winter, but Summer relationships are more volatile and risky. Similarly, ham selected 17-20 lbs generally could be hedged successfully except in December (possibly due to seasonal shifts in ham demand during the pre and post Christmas holiday season). Breaking December into half-month periods and relating the first half of the month to the December futures contract may help to improve the fit in the future. Finding additional forecastable market factors contributing to the volatility of ham-futures relationships in December might also help to improve the fit.

Based on this study, beef and pork slaughter firms and merchandisers should seriously consider using slightly more sophisticated cross hedge models to avoid poor results. Using an intercept term is a useful addition for some products. Further, using recent basis information at the time of making a firm priced contract offer and placing the subsequent hedge can provide significant improvements in hedging and forward contracting accuracy for several wholesale beef and pork products.

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Table 1. Estimates of Equation (1) for Beef Cuts

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chuck	β	1.74**	1.68**	1.62**	1.68**	1.64**	1.64**	1.61**	1.58**	1.68**	1.70**	1.71**	1.73**
	s	3.94	4.27	5.33	5.19	4.61	3.38	3.78	5.03	3.20	5.97	5.81	4.37
Top Butt	β	2.46**	2.49**	2.54**	2.98**	3.21**	3.23**	3.02**	2.87**	2.52**	2.30**	2.26**	2.33**
	s	10.39	7.83	12.33	14.31	11.63	8.16	13.51	12.61	13.72	10.01	9.3	9.27

Notes: 1. (*) and (**) denote coefficients significantly different from zero at the 5 percent and 1 percent level, respectively.
2. s is the standard error of the regression.

Table 2. Estimates of Equation (2) for Beef Cuts

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chuck	α	-0.71	-19.09	-36.32*	-93.16**	-58.49**	15.26*	14.41	-35.55**	-41.42**	-138.13**	-178.52**	-45.52**
	β	1.75**	1.93**	2.09**	2.96**	2.44**	1.42**	1.41**	2.06**	2.23**	3.54**	4.09**	2.34**
	s	3.96	4.25	5.21	4.28	4.43	3.32	3.73	4.88	2.73	5.51	3.46	4.21
	R^2	0.76	0.57	0.53	0.73	0.47	0.64	0.65	0.57	0.86	0.41	0.85	0.57
Top Butt	α	-32.29	130.35**	-68.00	83.62	354.91**	83.04**	90.99**	-193.23**	125.65**	-335.75**	-185.88**	-121.53**
	β	2.90**	0.78**	3.42**	1.84**	-1.63**	2.05**	1.76**	5.49**	0.82	6.77**	4.74**	3.96**
	s	10.29	6.62	12.17	14.15	8.32	7.23	12.77	10.35	12.77	8.27	7.91	8.67
	R^2	0.58	0.08	0.36	0.08	0.10	0.47	0.20	0.69	0.04	0.53	0.59	0.48

Notes: 1. (*) and (**) denote coefficients significantly different from zero at the 5 percent and 1 percent level, respectively.
2. s is the standard error of the regression.

Table 3. Estimates of Equation (1) for Pork Cuts

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Combo	β	1.36**	1.36**	1.34**	1.25**	1.37**	1.42**	1.49**	1.62**	1.45**	1.33**	1.20**	1.27**
72%	s	11.29	8.95	8.54	7.69	8.85	6.73	7.80	12.26	12.10	8.89	8.07	10.32
Ham	β	1.40**	1.57**	1.48**	1.24**	1.25**	1.39**	1.50**	1.75**	1.78**	1.84**	1.80**	1.69**
17-20	s	2.91	4.97	5.93	2.45	3.27	3.31	3.43	4.41	4.29	5.64	5.20	12.41
Loin	β	2.19**	2.26**	2.18**	1.99**	2.17**	2.29**	2.49**	2.68**	2.48**	2.28**	1.96**	2.20**
	s	8.90	7.10	7.15	5.89	6.61	9.04	6.80	8.10	7.69	7.52	8.23	10.03

Notes: 1. (*) and (**) denote coefficients significantly different from zero at the 5 percent and 1 percent level, respectively.
2. s is the standard error of the regression.

