CROSS-HEDGING PERFORMANCE OF WHOLESALE BEEF IN LIVE CATTLE FUTURES CONTRACTS REVISITED

by

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Abstract

Risk management decision makers face significant price risk when purchasing or selling wholesale beef. Previous research has identified cross-hedging wholesale beef in Live Cattle futures as a plausible means of reducing this risk.

Changes in the way beef is marketed have led to poor performance of cross-hedging programs. Unlike earlier research, more recent studies have shown that Live Cattle futures are a poor venue for effective cross-hedging. This study replicates previous research to evaluate the current state of traditional cross-hedging performance. Focus then shifts to improving cross-hedging methods.

Hedge ratios derived from a traditional cross-hedging methodology exhibit a great deal of sensitivity to season, estimation technique, and quality grade. Basis risk is abundant for this type of cross-hedging.

To reduce the basis risk inherent with cross-hedging wholesale beef, bundling is proposed. This involves combining two or more cuts together in a single unit to be cross-hedged. Firms merchandising meat from a whole carcass would be able to provide a valuable risk management service if the basis risk faced when hedging a bundled product is less than the basis risk faced when cross-hedging the corresponding products independently.

This research found that bundling has neither a positive or negative effect on basis risk. Therefore bundling is a plausible practice, but will not offer reduced basis risk to decision makers.

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CHAPTER 1 - Introduction

1.1 Background

Seasonal changes in demand and supply cause variability in wholesale beef prices. Namken, Farris, and Capps (1994) and Capps et al, (1994) investigated determinants of price and demand for wholesale beef cuts. Both studies conclude that demand and supply tend to follow a systematic seasonal pattern which influences prices. Specifically, Capps et al, (1994) found that relative to December prices, wholesale beef cut prices may be as much as 6 percent lower to 21 percent higher during other months due to seasonality. Other determinants of wholesale beef cut prices include quantity of the wholesale cut, quantity of competing proteins available, stickiness or inertia of prices, and marketing costs. Namken, Farris and Capps conclude that changes in seasonal demand were mostly responsible for fluctuations in the ratios of wholesale cut prices to total boxed beef price.

Variability in prices and price relationships can be troublesome to decision makers who sell or purchase wholesale beef. Unforeseen price changes make annual budgeting for public sector institutions difficult. Also, private sector food service institutions may find themselves at a competitive disadvantage if faced with an unexpected price increase. While it is also true that an unexpected price decrease (increase) would be beneficial to procurers (sellers), the volatility inherent in commodity markets makes planning and budgeting more difficult. Miller (1980) identified four options for dealing with uncertain future wholesale meat prices. These options included: purchasing meat only on the spot or cash market and accepting the price variability associated with this strategy, purchasing meat in advance of actual use and storing until needed, forward contracting for future delivery at a fixed price, or use of futures markets to hedge anticipated meat purchases. His study concluded that cross hedging wholesale beef on cattle futures contracts allowed food service institutions to reduce the variability of wholesale meat procurement prices. Hayenga & DiPietre (1982a and 1982b) reached similar conclusions. In the time since this early work, many studies have evaluated the feasibility of cross hedging wholesale meat products (Miller and Luke, 1982; Bailey and Brorsen, 1985; Hayenga, Jiang, and Lence, 1996; Schroeder and Yang, 2001; Mattos et al, 2003).

Despite evidence indicating the usefulness of alternative marketing arrangements, the majority of wholesale beef transactions are carried out on the spot market. Lawrence, Schroeder, and Hayenga (2001) illustrate that 70 percent of beef sales from packers are on the spot market. Comparatively, forward contracts and marketing arrangements constituted 20 percent of beef sales. Given the fact that alternative marketing arrangements (AMA's) have been shown to decrease price variability, the low adoption rate seems counter-intuitive. Hayenga (1979) addresses this issue. He suggests that theoretically, a profit maximizing firm in a perfectly competitive environment would be expected to minimize input costs in order to achieve maximum profits. However, food manufacturers are faced with volatile markets and imperfect market structures in which the actions of rivals may significantly influence the optimal procurement strategy of the firm. Therefore, these firms may have motivations other than cost minimization that impact their procurement strategies. The possibility of being locked into an unfavorable procurement price when experiencing an unexpected price move could result in a competitive disadvantage that smaller firms or those with thin margins may not be able to endure. Firms are likely to forgo the high probability of a favorable future procurement price to avoid the risk of becoming competitively disadvantaged. This is accomplished by engaging in similar procurement strategies as their competitors.

In 1996, Hayenga again addresses the poor performance of cross hedges as a vehicle for risk management in wholesale meat sales. He states that at the time of publication, the current industry practice involved the use of historical cash to futures price ratios to estimate future cash prices and the amount of product to be cross-hedged. While this method was appealing to managers because of its simplicity, the performance of these types of cross hedges was often poor. He concluded that more sophisticated models would improve the performance of forward contracting programs currently in use.

Under these contexts, the primary goal of this work is to contribute to the body of knowledge that has been accumulated in regards to forward contracting wholesale beef. By continuing to build on and enhance the methods of cross hedging that have been established, the feasibility and performance of cross hedging programs for wholesale beef should be improved.

1.2 Objectives

This research is carried out through three main objectives: First, wholesale cutout and live cattle futures prices are evaluated. Trends and relationships between quality grades and primal cuts are examined. Secondly, previous models presented by Hayenga (1982a & 1982b) are used to analyze current data. Duplicating previous research proves valuable from a comparative standpoint. The final objective of this research is to evaluate the impact of bundling primal cuts to improve the efficiency of cross hedging wholesale beef. Bundling consists of combining two or more cuts into a single weighted price. These cuts are treated as one unit for cross-hedging purposes.

A review of previously published studies provides the foundation for this research. Contributions are made to this previous work through improving and expanding the models established in earlier studies.

1.3 Organization of Thesis

This thesis is organized into seven chapters. Chapter 2, a review of pertinent literature follows this introductory chapter. Chapter 3 discusses the methodology used to conduct this research. Chapter 4 discusses the data sources and trends and relationships in wholesale beef and live cattle prices. This chapter serves to fulfill the first objective of this research. The second objective of this research is addressed in Chapter 5, which details the updated traditional cross-hedging methods. Chapter 6 evaluates the feasibility of bundling primal beef cuts to improve cross hedging efficiency, which satisfies the third and final objective of this research. Chapter 7 provides concluding thoughts, implications, and suggestions for future research.

CHAPTER 2 - Literature Review

Understanding the current body of knowledge related to cross-hedging wholesale beef is a crucial first step to contributing to this area of research. This chapter includes a summary of the theoretical background regarding cross hedging commodities followed by a review of previous studies that analyze wholesale beef cross hedging.

2.1 Cross Hedging Commodities

Traditional hedging activities involve trading the same commodity in both cash and futures markets. The possibility of making or taking delivery of a good against a futures contract should force convergence between the spot and futures markets during the delivery period. Many commodities do not meet futures contract specifications, or a suitable futures contract does not exist. Hedging these commodities in a different but related futures market is known as cross hedging (Hayenga and DiPietre, 1982b).

Anderson and Danthine (1981) provide the theoretical background to this concept. They suggest cross-hedging is appropriate whenever the correlation between cash and futures is a constant that is not zero. They further postulate that the best cross-hedge ratio may be calculated in the same way as a standard hedge.

The standard hedging method alluded to by Anderson and Danthine is set forth by Johnson (1960). Johnson found the traditional notion of hedging, in which a person dealing in a cash commodity takes an equal and opposite position in a futures market to reduce price risk for a future cash transaction, inadequate. Johnson explains that previous hedging approaches are correct in theory. In practice, however, the line between hedging and speculation is blurred and often crossed by market participants who have expectations regarding both relative and absolute price changes. The reformulated method described by Johnson minimizes the expected variance of return for the combination of the two markets traded. Under this method, the variance of return reduces to the total price risk of a good measured by the variance of return for that good, multiplied by one minus the coefficient of correlation squared, where the correlation coefficient refers to the cash and futures market price changes. A larger correlation between the two markets indicates greater price risk reduction associated with hedging. The traditional hedging ideology mentioned previously is a special case of Johnson's new method, the portfolio theory, in which the correlation coefficient for the two markets is one. Johnson's findings are strengthened by Ederington (1979) and applied to financial securities markets.

Benninga, Eldor, and Zilcha (1984) contributed to this growing body of work by highlighting two key assumptions. The first assumption made by the authors suggests unbiasedness of futures markets. In other words, the futures price is an unbiased predictor of future spot prices. The second assumption made by the authors is that of regressibility. This means that cash prices are a linear function of futures prices.

By assuming that futures markets are unbiased, Benninga, Eldor, and Zilcha show that the minimum variance hedge ratio is also an optimal hedge ratio. In previous literature, it was generally agreed that the hedge ratio that minimized the variance of future returns was not necessarily an optimal hedge ratio as defined by maximizing a producer's utility. By assuming that futures markets are unbiased, a minimum variance hedge position has two distinctive properties. The first property of this hedge ratio is that it does not affect a producer's expected income since it is impossible to consistently gain from hedging activities. Therefore the only motivation for engaging in hedging activities is to reduce risk. The second property of this hedge ratio is that it reduces all the uncertainty about expected returns except the residual uncertainty (in this case the error term) which is unhedgeable. Therefore the minimum variance hedge ratio is also an optimal hedge ratio. The fact that no assumptions regarding the producer's utility function (other than risk aversion) are necessary strengthens earlier work by Johnson (1960) and Ederington (1979).

The authors also demonstrate that the equation which minimizes a producer's expected price variance can easily be manipulated to become the slope coefficient of a regression of cash on futures prices. Therefore, the authors conclude the regression of cash prices on futures prices determines the optimal hedge ratio. This is reviewed more thoroughly in Chapter 3.

With the discussion regarding the optimal hedging ratio seemingly settled, researchers turned their attention to the best procedure to estimate this optimal hedge ratio. Three methods became popular in the literature. Witt, Schroeder, and Hayenga (1987) set out to determine whether optimal hedge ratios are best calculated using price levels, price changes, or percentage price changes in a regression of cash prices on futures prices.

The motivation behind utilizing a price change or a percentage price change model is to alleviate the potential for autocorrelation in time series data. If data are autocorrelated, OLS assumptions would be violated and estimates would be inefficient. Witt, Schroeder, and Hayenga assert that statistically there is no reason to believe that price change or percentage change models are more appropriate than price level models. They point out that taking first differences of data can eliminate autocorrelation, but a price change or percentage price change model takes the difference of the prices for the duration of the hedge and are therefore not first differences. Therefore, the only time a price change or percentage price change model would serve to eliminate autocorrelation would be the case in which a hedge is held for a time similar in frequency to the analyst's data (e.g. a model constructed with weekly data used to evaluate a hedge held for one week). They suggest that autocorrelation-corrected parameter estimates would be appropriate; however price change models do not serve this purpose. The authors conducted empirical analysis and found that hedge ratios based on price change models were not statistically superior to price level models. Furthermore, price level models are simpler to estimate because the length of time a hedge is to be held does not have to be defined as in price change models. For anticipatory hedges, the authors conclude that price level models are appropriate.

The appropriate hedge ratio estimation technique was modified once again by Myers and Thompson (1989). The authors point out that the slope coefficient from a simple regression gives the ratio of the unconditional covariance between cash and futures prices to the unconditional variance of futures prices. They fault this method and assert that the covariance and variance in an optimal hedging ratio are conditional moments that depend on the information available at the time a hedge is placed. Therefore a generalized approach is proposed that accounts for conditioning information. This is achieved in a single equation approach estimated by OLS that includes lagged variables to account for conditional market information. In the Myers and Thompsons study, lagged spot and futures price variables are included in the regression.

Myers and Thompson conclude that hedge ratios estimated in this manner are significantly different than those obtained through the historical method in a price level regression. Therefore utilizing a simple regression technique using price levels may result in large errors.

Viswanath (1993) modified the approach set forth by Myers and Thompson. He suggests that current basis information has the power to predict future changes in futures or cash prices. Therefore the model proposed by Viswanath is a regression of spot prices on futures prices and current basis. This method also addresses an issue raised previously by Castelino (2000) in 1992 which suggests that current models are insufficient because they fail to account for convergence of futures and cash markets at maturity. By incorporating basis information into the hedge ratio estimation, Viswanath adjusted for cash-futures convergence at maturity and improved the generalized approach set forth by Myers and Thompson. This approach yielded smaller hedge return variations in many cases, although results seemed to be inconsistent across commodities.

2.2 Cross Hedging Wholesale Beef

Miller (1980) provides the earliest research addressing the use of fed cattle futures as a means of reducing wholesale beef price risk. To the extent that wholesale beef prices exhibit variability, food service institutions face price risk. Aside from accepting the price variability associated with purchasing all meat on the spot market, the options for reducing price variability for food service institutions are limited. They are:

1. Purchasing meat prior to actual use and storing the product.

2. Forward contracting with a broker or packer for future delivery at a pre-determined price.
3. Hedging anticipated meat purchases utilizing futures markets.

Purchasing and storing meat can serve as a means of securing product at a favorable price, but often storage is not feasible and storage costs may be high. Forward contracting is appealing from a food service standpoint, however it may be difficult finding packers or brokers willing to engage in forward contracting.

Miller sets out to explore the final option listed above. By utilizing a minimum variance hedge ratio estimated with historical data of wholesale prices for steer hinds, boneless beef, and sirloin butts and futures prices, the variability that would be faced by food service institutions was reduced compared to a spot purchasing strategy. The reduction in price variability did not come at the expense of higher average prices, which increases the appeal of this finding.