Table 4. Estimates of Equation (2) for Pork Cuts

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Combo	α	-66.34**	-81.33**	-32.50**	-52.52**	-48.96**	-35.83**	-17.18**	-21.18	-1.56	-57.74**	-76.48**	-111.55**
72%	β	2.77**	3.15**	2.02**	2.24**	2.25**	2.11**	1.83**	2.11**	1.48**	2.57**	2.83**	3.71**
	s	9.57	6.54	7.75	5.06	6.58	5.37	7.52	12.16	12.16	6.86	4.55	6.71
	R^2	0.61	0.73	0.66	0.87	0.84	0.85	0.70	0.32	0.27	0.75	0.87	0.76
Ham	α	-3.17	-6.47	22.76**	2.05	-0.02	-4.60	-11.02**	-29.62**	-10.99**	-18.28**	-18.85**	17.94
17-20	β	1.47**	1.71**	1.00**	1.20**	1.25**	1.48**	1.72**	2.43**	2.03**	2.23**	2.20**	1.29**
	s	2.91	4.97	5.36	2.45	3.29	3.28	3.14	3.51	4.13	5.36	4.96	12.41
	R^2	0.82	0.59	0.50	0.89	0.87	0.88	0.92	0.88	0.86	0.78	0.77	0.10
Loin	α	53.94**	32.26**	13.64*	18.98**	14.61**	55.99**	16.81**	57.88**	45.89**	18.30*	44.64**	19.63
	β	1.04**	1.55**	1.90**	1.63**	1.90**	1.22**	2.15**	1.34**	1.44**	1.88**	1.01**	1.77**
	s	7.45	6.70	7.01	5.53	6.40	6.41	6.48	6.20	5.74	7.33	7.29	9.99
	R^2	0.26	0.39	0.68	0.75	0.80	0.56	0.81	0.42	0.61	0.58	0.24	0.25

Notes: 1. (*) and (**) denote coefficients significantly different from zero at the 5 percent and 1 percent level, respectively.
2. Std Err is the standard error of the regression.

Figure 1. Monthly average cash/futures price ratio, 72% pork lean trimmings.

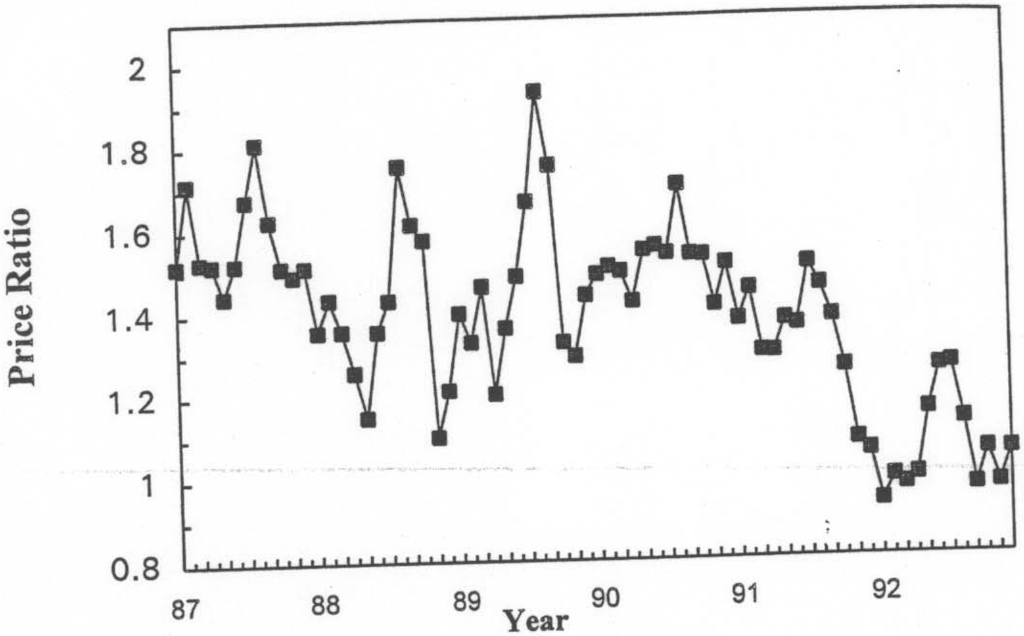

Figure 2. Comparison of estimated regression standard errors, beef chuck.

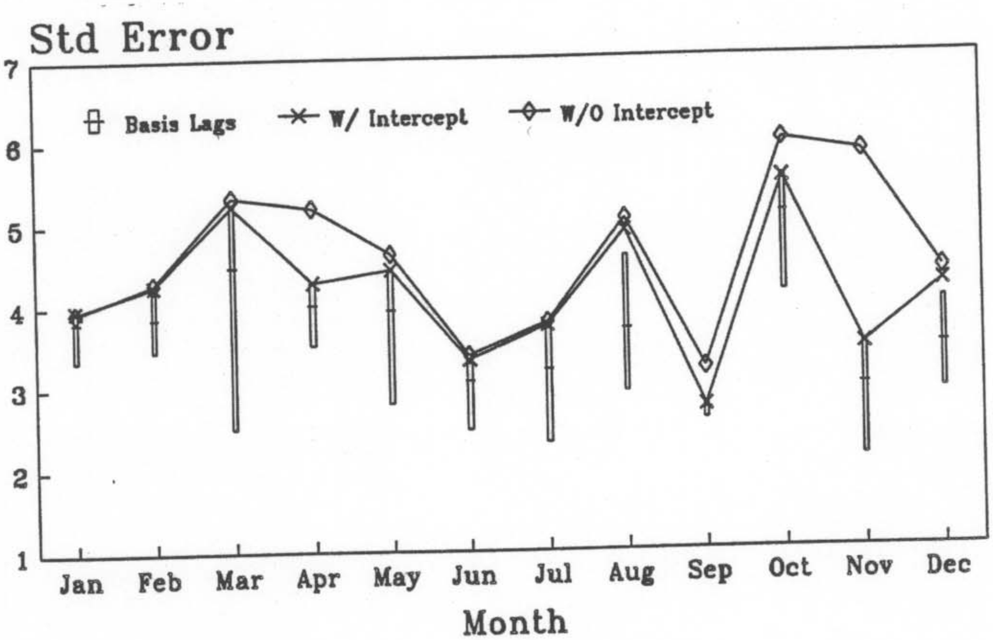

Figure 3. Comparison of estimated regression standard errors, top butt.