Miller concludes that cross hedging wholesale beef in Fat (Live) Cattle futures can be an effective means of reducing price risk. Forward pricing anticipated meat purchases through cross hedging should allow for more accurate budgeting and reduced profit margin volatility.

Hayenga and DiPietre (1982a) and Hayenga and DiPietre (1982b) conduct a similar analysis of cross hedging wholesale pork on Live Hog futures and wholesale beef on Live Cattle futures, respectively. These analyses build upon earlier work by Miller (1980). The authors utilize a similar methodology as Miller; however they estimate individual regressions for pre-determined contract periods. This method allows for both the intercept and slope coefficients of the regressions of wholesale cash prices on futures prices to vary seasonally.

Rather than comparing the variance of prices obtained through the spot market to those obtained through cross hedging like Miller, Hayenga & DiPietre focus on interpreting the correspondence between cash and futures prices during the period in which a hedge would be lifted. They analyze the size and frequency of the variations around the estimated cash to futures price relationship to provide a measure of the risk associated with employing a cross hedging strategy.

The standard error of the forecast (SEF) is the measurement used to evaluate the basis risk that a hedger would face. This, in association with the regression estimation, allows a decision maker to construct a confidence interval for the expected cash price associated with the hedge.

The authors provide illustrations of how a successful cross hedge may be utilized. By constructing a confidence interval from the SEF, a manager could expect the cash price at the time the cross-hedge is lifted to be within the SEF approximately two-thirds of the time. One-third of the time, the cash price would not be within the SEF, but the authors point out that statistically, only half of these occasions would be unfavorable. Furthermore, over long periods of time, the favorable and unfavorable cash prices should counteract each other.

In (1982b) Hayenga and DiPietre acknowledge that basis risk is still present when utilizing the best estimated hedging ratios. The decision to cross hedge wholesale beef on live cattle futures is dependent upon a manager's expectations regarding the future cash market, prevailing futures prices, and the manager's level of risk aversion. They conclude that Live Cattle futures may sometimes present opportunities for improving the risk management activities of firms dealing in wholesale beef.

Miller and Luke (1982) suggest an alternative technique for cross-hedging wholesale beef. The authors develop minimum variance hedge ratios calculated with ordinary least squares (OLS) following Miller (1980) and Hayenga and DiPietre (1982a, 1982b), as well as hedge ratios derived by a Cooley and Prescott (CP) method. The CP method is included to account for transitory or permanent changes in regression coefficients over time. The authors point to evidence which suggests that marketing margins for meat widen as supplies increase and narrow when supplies are tight. To the extent that beef supplies influence the relationship between cash and futures prices, it stands to reason that beef supply should be included in an OLS regression as an independent variable. However, the authors note that this makes interpretation of hedge ratios more difficult. The CP method is employed to allow for parameter variation. Specifically, the coefficients estimated from the CP method apply to time $T+1$ where T is the last observation in the sampling interval.

The Miller and Luke study then compares the variance and mean prices of top sirloin butts associated with an OLS strategy, a CP strategy, and spot purchasing or no cross hedging. Results indicate that in all instances, the OLS and CP methods of cross hedging reduce price variability without increasing the mean price. The OLS method also proved to be preferable to the CP method. Aside from the benefits of being a simpler model with less computational costs, the OLS method resulted in lower mean prices and lower price variance compared to the CP method.

Bailey and Brorsen (1985) analyzed the efficacy of hedging carcass beef to minimize short term price risk for meat packers. The motivation for this research is slightly different than the previous articles reviewed, but the underlying theory is similar.

In contrast to cattle feeding enterprises which are exposed to price risk over a long production period, meat packers face price risk over a shorter period when considering the length of time between signing a contract with a customer and purchasing cattle. Although price changes over a short period like this (one week) are small, a high volume business like a packing plant could sustain significant revenue losses if live cattle prices increased in the window of time between the writing of a forward contract and the purchase of cattle.

Bailey and Brorsen were attracted to the simplicity provided by utilizing a current ratio of choice carcass and live cattle futures price to determine a hedge ratio rather than calculating regression coefficients. As Hayenga, Jiang, and Lence (1996) point out, this method is a special case of the regression method used in previous studies in which the intercept is set to zero.

Results indicate that packers who instituted a routine hedging strategy could reduce the risk of price increases they face when engaging in short term contracts with buyers.

In 1996, Hayenga, Jiang, and Lence revisit cross hedging in wholesale beef and pork products. The authors recognize that meat processors and merchandisers have utilized cross hedging to offer firm priced forward contracts for wholesale beef and pork products. Generally, these managers used the cash to futures price ratio for a certain time of year to determine a forward price quotation, a method utilized by Bailey and Brorsen (1985). Poor performance of these hedging and contracting programs served as the motivation for Hayenga, Jiang, and Lence to examine the possible causes for this poor performance and research methods to improve cross hedging strategies.

The authors analyze and compare three approaches to cross hedging. The first is the general industry practice used at the time of publication which is described above. The second model analyzed is the traditional minimum variance hedging model advocated in previous literature including Hayenga and DiPietre (1982a, 1982b), Miller (1980) and Miller and Luke (1982). This hedge ratio is the slope coefficient of a regression of cash on futures prices. The third model stems from previous work by Myers and Thompson (1989) and Viswanath (1993), which suggested that the relationship between cash and futures prices is affected by various and evolving market conditions. Therefore a generalized conditional approach is advocated, which accounts for changes in market conditions. Viswanath expands this notion put forth by Myers and Thompson by suggesting that recent basis information is likely the most informative and practical market information necessary for hedge ratio estimation. Under these contexts, the third model analyzed by Hayenga, Jiang, and Lence includes a basis term lagged *k* weeks as an independent variable.

The authors point out that the traditional method of calculating hedge ratios is a special case of the modified model in which the slope coefficient on the lagged basis term is zero. Given this information, the first method is nested in the second method, which is nested in the third method. Therefore, statistical testing is applicable to verify shortcomings of the more simplistic models.

All three models were estimated and allowed to vary by month to account for seasonality. Results for both beef and pork indicate that the generalized conditional approach is a significant improvement over the two simpler models. F-tests confirmed these results. The authors suggest that risk managers could greatly improve their forward pricing performance for certain wholesale cuts by employing the more sophisticated models set forth in their article.

Schroeder and Yang (2001) found results that contradicted earlier work. Utilizing the method advocated by Hayenga, Jiang, and Lence (1996), Schroeder and Yang analyzed the effectiveness of cross hedging wholesale beef on live cattle futures. They found live cattle futures to be a poor venue for minimizing wholesale beef price risk. The authors cite the many structural changes that have occurred in the beef industry since original research was published including changes to contract specifications and grading procedures as possible explanations for the contradictory results.

By using cash prices as a proxy, the authors test the effectiveness of establishing a Choice wholesale beef futures contract and a Choice-Select spread futures contract. Their findings indicate that a Choice beef futures contract would provide the most potential as a means of managing wholesale beef price risk. This would be complemented by the addition of a Choice-Select spread contract.

Mattos et al (2003) conduct a similar analysis. They, like Schroeder and Yang, conclude that Live Cattle futures are an inadequate tool for managing wholesale beef price risk. The authors suggest a boxed beef cutout index futures market would provide much more potential for wholesale beef price risk reduction.

2.3 Summary

Theory and technique regarding cross hedging has been evolving constantly since early research was conducted. The many changes and modifications that have taken place have led to a technique that seems to be, reliable, and well understood.

In terms of cross-hedging wholesale beef, the efficacy of utilizing Live Cattle futures to cross-hedge seems to be in question. Early work by Hayenga & DiPietre (1982a, 1892b), Miller

(1980) and Miller and Luke (1982) suggested Live Cattle futures may be a promising venue for minimizing wholesale beef price risk. More recent research by Hayenga, Jiang, and Lence (1996), Schroeder and Yang (2001), and Mattos et al (2003) suggested that cross hedging in Live Cattle futures is appropriate only for some primal cuts or completely ineffective. Structural changes in the beef industry and the way in which cattle are marketed have been cited as a potential explanation for the discrepancies between studies.

In spite of the poor performance of cross-hedging wholesale beef noted by recent research, the concept provided by Anderson and Danthine (1981), which suggests that cross hedging is plausible as long as the covariance between cash prices and futures prices is significantly different from zero, still holds true. Given the fact that Live Cattle futures prices and wholesale beef prices are related, cross-hedging should be applicable. The following sections are devoted to improving the performance and efficiency of this practice.

CHAPTER 3 - Methodology

This study hinges on the formulation and evaluation of optimal cross-hedge ratios for wholesale beef in Live Cattle futures. The literature described in the previous chapter provides a template that is used to formulate and evaluate these ratios. This chapter is devoted to describing the processes and methods used in this study more thoroughly.

3.1 Formulating a Cross-Hedge

Johnson (1960) and Ederington (1979) provide the theoretical foundation for formulating an effective hedge ratio. Johnson found the current definition of hedging to be inadequate and put forth an updated definition. Traditionally, hedgers were assumed to be engaged in purely risk reducing activities. It was believed that hedgers were unsophisticated traders that did not have any expectations regarding market conditions or price making activities. Through a series of interviews, Johnson found that the primary motivation for hedging in the New York City coffee trade was to reduce price risk. He also found that market participants were concerned with expected relative price movements as well as expected absolute price movements. For example, if the trader was bearish, they might increase their short positions more than would be necessary for purely hedging purposes. Similarly, if a price increase were expected, the trader might go long in both the spot and futures markets simultaneously. This is obviously speculative in nature.

To generalize, Johnson concludes that the motivation to hedge lies in price risk reduction. However the levels of inventory held seem to be related to expected profits from hedging. The line between hedging and speculation is somewhat blurred. Therefore a definition of hedging that does not account for expected profits from hedging is inadequate.

Johnson's updated definition of hedging states that given a position of x_c units in market c, a hedge is a position in market f of size x_f* that minimizes the price risk for holding x_c and x_f* from time t_1 to time t_2. The price risk is evaluated by the variance of a subjective probability distribution for the price change from t_1 to t_2 that the trader faces at t_1. The variance of price change, or price risk, in market c from time t_1 to time t_2 is denoted by σ_c^2. The variance of return for holding x_c units is denoted by $x_c^2\sigma_c^2$. A similar formulation is used to determine the price risk in market f. The variance of return for trading a combination of positions in c and f is given by:

$$V(R) = x_c^2\sigma_c^2 + x_f^2\sigma_f^2 + 2x_c x_f cov_{cf}. \qquad (1)$$

This equation can then be used to find the value x_f* that will minimize the variance of return for trading in two different markets. Differentiating the above equation with respect to x_f and setting the derivative equal to zero yields:

$$x_f^* = x_c \frac{cov_{cf}}{\sigma_f^2}. \qquad (2)$$

From this equation, Benninga, Eldor, and Zilcha (1984) show that the minimum variance (and optimal) hedge ratio is:

$$\frac{x_f^*}{x_c} = \frac{cov_{cf}}{\sigma_f^2}. \qquad (3)$$

This is also the slope coefficient of a simple regression of C on F denoted by b below.

$$C = a + bF + e. \qquad (4)$$

Following Myers and Thompson (1989) and Viswanath (1993), lagged basis information is incorporated into the regression. This is necessary to account for ever changing market conditions that persist in commodity markets. Incorporating basis information allows for hedge ratios to be calculated from the conditioned ratio of the covariance of cash and futures prices over the conditioned variance of futures prices rather than unconditioned information. Furthermore, basis information captures convergence between spot and futures markets at maturity, which is a major criticism of simpler models.

After the addition of basis information, the hedge ratios used for this research are calculated from the regression:

$$CP_i = \alpha_i + \beta_{1i} FP + \beta_{2ik} BASIS_{ik} + \sum_{j=1}^{11} \beta_{3ij}\, MD_j + \sum_{j=1}^{11} \beta_{4ij}\, MD_j * FP + e_i. \quad (5)$$

CP_i is the wholesale cash price of cut *i*. *FP* is the weekly average nearby live cattle futures contract price, $BASIS_{ik}$ is the difference between cash and futures prices for cut *i* and lagged *k* weeks. MD_j represents monthly dummy variables and MD_j*FP is the interaction term of monthly dummies with futures price. Seasonality issues necessitate the calculation of a unique hedge ratio for every month, therefore *j=1,2,3,…,11* with month 12 serving as the base month. These two variables allow both the slope and intercept of the regression to vary by month. α_i is a constant intercept term. β_{1i} is a slope coefficient, which as previously stated is the optimal hedge ratio. β_{2ik} is the coefficient for the lagged basis estimate of cut *i* lagged *k* weeks. β_{3ij} is added to the intercept term to determine the appropriate intercept for cut *i* in month *j* when *j* is not the base month. β_{4ij} is combined with β_{1i} to determine the appropriate slope intercept (hedge ratio) for cut *i* in month *j* when *j* is not the base month. e_i is an error term.

3.1.1 Testing Nonstationarity

When a data set is stationary, it is said that the moments of the variable in question are independent of time (Kennedy, 1997). This is a desirable characteristic for time series analysis. If data are nonstationary, regressions may produce spurious results. To determine if the data were stationary, the Dickey-Fuller unit root test was performed on all cash and futures price series. If the null hypothesis of the unit root test is rejected, a unit root is not present and prices can be treated as stationary in levels. With the exception of briskets, all primal cut prices, composite cutout prices and futures prices were stationary at the 5 percent significance level. Therefore, price levels, rather than differences, were used for this analysis. Results of the Dickey-Fuller unit root test are reported in Table 3.1.