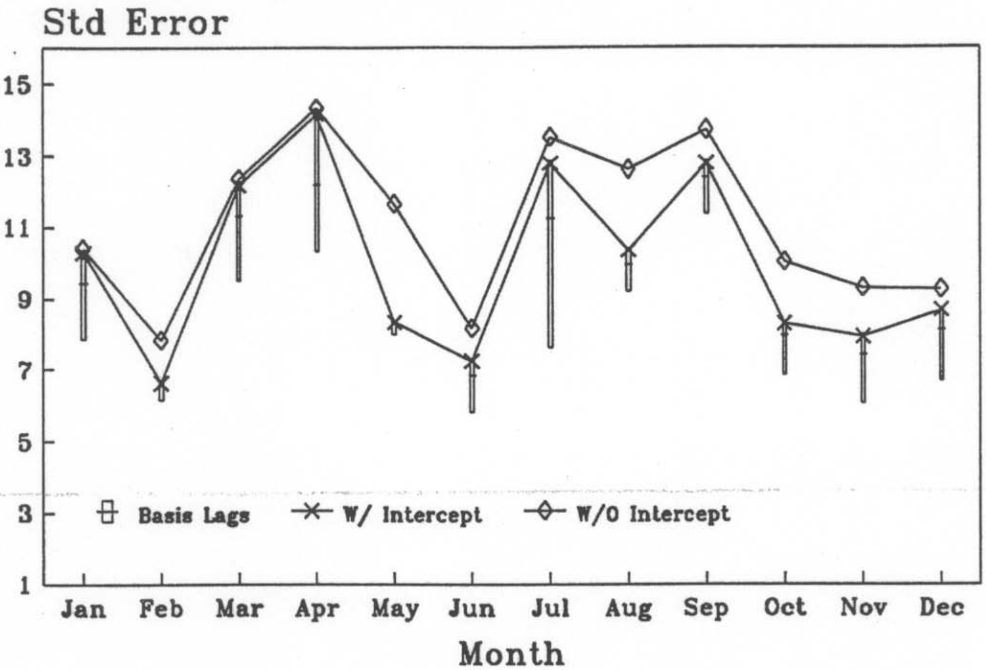

Figure 4. Comparison of hedge ratio estimates, beef chuck.

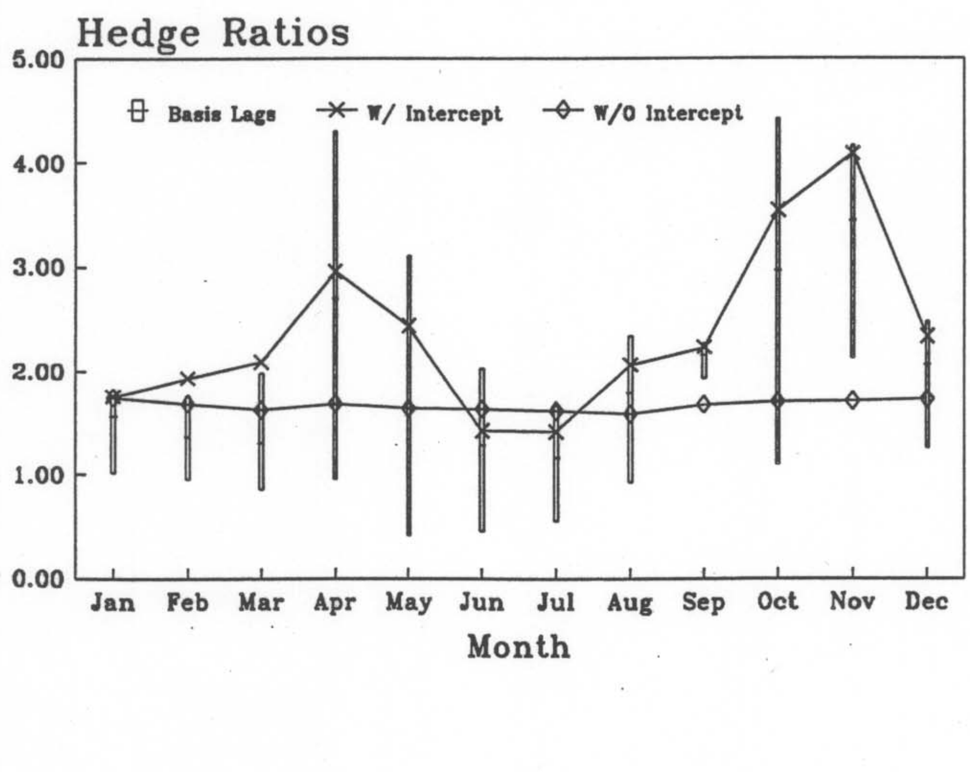

Figure 5. Comparison of estimated regression standard errors, 72% lean pork trimmings.