Table 3.1 Dickey Fuller Unit Root Tests-Weekly Futures and Wholesale Cash Prices, 1/2/2004-1/8/2010

Variable	Tau	Pr < Tau
Weekly Nearby Futures Price	-3.24	0.0189
Prime Cutout	-3.03	0.0340
Branded Cutout	-5.15	<.0001
Choice Cutout	-4.89	0.0001
Select Cutout	-4.56	0.0003
Choice Rib	-4.49	0.0003
Choice Chuck	-3.95	0.0020
Choice Round	-4.50	0.0003
ChoiceLoin	-3.11	0.0272
Choice Brisket	-2.64	0.0862
Choice Short Plate	-3.16	0.0237
Choice Flank	-3.33	0.0149
Select Rib	-5.38	<.0001
Select Chuck	-3.91	0.0023
Select Round	-4.07	0.0013
Select Loin	-3.39	0.0123
Select Brisket	-2.34	0.1596
Select Short Plate	-3.16	0.0236
Select Flank	-4.12	0.0011

N=315

3.1.2 Dealing with Autocorrelation

When dealing with time series data, such as cash beef or futures contract prices, autocorrelation becomes a concern. If errors are autocorrelated, ordinary least squares (OLS) estimates will remain unbiased but will be inefficient. Therefore statistical testing becomes challenging due to the unreliability of *t* and *F* statistics (Maddala, 2009). To address the possibility of first order autocorrelation, AR(1), an autoregressive (AutoReg) function can be estimated that accounts for correlation of the error terms. Estimates from this procedure should yield unbiased and efficient estimates.

The practical value of adjusting for autocorrelation in hedge ratio estimation is somewhat debatable. Elam (1991) found that increasing the efficiency of estimates for beef cattle hedges can increase hedging risk. Therefore, the proper methodology is dependent on the user's end goal. Elam indicates that, particularly in beef cattle hedges to be held for longer than one month, practicing hedgers would be better off using an OLS method that will provide the least hedging risk. If a user is more concerned with hypothesis testing, an autocorrelation corrected model with more efficient estimates would be preferable.

Both OLS and autoregressive hedge ratios are reported in this thesis.

3.2 Bundling Primal Beef Cuts

In light of the fact that recent evaluations of cross-hedging wholesale beef prices have found current methods to be inadequate, (Hayenga, Jiang, and Lence, 1996; Schroeder and Yang, 2001; Mattos et al, 2003) a primary objective of this research is to determine the effect of combining two or more cuts into a single, hedgeable unit. From the perspective of a wholesale beef distributor, having an entire carcass to merchandise provides greater flexibility in marketing. If a bundled product provides less hedging risk than the combined risk of hedging the corresponding un-bundled cuts independently, beef wholesalers would be able to provide a valuable risk management service to customers by offering forward pricing on the cross-hedged bundles with a lesser amount of risk than if customers attempted to hedge the products themselves.

To construct a bundle, the correct proportion of wholesale cuts to be included must be determined. A beef carcass is comprised of seven primal cuts. These primals vary in both proportion of total carcass and value. Table 3.1 shows the proportions of each wholesale primal to the composite cutout.

Table 3.2 Proportions of Primal Cuts to Composite Cutout Value

Primal	Percent of Composite Cutout Value
Chuck	29.56%
Rib	11.31%
Round	22.44%
Loin	21.18%
Brisket	4.97%
Short Plate	7.16%
Flank	3.38%
	100.00%

The percentages of composite cutout values which are provided by the USDA Agricultural Marketing Service (USDA-AMS) are used to determine the proportions of each cut to include in a bundle. This is accomplished by using a ratio of each cut's percentage of cutout value to the total percentage of the carcass represented by the cuts to be bundled. For example, a bundle of chucks and ribs would account for 40.87 percent of the wholesale cutout value and be comprised of 27.7 percent rib value and 72.3 percent chuck value (29.56/40.87

and 11.31/40.87). This newly created variable becomes the dependent variable in the same regression of cash prices on futures prices described previously in equation (5).

To evaluate the risk reduction attained through this procedure, the variance of the error term for the bundled regression is compared to the combined variance of errors for the corresponding cuts hedged independently. A decrease in variance of the error term for the bundle would indicate a risk reduction which can be statistically tested by utilizing an F-test. To test for differences between two variances an F test is used where:

$$F = \frac{S_1^2}{S_2^2}. \qquad (6)$$

CHAPTER 4 - Data Sources and Description

Wholesale cash beef prices and live cattle futures prices are employed to perform this analysis. An examination of these price series is valuable. Understanding the trends and relationships between prices will provide insight into the usefulness of cross-hedging wholesale beef. This chapter will focus on describing the data and data sources used for this thesis.

4.1 Data Sources

The estimated value of a beef carcass can be represented by the boxed beef cutout (BBC), which is reported by the USDA-AMS. This figure is derived from current prices paid for the individual beef primals that make up a carcass. Both primal prices and composite cutout values are used in portions of this analysis as a proxy for wholesale cash beef price.

The Livestock Marketing Information Center (LMIC) provides data for the boxed beef composite cutout and primal values for Prime, Branded, Choice, Select, and Ungraded beef, which are reported by USDA-AMS in report LM_XB463. Live cattle futures prices are also obtained from LMIC. Weekly data are used in this analysis. For live cattle futures prices, daily closing data are converted to a weekly average price. Nearby futures contract prices are used. This price series is comprised of the nearest futures contract price at a given time excluding the delivery month. For example in January the corresponding futures contract would be the February contract. In February and March the corresponding contract would be April.

Summary statistics for the nearby futures price series and all wholesale beef prices from January 1, 2004 to January 8, 2010 are provided in Table 4.1.

Table 4.1 Summary Statistics for Wholesale Beef and Live Cattle Futures Prices, 1/2/2004-1/8/2010 ($/cwt)

Variable	Description	Mean	Std Dev	Minimum	Maximum
wknearby	Weekly Nearby Futures Price	88.37	6.63	72.55	107.32
PrCom	Prime Composite Cutout	171.15	11.57	149.16	196.93
PrRib	Prime Rib	283.37	30.19	211.63	393.76
PrChuck	Prime Chuck	108.49	9.88	84.94	141.18
PrRound	Prime Round	125.67	9.63	108.06	148.14
PrLoin	Prime Loin	308.98	39.62	218.88	379.25
PrBrisket	Prime Brisket	87.20	9.02	65.71	107.39
PrSPlate	Prime Short Plate	89.63	11.52	61.17	119.73
PrFlank	Prime Flank	84.81	9.27	64.09	112.93
BrandCom	Branded Composite Cutout	150.72	8.39	129.96	176.41
BrandRib	Branded Rib	232.56	20.42	183.04	286.04
BrandChuck	Branded Chuck	110.03	9.82	85.75	143.37
BrandRound	Branded Round	127.72	9.69	108.51	151.21
BrandLoin	Branded Loin	234.33	26.04	189.86	310.00
BrandBrisket	Branded Brisket	88.83	8.87	69.00	109.70
BrandSPlate	Branded Short Plate	89.63	11.52	61.17	119.73
BrandFlank	Branded Flank	86.19	9.03	65.87	113.63
ChCom	Choice Composite Cutout	145.12	8.15	124.41	170.44
ChRib	Choice Rib	221.28	16.90	176.07	269.16
ChChuck	Choice Chuck	108.49	9.87	84.94	141.20
ChRound	Choice Round	125.65	9.62	108.04	148.12
ChLoin	Choice Loin	219.09	23.63	178.10	286.38
ChBrisket	Choice Brisket	87.21	9.02	65.71	107.39
ChSPlate	Choice Short Plate	89.63	11.52	61.17	119.73
ChFlank	Choice Flank	84.80	9.27	64.09	112.93
SelCom	Select Composite Cutout	137.13	7.97	119.27	163.91
SelRib	Select Rib	202.03	13.32	171.04	241.85
SelChuck	Select Chuck	108.10	9.79	86.08	140.58
SelRound	Select Round	124.41	10.12	101.76	149.53
SelLoin	Select Loin	194.15	16.21	167.48	241.59
SelBrisket	Select Brisket	86.67	8.86	67.48	107.04
SelSPlate	Select Short Plate	89.63	11.52	61.17	119.73
SelFlank	Select Flank	80.29	8.18	62.46	104.69
UngrCom	Ungraded Composite Cutout	132.71	7.73	116.46	165.48
UngrRib	Ungraded Rib	187.99	12.72	154.92	224.79
UngrChuck	Ungraded Chuck	108.30	9.78	85.07	142.41
UngrRound	Ungraded Round	123.55	10.23	101.87	149.77
UngrLoin	Ungraded Loin	180.86	17.38	148.36	222.81

UngrBrisket	Ungraded Brisket	87.12	9.01	66.56	106.25
UngrSPlate	Ungraded Short Plate	89.63	11.52	61.17	119.73
UngrFlank	Ungraded Flank	81.98	7.88	64.11	105.80

N=315

Other pertinent data used for this analysis includes basis information which is calculated from the LMIC data. In all cases, basis refers to cash beef price minus Live Cattle futures price.

4.2 Examining Wholesale Cash Prices

Figure 4.1 illustrates the price variability for wholesale boxed beef. This chart represents the composite cutout price for five quality grades. Prices for all quality grades are positively correlated. While much price variability exists, the ordinal ranking of price corresponding to quality grade is almost never violated. Prime is the most valuable quality grade followed by Branded, Choice, Select, and Ungraded. Demand and supply components determine these cutout values, the latter of which is illustrated in Figure 4.2.

Figure 4.1 Weekly Average Boxed Beef Cutout Prices, 1/2/2004-1/8/2010

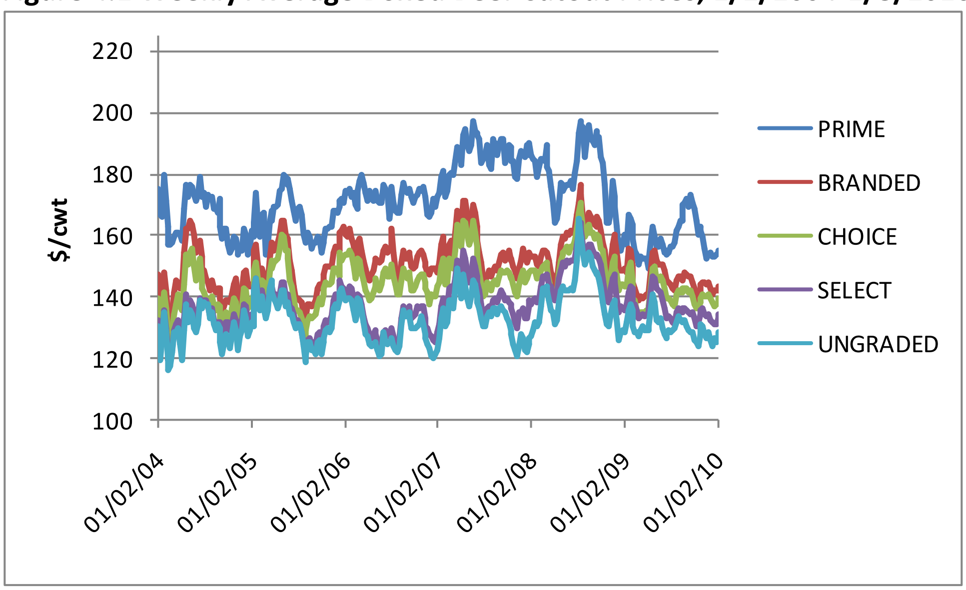
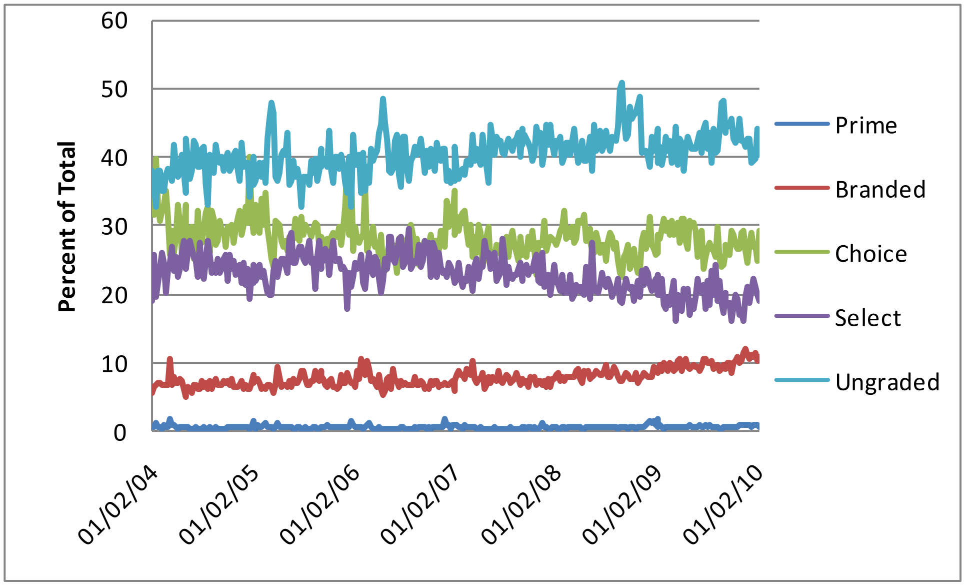


Figure 4.2 Percent of Total Weekly Boxed Beef Loads, 1/2/2004-1/8/2010



Ungraded, Choice, and Select product make up the bulk of total boxed beef loads shipped weekly. Ungraded product includes cuts, grinds, and trims, and is usually destined for markets that differ from that of Choice and Select product. Therefore, Choice and Select quality grades will receive the bulk of the attention in this research.

The price relationship between quality grades is a concept that has been studied extensively. Understanding this concept becomes important when cross-hedging wholesale beef because of changes in the way cattle are marketed in the U.S. As Schroeder and Yang (2001) point out, since the earliest research on cross-hedging wholesale beef was conducted, many changes have occurred in beef markets that may have led to the declining performance of cross-hedging programs. Live Cattle futures contract specifications, beef quality grading prevalence, wholesale beef market structures, grid premiums and more recently, dynamics related to the Choice-Select spread, all have undergone significant changes in the past 30 years which may have impacted the performance of wholesale beef cross-hedges.

When the earliest research on cross-hedging wholesale beef was conducted, Live Cattle futures contracts traded 100% Choice steers. Beginning with the June 1995 contract, Live Cattle contract specifications changed to 55% Choice and 45% Select steers. Intuitively, hedging Choice beef cuts will involve more basis risk under the current contract specification due to the fact that cross-hedging performance is fundamentally linked to the correlation between the commodity to be hedged and the underlying futures contract. Table 4.2 shows the correlation between Prime, Branded, Choice, and Select quality grades and the nearby futures price.

Table 4.2 Weekly Nearby Futures and Cutout Correlation Matrix 1/2/2004-1/8/2010

	LCF	Prime Cutout	Branded Cutout	Choice Cutout	Select Cutout
LCF	1	0.63558	0.59692	0.65004	0.70355
Prime Cutout	0.63558	1	0.71715	0.72274	0.59261
Branded Cutout	0.59692	0.71715	1	0.98266	0.80220
Choice Cutout	0.65004	0.72274	0.98266	1	0.86005
Select Cutout	0.70355	0.59261	0.80220	0.86005	1

The correlation between wholesale cash prices and the nearby futures price ranges from 0.60 to 0.70. From these correlations, it seems cross-hedging wholesale beef in Live Cattle futures will have a significant amount of basis risk which underlines results found by Schroeder and Yang (2001). Their research indicated that Live Cattle futures prove to be a challenging venue for effective cross-hedging of wholesale beef. Schroeder and Yang attempted to adjust for price differences between quality grades by incorporating Choice-Select spread information. Results indicated that if a Choice-Select spread futures contract existed, cross-hedging wholesale beef in Live Cattle futures together with a Choice-Select spread hedge would only modestly improve cross-hedging performance.

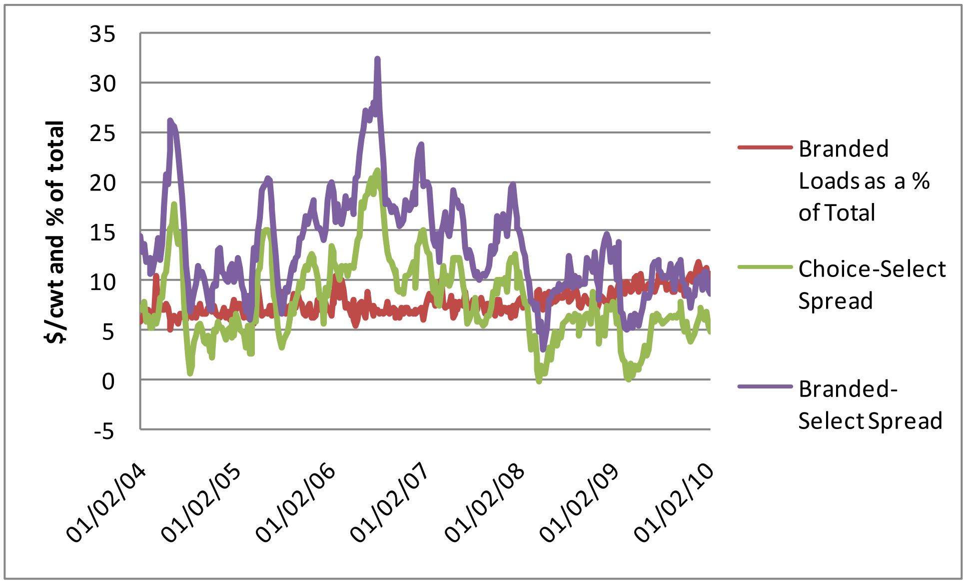
Choice quality grade beef cutout (0.65) has a less positive correlation coefficient with nearby live cattle futures prices than Select quality grade cutout (0.70). This is an interesting finding given the fact that a higher percentage of Choice graded cattle make up the Live Cattle futures contract.

4.2.1 The Impact of Branded Beef

USDA-AMS began recording cutout information for branded beef in April, 2003. Roughly 10 percent of wholesale boxed beef loads are branded product (Figure 4.2). By AMS definition, the Branded cutout consists of Choice product including upper 2/3 and lower 1/3 Choice. The effect of increased amounts of branded beef on wholesale beef prices is somewhat unclear. McCully (2010) suggests that although the Branded beef cutout includes all Choice grading branded beef, the popularity of Certified Angus Beef and other brands which include only upper 2/3 Choice product have diluted Choice cutout quality. As higher quality Choice product is pulled into the Branded cutout, a greater proportion of lower 1/3 Choice product makes up the Choice cutout. McCully points to evidence suggesting that differences between lower 1/3 Choice quality grade and Select quality grade are minimal. Because of this, procurement managers have altered their strategies to reflect this structural change which has in turn reduced the value of the Choice cutout. This is manifested in a reduced Choice-Select spread over time. Figure 4.3 charts the proportion of Branded boxed beef with the Choice-Select Spread and the Branded-Select spread.

Branded beef loads have increased significantly since AMS began tracking this cutout. Clearly, the Choice-Select spread has decreased over time which seems to support McCully's findings. However, the Branded-Select spread has also decreased over the same time period, following the Choice-Select spread closely. A structural shift of the Choice cutout may be partially responsible for the decrease in the Choice-Select spread, but other factors alluded to by McCully, namely a difficult retail environment brought about by a faltering economy, likely have had just as much impact on the weak Choice cutout price.

Figure 4.3 Proportion of Branded Boxed Beef with Choice-Select Spread and Branded-Select Spread, 1/2/2004-1/8/2010



To generalize, the U.S. beef industry has responded to consumer demand for higher quality by shifting away from commodity beef production and focusing more on producing differentiated, higher quality beef. This is evidenced by the increase in the amount of Branded boxed beef available. In relation to cross-hedging strategies, the effect of this production shift has been an erosion of the correlation between wholesale beef prices and live cattle futures price. This may partially explain why Select cutout prices are more closely aligned with the nearby futures contract prices than Choice cutout prices.

4.3 Relationship between Wholesale Beef and Live Cattle Futures Prices

Accepting the fact that cash and futures price correlations indicate basis risk will be inherent for cross-hedging purposes, our attention shifts to understanding the relationship between wholesale beef prices and live cattle futures prices. The following figures are scatter plots of Live Cattle futures price and wholesale beef price for a given month and quality grade.

The addition of a trend line with a slope coefficient to the scatter plots above would provide the optimal hedge ratio for the selected cut in the selected month. These figures demonstrate that hedge ratios may be quite different between quality grades. Hedge ratios can also vary a great deal for different months within the same quality grade. Hayenga & DiPietre (1982a) explain that seasonality differences and demand elasticities can explain the differences in hedge ratios. Comparing Figure 4.6 and 4.7, it is evident that the July hedge ratio will be larger than the October hedge ratio. In other words, the slope coefficient will be larger for Figure 4.6. Strong grilling demand in the summer months leads to the Choice cutout price rising at a faster rate than the nearby futures price during this period. Similarly, during periods of lower demand, the slope coefficient will be smaller.

Figure 4.4 Choice Cutout and January Live Cattle Futures (LCF)

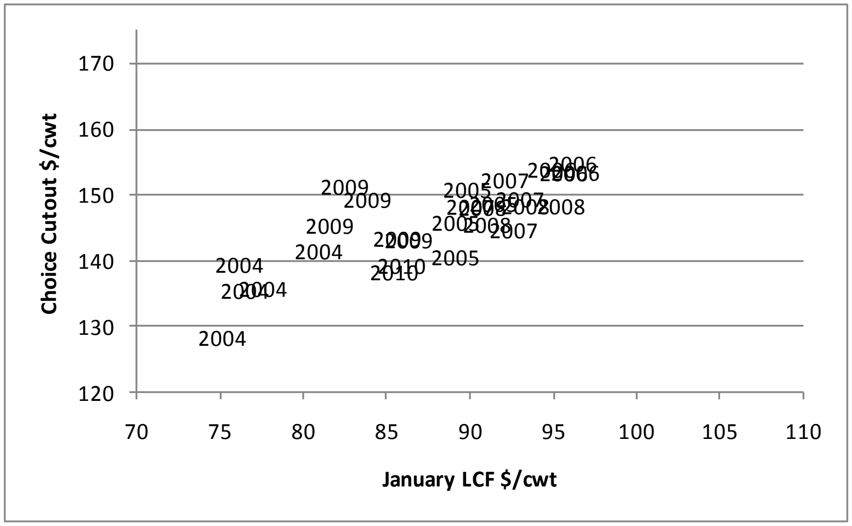


Figure 4.6 Choice Cutout and July Live Cattle Futures (LCF)

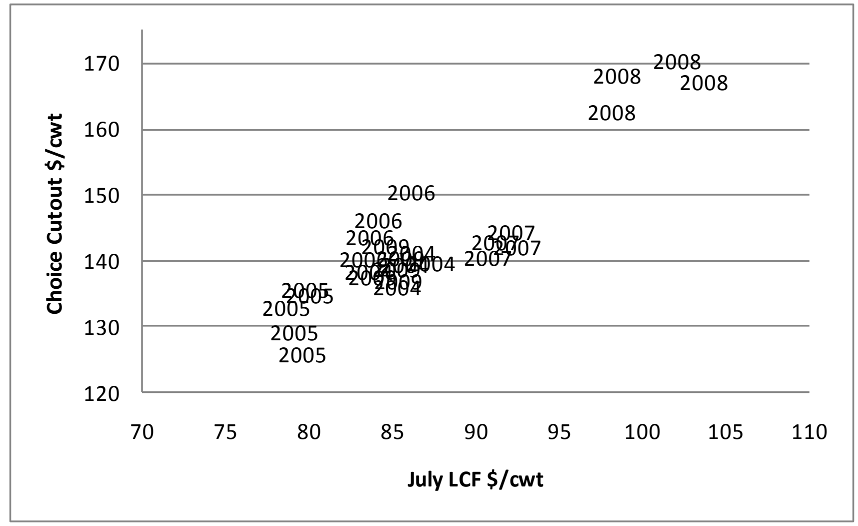


Figure 4.5 Choice Cutout and May Live Cattle Futures (LCF)

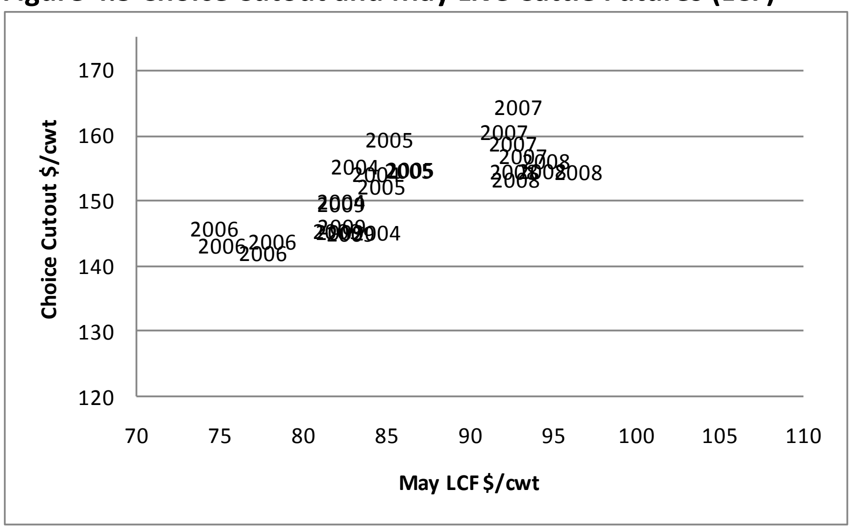


Figure 4.7 Choice Cutout and Oct. Live Cattle Futures (LCF)