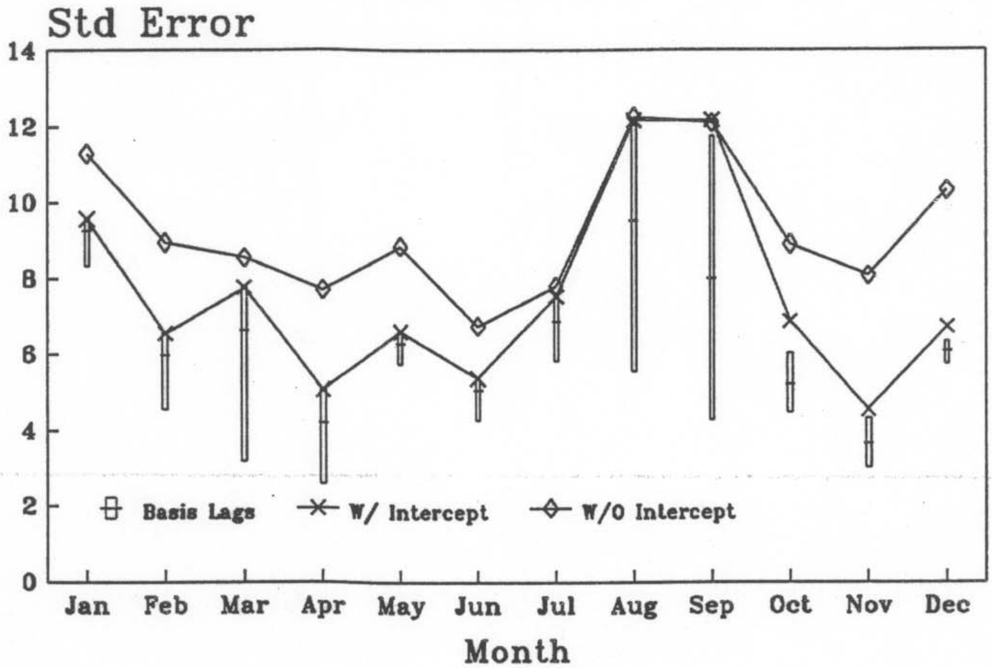

Figure 6. Comparison of estimated regression standard errors, ham 17-20 lbs.

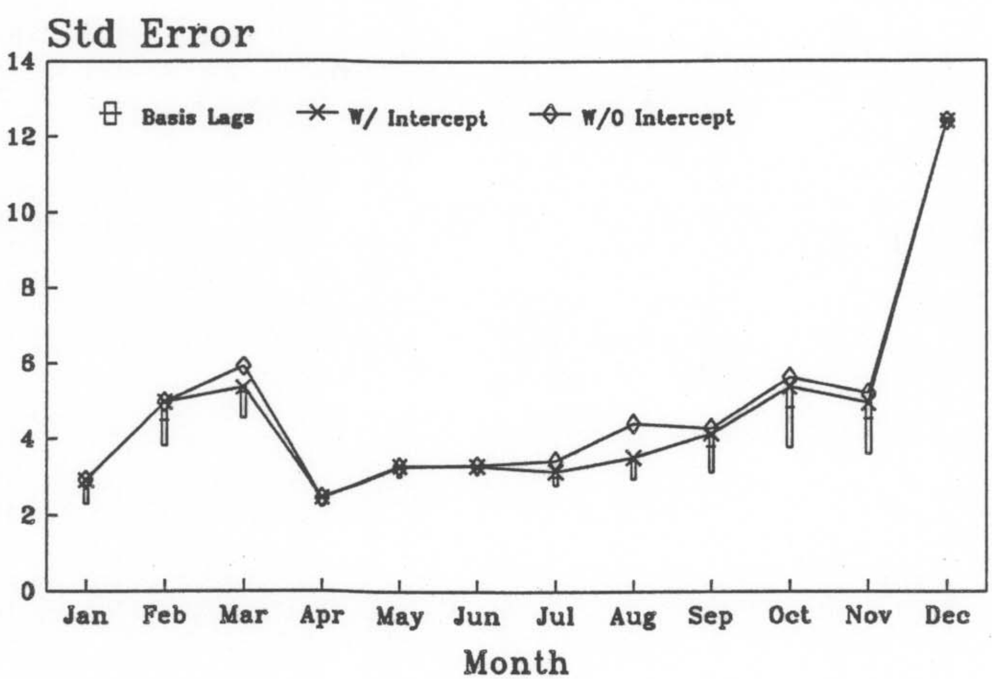

Figure 7. Comparison of estimated regression standard errors, pork loin 14-18 lbs.