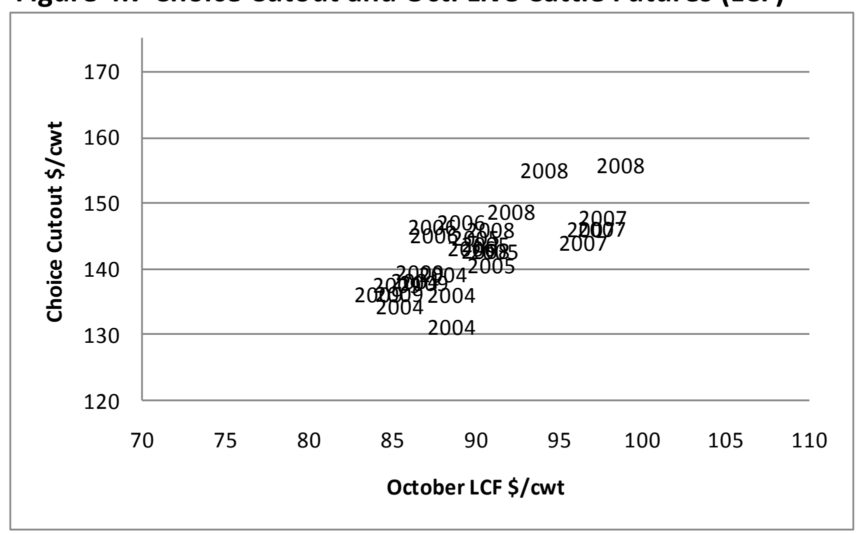


Figure 4.8 Select Cutout and January Live Cattle Futures (LCF)

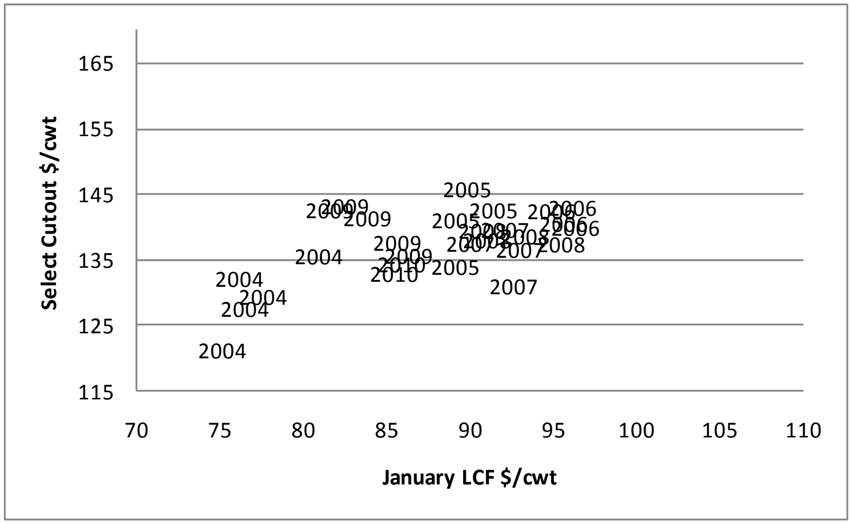


Figure 4.10 Select Cutout and July Live Cattle Futures (LCF)

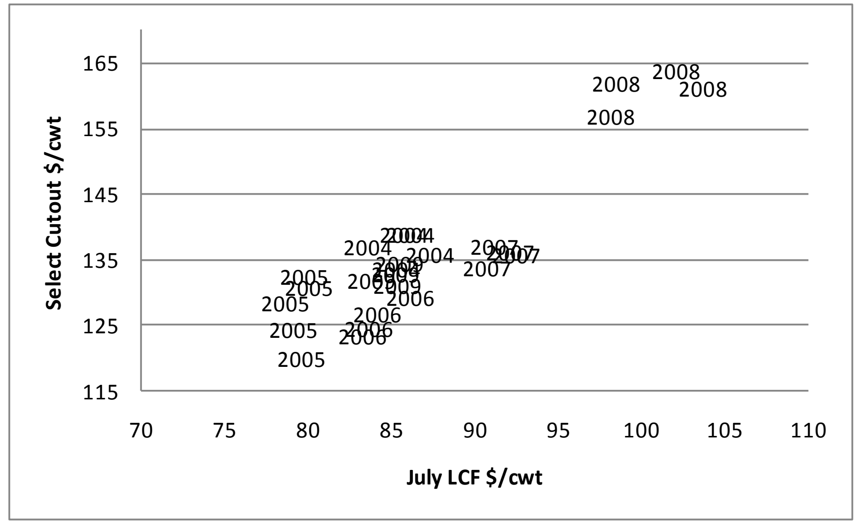


Figure 4.9 Select Cutout and May Live Cattle Futures (LCF)

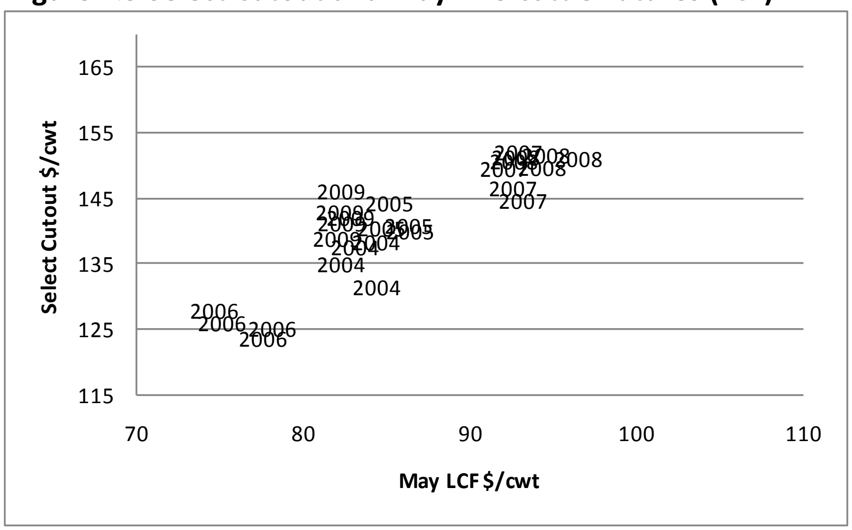
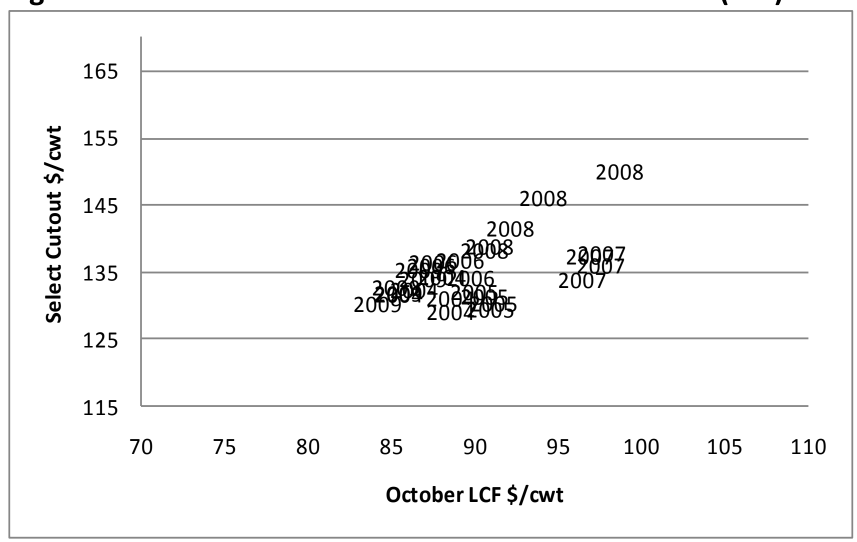


Figure 4.11 Select Cutout and Oct. Live Cattle Futures (LCF)



4.4 Summary

This study hinges on price relationships. The interaction of wholesale cash prices with Live Cattle futures prices dictates cross-hedging effectiveness. Thirty years ago, when the notion of cross-hedging wholesale beef on Live Cattle futures was introduced, cash and futures prices were closely related. Today, that relationship is not as consistent. Differentiation has increased substantially in beef production systems. This shift has impacted the correlation between cash and future beef prices which has made cross-hedging more difficult. In examining the relationship between live cattle futures and cash beef prices, it is evident that optimal hedge ratios will be substantially different for different quality grades and seasons.

CHAPTER 5 - Cross-Hedging Analysis

Results for a traditional cross-hedge are reported in this chapter. A general analysis of cross-hedging whole carcasses using the cutout price is conducted to provide a broad look at cross-hedging. Next, primal cut level cross-hedges are discussed to present a more in-depth look at cross-hedging performance. A practical example of how a cross-hedge can be used is provided in section 5.3.

5.1 Composite Cutout Level Cross-Hedge Analysis

Equation (5) is used to regress Prime, Branded, Choice, and Select quality grade prices on Live Cattle futures. The resulting hedge ratios display a great deal of seasonality. Differences in estimation techniques (AutoReg vs. OLS) also lead to different cross-hedge ratios. Results for each quality grade are reported individually before comparing differences between grades.

5.1.1 Prime Cutout Hedge Ratios

Table 5.1 reports cross-hedge ratios for the Prime Composite cutout. The standard error for the slope coefficient is reported as well. This statistic can be used to construct a confidence interval for the hedge ratio which is illustrated in Figure 5.1. A quick scan of the reported hedge ratios reveals a great deal of seasonal variation and much discrepancy between OLS reported hedge ratios and AutoReg hedge ratios. Seasonality can also be illustrated in Figure 5.1. A comparison of hedge ratios derived from differing estimation techniques is presented in Figure 5.2. OLS hedge ratios are consistently larger than AutoReg hedge ratios. Following results from Elam (1991), which suggests that OLS hedge ratios will provide less basis risk than autocorrelation corrected hedge ratios, it appears that the AutoReg procedure underestimates the optimal hedge ratio. If this is the case, hedgers using these ratios will not take out enough positions in the futures market to offset cash price risk.

Table 5.1 Prime Cutout Hedge Ratios, Weekly Data 1/2/2004-1/8/2010

	No Lag		**4-Week Lag**		**8-Week Lag**		**12-Week Lag**	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	0.5927	0.5686	0.8957	1.0698	0.7225	1.5377	0.5858	1.4824
	(0.23)	(0.23)	(0.23)	(0.23)	(0.30)	(0.31)	(0.31)	(0.34)
February	0.9082	1.1771	1.0894	1.3060	1.2173	1.7282	1.5018	2.3253
	(0.21)	(0.22)	(0.19)	(0.15)	(0.25)	(0.28)	(0.35)	(0.40)
March	0.7006	1.2855	0.9393	1.2234	0.9001	1.3075	0.8616	1.2344
	(0.24)	(0.25)	(0.21)	(0.17)	(0.23)	(0.20)	(0.26)	(0.25)
April	0.4917	0.5882	0.6334	0.6401	0.6114	0.5877	0.5824	0.5776
	(0.21)	(0.23)	(0.19)	(0.16)	(0.20)	(0.19)	(0.21)	(0.20)
May	0.5854	0.9363	0.9688	1.1513	0.7476	0.8935	0.6829	0.7287
	(0.24)	(0.25)	(0.21)	(0.17)	(0.23)	(0.20)	(0.24)	(0.22)
June	0.5765	0.8217	0.9036	0.9375	0.7680	0.9058	0.6849	0.7556
	(0.21)	(0.21)	(0.18)	(0.15)	(0.20)	(0.17)	(0.20)	(0.19)
July	0.9276	1.6196	1.3815	1.7476	1.2088	1.7155	1.0851	1.7167
	(0.22)	(0.23)	(0.19)	(0.16)	(0.21)	(0.18)	(0.22)	(0.20)
August	0.7958	1.4378	1.0803	1.0623	1.1062	1.4774	0.9600	1.4882
	(0.21)	(0.20)	(0.18)	(0.14)	(0.20)	(0.16)	(0.21)	(0.18)
September	0.9386	1.7789	1.3191	1.4117	1.2124	1.4198	1.1250	1.7365
	(0.24)	(0.24)	(0.20)	(0.17)	(0.22)	(0.20)	(0.23)	(0.21)
October	1.0065	1.9985	1.3949	1.4227	1.3202	1.5684	1.1819	1.4888
	(0.30)	(0.37)	(0.28)	(0.26)	(0.29)	(0.30)	(0.30)	(0.34)
November	0.8415	1.9565	1.0511	1.2629	1.1082	1.6305	1.0033	1.7081
	(0.31)	(0.37)	(0.30)	(0.26)	(0.31)	(0.30)	(0.31)	(0.33)
December	0.7466	1.8996	1.2100	1.6607	1.0043	1.9056	0.8702	2.0704
	(0.28)	(0.32)	(0.26)	(0.22)	(0.29)	(0.26)	(0.29)	(0.29)
Lagged Basis			0.4332	0.6857	0.1898	0.5109	0.0500	0.3618
Estimates			(0.05)	(0.04)	(0.06)	(0.05)	(0.06)	(0.05)
R-Square	0.1715	0.5763	0.5033	0.7946	0.3034	0.7204	0.2323	0.6646
Total R-Square	0.8945		0.8877		0.89		0.8929	
Estimates of Autoregressive Parameters	-0.82577		-0.60057		-0.71942		-0.76567	
Standard Errors are in Parentheses								
N=		315		311		307		303

R-Square statistics for OLS estimations range from 0.58 for the model with no lagged basis information to 0.79 for the model with basis information lagged 4 weeks. The improved fit of the models including basis information is consistent with earlier work by Myers and Thompson (1989) and Viswanath (1993). As the hedging horizon increases to 8 and 12 weeks, R-Square values decline. This indicates that past basis information is less useful for hedges that will be held for longer periods of time. R-Square statistics and estimates of autoregressive parameters for the AutoReg models indicate that a great deal of autocorrelation is present in wholesale cash prices. As previously discussed, the high degree of autocorrelation is a concern if statistical testing is necessary when using OLS estimates. However, practicing hedgers who plan to hold a hedge for longer than 4 weeks will benefit from the greater risk reduction provided by OLS (Elam, 1991). AR (1) error coefficients range from 0.60 to 0.83.

Figure 5.1 Prime Cutout OLS Hedge Ratio and Standard Error-8 Week Lag

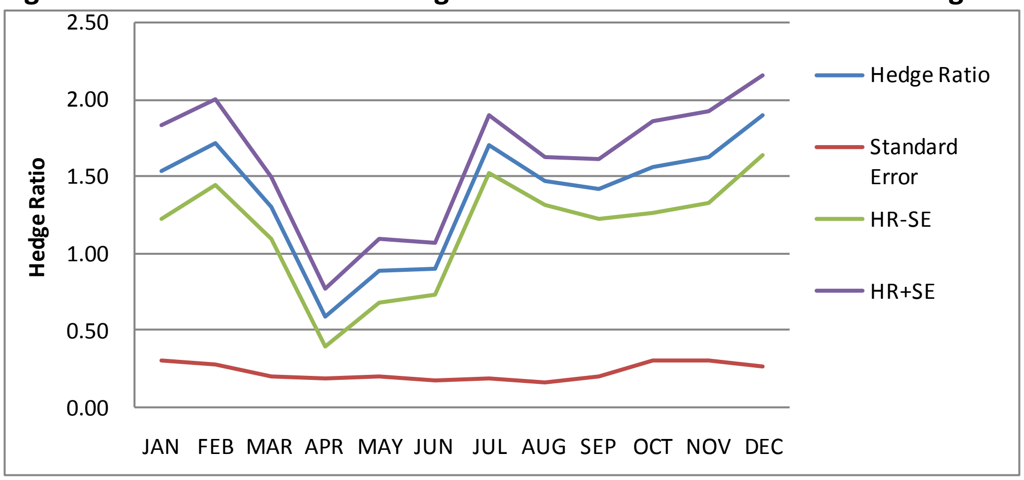
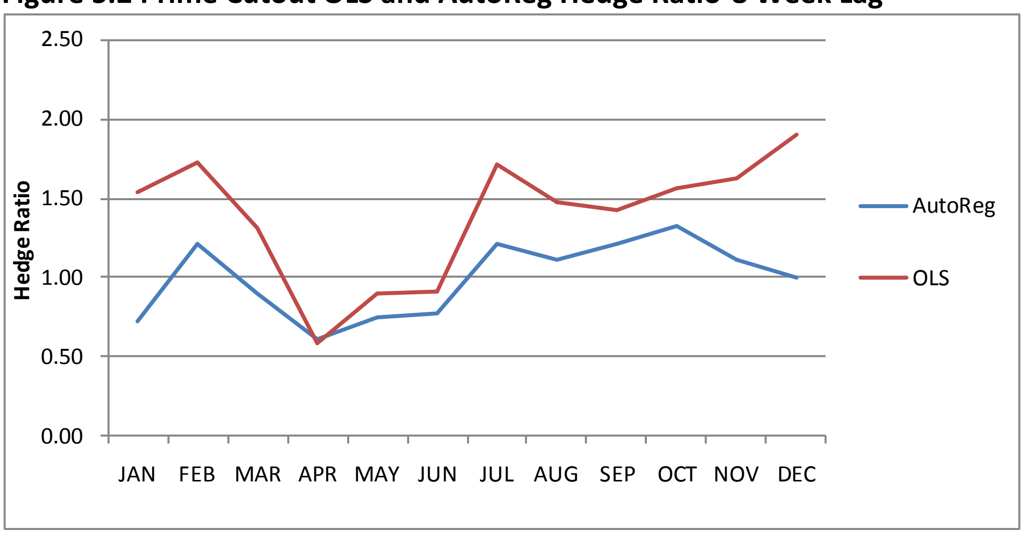


Figure 5.2 Prime Cutout OLS and AutoReg Hedge Ratio-8 Week Lag



5.1.2 Branded Cutout Hedge Ratios

Branded cutout hedge ratios and standard errors are reported in Table 5.2. Seasonality and estimation techniques lead to variation in Branded hedge ratios (Figures 5.3 and 5.4). Again, strong seasonality is present and OLS hedge ratios are consistently larger than AutoReg hedge ratios.

Table 5.2 Branded Cutout Hedge Ratios, Weekly Data 1/2/2004-1/8/2010

	No Lag		**4-Week Lag**		**8-Week Lag**		**12-Week Lag**	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	0.6731	0.8050	0.7432	0.9166	0.507	0.9165	0.4475	0.7249
	(0.18)	(0.15)	(0.19)	(0.19)	(0.24)	(0.24)	(0.24)	(0.24)
February	0.9244	1.0607	0.9529	1.1136	1.0619	1.2399	0.9309	1.1835
	(0.16)	(0.14)	(0.15)	(0.13)	(0.20)	(0.21)	(0.28)	(0.29)
March	0.6543	1.0155	0.7482	1.0832	0.6925	1.0617	0.5853	1.0818
	(0.18)	(0.16)	(0.17)	(0.14)	(0.18)	(0.15)	(0.20)	(0.18)
April	0.4907	0.5332	0.5337	0.6062	0.5244	0.6113	0.4655	0.5487
	(0.16)	(0.14)	(0.15)	(0.13)	(0.16)	(0.14)	(0.16)	(0.15)
May	0.5510	0.6212	0.6544	0.8015	0.5615	0.6747	0.5371	0.6366
	(0.18)	(0.16)	(0.17)	(0.14)	(0.18)	(0.15)	(0.18)	(0.16)
June	0.6446	0.6686	0.7358	0.7947	0.6786	0.7683	0.6213	0.6901
	(0.16)	(0.13)	(0.15)	(0.12)	(0.15)	(0.13)	(0.16)	(0.14)
July	0.9722	1.4629	1.1184	1.5656	1.0210	1.5480	0.9281	1.5190
	(0.17)	(0.14)	(0.15)	(0.13)	(0.16)	(0.14)	(0.17)	(0.15)
August	0.8209	1.1203	0.8922	0.9483	0.8793	1.1542	0.7997	1.1445
	(0.16)	(0.12)	(0.14)	(0.12)	(0.15)	(0.12)	(0.16)	(0.13)
September	0.9174	1.2792	1.0268	1.2236	0.9265	1.1401	0.8912	1.2887
	(0.18)	(0.15)	(0.16)	(0.14)	(0.17)	(0.15)	(0.18)	(0.15)
October	0.8295	1.0430	0.9207	1.0293	0.8570	1.1076	0.8346	1.0292
	(0.24)	(0.23)	(0.23)	(0.21)	(0.23)	(0.23)	(0.23)	(0.24)
November	0.6260	0.5715	0.6134	0.5877	0.5948	0.5746	0.6015	0.5974
	(0.25)	(0.23)	(0.24)	(0.21)	(0.24)	(0.23)	(0.25)	(0.24)
December	0.6874	0.8982	0.7535	1.0429	0.6291	0.9344	0.6111	0.9242
	(0.22)	(0.20)	(0.21)	(0.18)	(0.22)	(0.20)	(0.23)	(0.21)
Lagged Basis			0.1906	0.4181	0.1274	0.2721	-0.0716	0.0871
Estimates			(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)
R-Square	0.2911	0.6766	0.4099	0.7325	0.3086	0.6804	0.2551	0.6516
Total R-Square	0.862		0.8617		0.8608		0.8591	
Estimates of Autoregressive Parameters	-0.70933		-0.6215		-0.6909		-0.71336	
Standard Errors are in Parentheses								
N=		315		311		307		303

R-Square values for OLS estimations range from 0.65 for a model with a 12-week lag to 0.73 for the model with a 4-week lag. Unlike results from the Prime cutout reported in the previous section, a model with basis information lagged 12 weeks has less explanatory power than a model that does not include basis information.

Autocorrelation is again noted in Branded beef cash prices as represented by the estimates of autoregressive parameters. Coefficient for AR(1) errors range from 0.6215 to 0.7134.

Figure 5.3 Branded Cutout OLS Hedge Ratio and Standard Error, 8 Week Lag

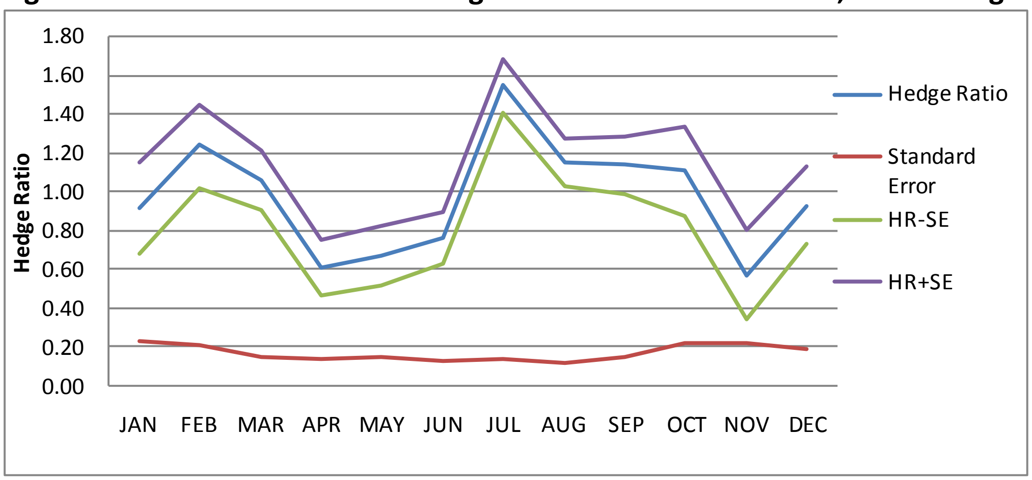
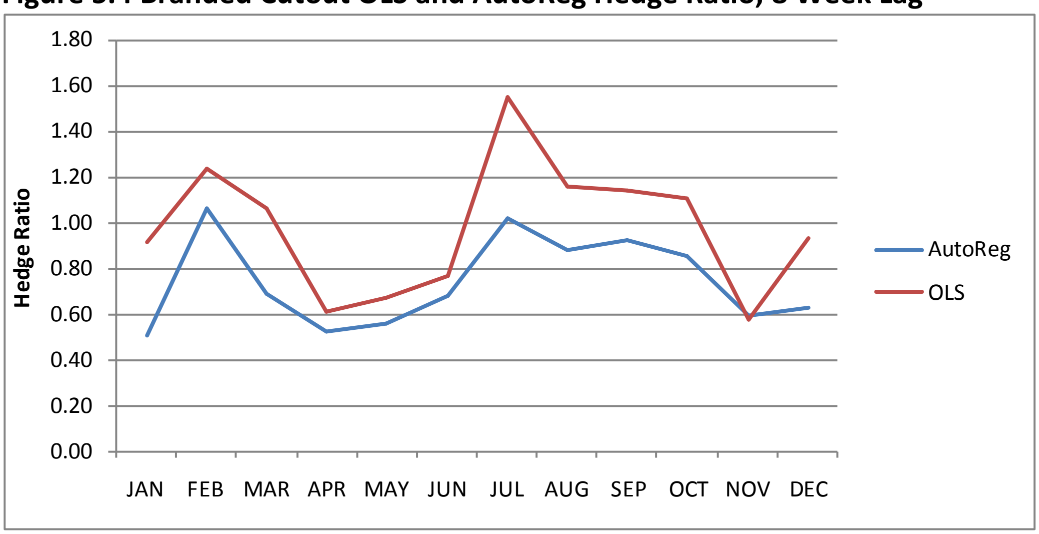


Figure 5.4 Branded Cutout OLS and AutoReg Hedge Ratio, 8 Week Lag



5.1.3 Choice Cutout Hedge Ratios

Table 5.3 reports hedge ratios and standard errors for the Choice cutout. Once again, seasonality and estimation techniques lead to quite different hedge ratios. Visual assessments of these differences can be seen in Figures 5.5 and 5.6.

Table 5.3 Choice Cutout Hedge Ratios, Weekly Data 1/2/2004-1/8/2010

	No Lag		**4-Week Lag**		**8-Week Lag**		**12-Week Lag**	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	0.6909	0.7933	0.7798	0.9012	0.4894	0.7264	0.4297	0.5907
	(0.16)	(0.13)	(0.18)	(0.17)	(0.22)	(0.21)	(0.22)	(0.22)
February	0.9745	1.1038	0.9981	1.1528	1.0597	1.2086	0.9375	1.1084
	(0.15)	(0.12)	(0.14)	(0.11)	(0.19)	(0.20)	(0.26)	(0.26)
March	0.7999	1.0589	0.8656	1.1072	0.8195	1.1001	0.7221	1.0938
	(0.17)	(0.14)	(0.15)	(0.13)	(0.17)	(0.14)	(0.19)	(0.16)
April	0.7070	0.7050	0.7378	0.7525	0.7268	0.7512	0.6800	0.7114
	(0.15)	(0.13)	(0.14)	(0.12)	(0.15)	(0.13)	(0.15)	(0.13)
May	0.6734	0.7458	0.7648	0.8774	0.6811	0.7743	0.6579	0.7521
	(0.17)	(0.14)	(0.16)	(0.13)	(0.17)	(0.14)	(0.17)	(0.14)
June	0.7455	0.7292	0.8210	0.8365	0.7758	0.8032	0.7287	0.7392
	(0.14)	(0.12)	(0.13)	(0.11)	(0.14)	(0.12)	(0.15)	(0.12)
July	1.1028	1.4949	1.2184	1.5848	1.1254	1.5498	1.0723	1.5240
	(0.15)	(0.13)	(0.14)	(0.12)	(0.15)	(0.13)	(0.16)	(0.13)
August	0.8878	1.1454	0.9108	0.9576	0.9210	1.1645	0.8707	1.1565
	(0.14)	(0.11)	(0.13)	(0.10)	(0.14)	(0.11)	(0.14)	(0.11)
September	0.9544	1.2757	1.0227	1.2063	0.9481	1.1613	0.9330	1.2793
	(0.16)	(0.13)	(0.15)	(0.12)	(0.16)	(0.14)	(0.16)	(0.14)
October	0.7858	1.0028	0.8444	0.9689	0.7939	1.0428	0.7767	0.9912
	(0.22)	(0.21)	(0.21)	(0.19)	(0.21)	(0.21)	(0.22)	(0.21)
November	0.6258	0.5637	0.5951	0.5973	0.5895	0.5654	0.5954	0.5774
	(0.23)	(0.21)	(0.22)	(0.19)	(0.23)	(0.21)	(0.23)	(0.21)
December	0.6521	0.7459	0.7064	0.9182	0.5906	0.7994	0.5676	0.7614
	(0.21)	(0.18)	(0.20)	(0.17)	(0.21)	(0.18)	(0.21)	(0.18)
Lagged Basis			0.2331	0.4176	0.1232	0.2194	-0.0348	0.0498
Estimates			(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)
R-Square	0.3674	0.7239	0.4834	0.7702	0.3683	0.7182	0.3216	0.6982
Total R-Square	0.8721		0.8754		0.8701		0.8667	
Estimates of Autoregressive Parameters	-0.68975		-0.61006		-0.682		-0.69757	
Standard Errors are in Parantheses								
N=		315		311		307		303

Figure 5.5 Choice Cutout OLS Hedge Ratio and Standard Error, 8 Week Lag

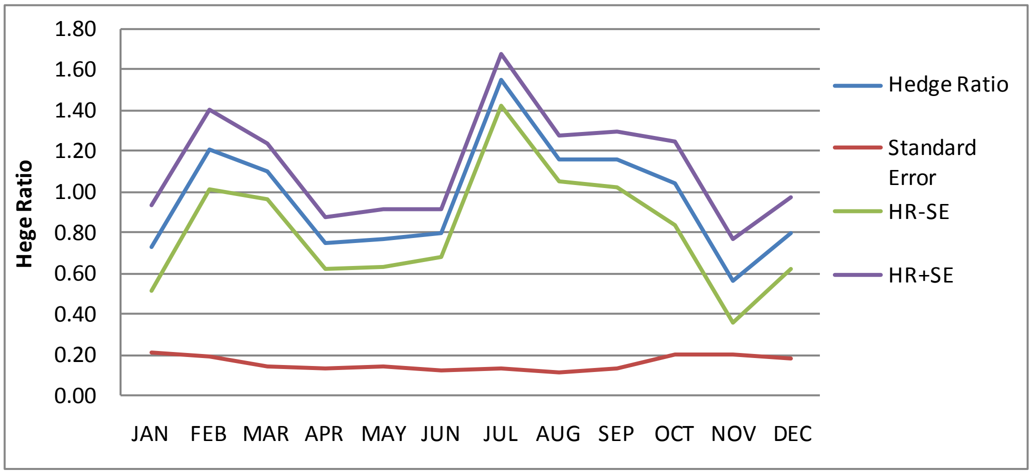
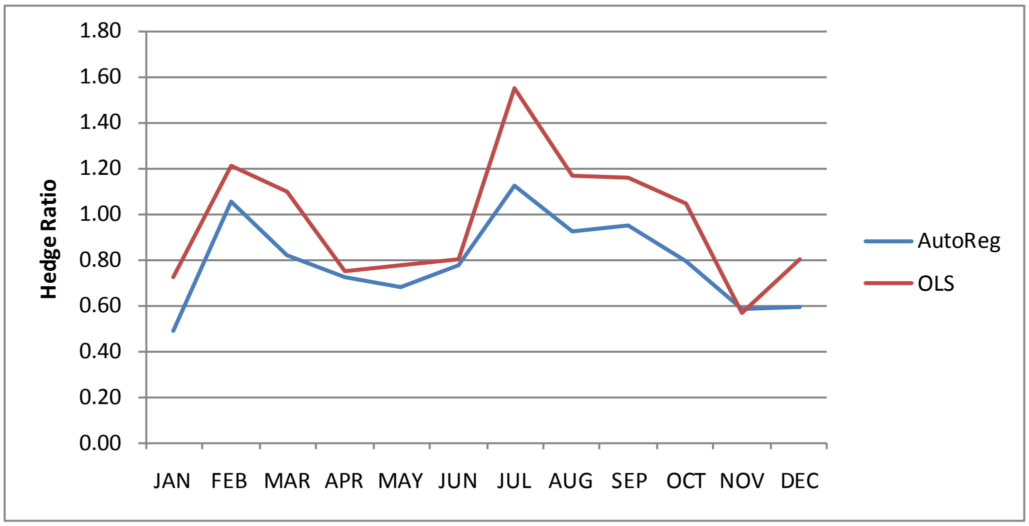


Figure 5.6 Choice Cutout OLS and AutoReg Hedge Ratio, 8 Week Lag



OLS estimations provide R-Square statistics ranging from 0.70 for a model including 12-week lagged basis information to 0.77 for a model with 4-week lagged basis information. For the Choice cutout, models with 8 and 12-week basis lags provide less explanatory power than a model with no lagged basis information.

Autoregressive parameter estimates range from 0.61 to 0.70, a result which is consistent with the other quality grades discussed.

5.1.4 Select Cutout Hedge Ratios

Table 5.4 shows hedge ratios and standard errors for the Select cutout. Similar to other quality grades, Select cutout hedge ratios exhibit strong seasonal differences. Discrepancies between the OLS and AutoReg techniques are evident.

Table 5.4 Select Cutout Hedge Ratios, Weekly Data 1/2/2004-1/8/2010

	No Lag		**4-Week Lag**		**8-Week Lag**		**12-Week Lag**	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	0.4938	0.4991	0.4409	0.5020	0.2108	0.3108	0.0971	0.1569
	(0.15)	(0.12)	(0.17)	(0.16)	(0.20)	(0.20)	(0.20)	(0.20)
February	0.844	0.9939	0.8625	1.1158	0.9822	1.1334	0.7983	0.9572
	(0.14)	(0.12)	(0.13)	(0.11)	(0.17)	(0.19)	(0.24)	(0.24)
March	0.6965	0.9844	0.7653	1.0596	0.7435	1.0832	0.7684	1.1464
	(0.15)	(0.13)	(0.14)	(0.12)	(0.15)	(0.13)	(0.17)	(0.15)
April	0.7409	0.9976	0.8085	0.9741	0.7750	1.0226	0.7701	1.0325
	(0.14)	(0.12)	(0.13)	(0.11)	(0.13)	(0.12)	(0.14)	(0.12)
May	0.8815	1.2049	0.9885	1.2030	0.8883	1.1777	0.8937	1.2039
	(0.16)	(0.13)	(0.15)	(0.12)	(0.15)	(0.13)	(0.15)	(0.13)
June	0.8205	1.0023	0.8973	0.9748	0.8405	1.0069	0.8430	0.9979
	(0.14)	(0.11)	(0.12)	(0.10)	(0.13)	(0.11)	(0.13)	(0.11)
July	1.0871	1.5191	1.1998	1.5302	1.1040	1.4803	1.1266	1.5436
	(0.14)	(0.12)	(0.13)	(0.11)	(0.14)	(0.12)	(0.14)	(0.12)
August	0.8845	1.2067	0.9334	1.0524	0.9325	1.2151	0.8965	1.1815
	(0.13)	(0.10)	(0.12)	(0.10)	(0.13)	(0.10)	(0.13)	(0.10)
September	0.9409	1.2642	1.0040	1.2024	0.9546	1.1793	0.9600	1.2816
	(0.15)	(0.13)	(0.14)	(0.12)	(0.14)	(0.12)	(0.15)	(0.12)
October	0.7253	0.6698	0.7488	0.6812	0.7446	0.7000	0.7019	0.6143
	(0.20)	(0.20)	(0.19)	(0.18)	(0.20)	(0.19)	(0.20)	(0.19)
November	0.5652	0.2359	0.5352	0.4485	0.5282	0.3032	0.5078	0.2787
	(0.21)	(0.20)	(0.20)	(0.18)	(0.21)	(0.19)	(0.21)	(0.19)
December	0.5940	0.4972	0.6066	0.7971	0.5077	0.6807	0.4822	0.6274
	(0.19)	(0.17)	(0.18)	(0.16)	(0.19)	(0.17)	(0.19)	(0.17)
Lagged Basis			0.1720	0.3729	0.1499	0.2657	0.0921	0.2171
Estimates			(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)
R-Square	0.3651	0.7460	0.4761	0.7844	0.3951	0.7588	0.3625	0.7495
Total R-Square	0.8852		0.8882		0.8886		0.8854	
Estimates of Autoregressive Parameters	-0.70062		-0.62872		-0.68577		-0.69026	
Standard Errors are in Parantheses								
N=		315		311		307		303

Figures 5.7 and 5.8 illustrate the seasonality of Select cutout cross-hedges and differences between OLS and AutoReg estimates, respectively. In Figure 5.8, the AutoReg

hedge ratio is larger than the OLS hedge ratio in October and November. From July to November, the OLS hedge ratio decreases from 1.48 to 0.30. The AutoReg hedge ratio decreases in this time period as well, but in a much less dramatic fashion. This may suggest that the AutoReg hedge ratio would lead hedgers to take out too many futures positions late in the year for Select wholesale product.

Figure 5.7 Select Cutout OLS Hedge Ratio and Standard Error-8 Week Lag

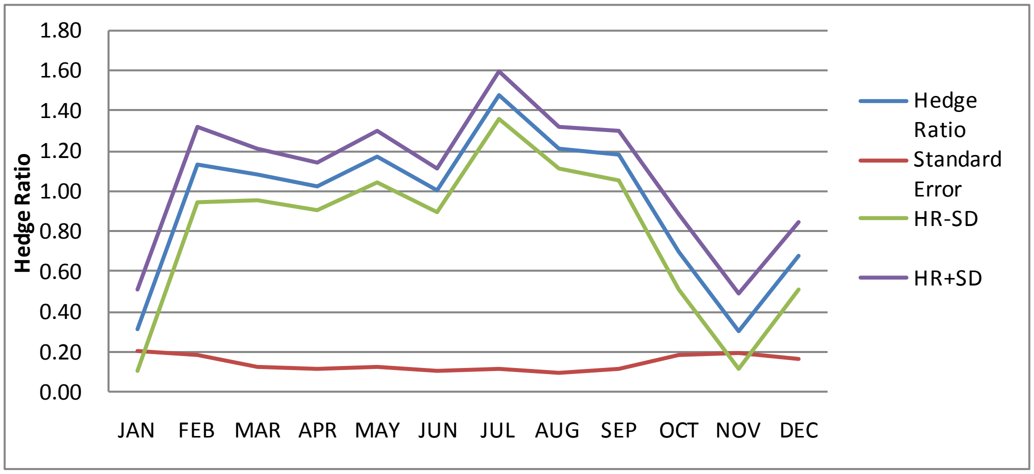
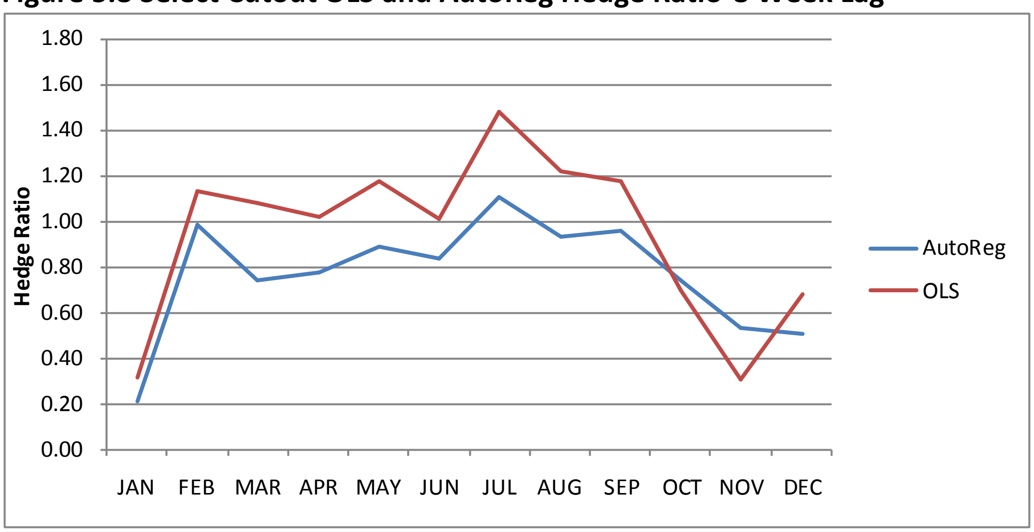


Figure 5.8 Select Cutout OLS and AutoReg Hedge Ratio-8 Week Lag



R-Square statistics for Select cutout cross hedges range from 0.75 to 0.78. The lowest R-Square statistic comes from model without lagged basis variable. The highest R-Square is associated with the model that includes 4-week lagged basis information. Unlike Branded or Choice quality grade models, 8 and 12-week lagged basis information is preferable to models that exclude basis information. Coefficients of autocorrelation range from 0.63 to 0.70

5.1.5 Calculating Basis Using Deferred Rather than Nearby Futures Prices

The analysis presented in this study used nearby basis information to formulate the lagged basis variable. This is the case even when the contract of interest is deferred. For example, if a hedge is placed in January to be lifted in March, the basis used to calculate the 8-week lagged basis variable was January Cash minus February (the nearby) futures despite the fact that the nearby contract in March would be April. This method is consistent with previous research. To determine how sensitive results are to using deferred instead of nearby basis, a deferred futures price series is constructed and employed in a Choice 8-week lagged basis model. Hedge ratios from the Choice cutout 8-week lagged basis model using nearby basis information and deferred basis information were compared to determine what impact, if any, basis specification has on results.

Hedge ratios calculated with lagged deferred basis information were between 4 percent lower and 8 percent higher than hedge ratios calculated with lagged nearby basis information. In December, January, and February, hedge ratios differed by greater than 1 percent. For the remaining months, hedge ratios varied by less than 1 percent. R-Square and RMSE values were also virtually identical.

Little difference exists between hedge ratios calculated using lagged nearby basis information and those calculated using lagged deferred basis information. Therefore, results reported in this study are from models that utilize lagged nearby basis information.

5.1.6 Comparisons between Quality Grades

Comparing hedge ratios by quality grade provides insight into seasonal differences and the variation of hedge ratios between grades. Hedge ratios for Branded and Choice graded beef tend to mirror one-another which is intuitive given the high level of correlation between their prices (Table 4.2). On average, Prime and Select quality grade hedge ratios can depart dramatically from Branded and Choice grade hedge ratios. On Average, prime hedge ratios are the highest and Select hedge ratios are the lowest, but the ranking of quality grades by hedge ratios can differ a great deal throughout the year. For example in April, May, and June, the Select hedge ratio is larger than the Prime hedge ratio. Figures 5.9-5.12 illustrate hedge ratios for Prime, Branded, Choice and Select quality grades.

Figure 5.9 Prime, Branded, Choice, and Select OLS Hedge Ratios, No Lag

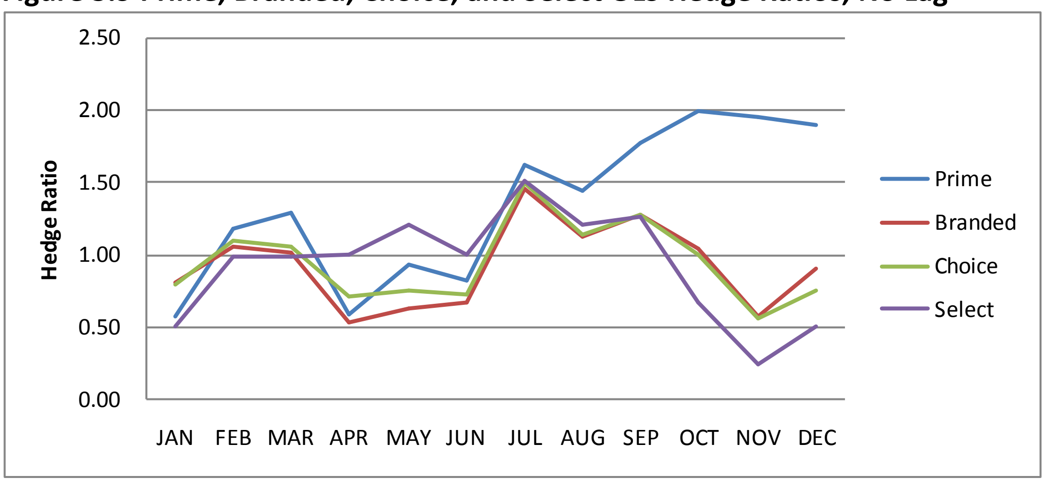


Figure 5.10 Prime, Branded, Choice, and Select OLS Hedge Ratios, 4-Week Lag

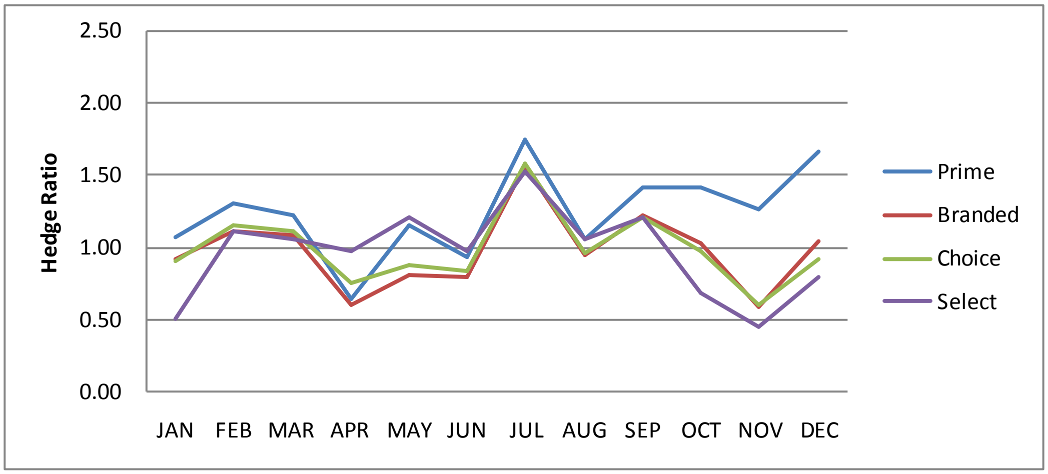


Figure 5.11 Prime, Branded, Choice, and Select OLS Hedge Ratios, 8-Week Lag

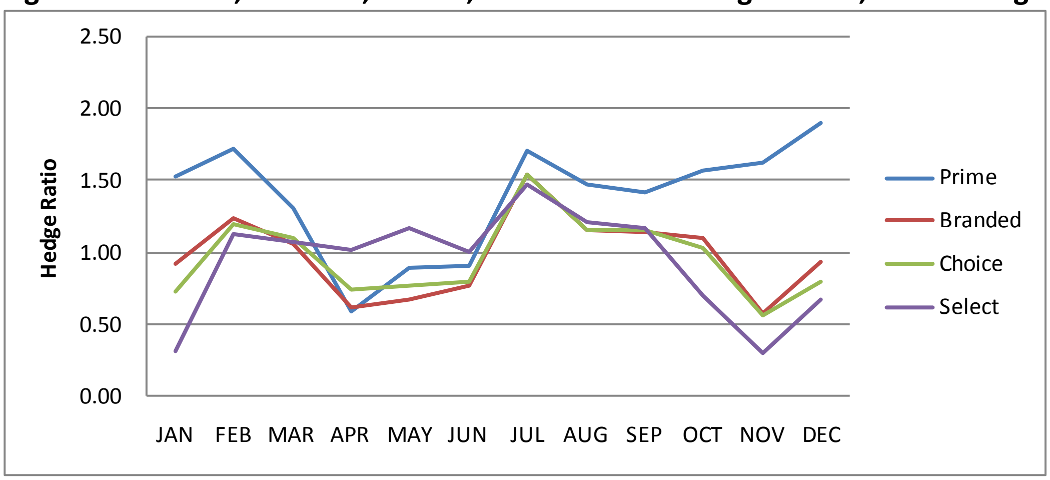
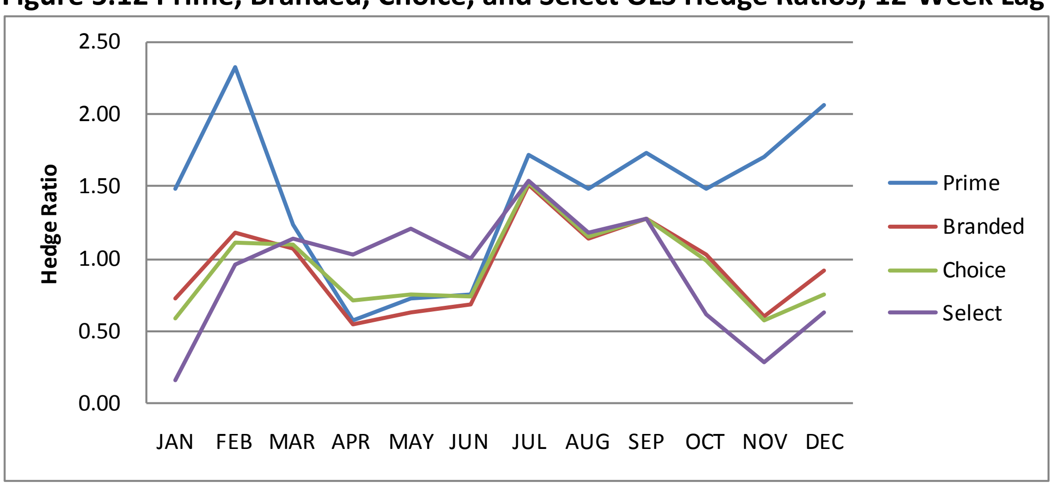


Figure 5.12 Prime, Branded, Choice, and Select OLS Hedge Ratios, 12-Week Lag



5.2 Primal Level Cross-Hedge Analysis

Primal cross-hedging ratios are constructed by regressing primal cut prices on Live Cattle futures prices. Hedge ratios for Choice and Select Ribs, Chucks, Rounds, Loins, Briskets, Short Plates, and Flanks are reported. A model without lagged basis information and a model with 8-week lagged basis information are provided. A model with 8-week lagged basis data enhances hedge ratios and represents a hedging horizon that would be likely for a decision maker interested in offering forward pricing. Therefore 4 and 12-week lagged basis models are omitted from this section.

5.2.1 Choice Primal Hedge Ratios

Tables 5.5 and 5.6 contain hedge ratios for seven Choice quality grade primal cuts. In Table 5.5, a regression of cash primal prices on futures prices with no basis information is used to calculate the hedge ratios. OLS R-Square statistics vary from 0.28 for Briskets to 0.67 for Rounds. None of the models estimated for primal level hedge ratios perform as well as the Choice cutout model reported in the previous section which has an R-Square value of 0.72.

Autocorrelation is evident in primal level models, particularly for Briskets, Short Plates, Flanks, and Chucks, with AR(1) coefficient estimates of 0.93, 0.88, 0.86 and 0.86, respectively.

Table 5.6 is reports hedge ratios conditioned by 8-week lagged basis information. OLS R-Square statistics are higher for this set of hedge ratios than those reported in Table 5.5 with the exception of Ribs. The OLS R-Square statistics for this set of models ranges from 0.44 for Flanks to 0.74 for Rounds. For the 8-week lagged models, regressions for Chucks, Rounds, Loins, and Short Plates have R-Square statistics similar to or slightly better than a similar model constructed for the Choice cutout which resulted in an OLS R-Square statistic of 0.72.

Table 5.5 Choice Primal Hedge Ratios-No Lagged Basis

	Choice Rib		Choice Chuck		ChoiceRound		Choice Loin		Choice Brisket		Choice S. Plate		Choice Flank	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	1.0449	1.1759	0.3310	0.1957	0.6175	0.5473	1.1390	2.0962	0.2060	-0.3240	0.4134	0.4134	0.3045	0.1853
	(0.45)	(0.37)	(0.18)	(0.20)	(0.18)	(0.17)	(0.38)	(0.48)	(0.16)	(0.24)	(0.20)	(0.25)	(0.20)	(0.22)
February	1.4604	1.6748	0.6341	1.0858	0.9966	1.0308	1.2189	1.1397	0.1776	0.0537	0.4594	1.1245	0.3691	0.5634
	(0.41)	(0.34)	(0.16)	(0.19)	(0.16)	(0.16)	(0.33)	(0.45)	(0.14)	(0.22)	(0.18)	(0.23)	(0.17)	(0.20)
March	1.3345	1.3638	0.4095	0.8673	0.8377	1.2244	0.9265	1.3154	0.0086	0.1586	0.2109	0.7076	0.2328	0.6793
	(0.46)	(0.38)	(0.18)	(0.21)	(0.18)	(0.18)	(0.38)	(0.50)	(0.16)	(0.25)	(0.20)	(0.26)	(0.20)	(0.23)
April	0.7866	0.3910	0.4521	0.9230	0.9015	0.9338	0.7148	0.1483	0.1447	0.6337	0.3143	1.0705	0.3002	0.8456
	(0.42)	(0.36)	(0.16)	(0.19)	(0.16)	(0.17)	(0.34)	(0.46)	(0.14)	(0.23)	(0.18)	(0.24)	(0.18)	(0.21)
May	0.5103	0.4878	0.5983	1.2273	0.8445	1.1316	0.5858	-0.2937	0.0471	0.4400	0.1377	1.0576	0.0655	0.9726
	(0.47)	(0.39)	(0.18)	(0.21)	(0.19)	(0.18)	(0.39)	(0.51)	(0.16)	(0.25)	(0.20)	(0.26)	(0.20)	(0.23)
June	0.9621	0.9812	0.5569	0.8145	0.7435	0.9332	0.7509	0.3351	0.0683	0.2117	0.2846	0.8175	0.1737	0.6624
	(0.40)	(0.33)	(0.16)	(0.18)	(0.16)	(0.15)	(0.34)	(0.43)	(0.14)	(0.21)	(0.18)	(0.22)	(0.18)	(0.19)
July	1.3609	1.8953	0.7390	1.4487	0.9916	1.5628	1.1694	1.4021	0.2786	0.9960	0.3170	1.3169	0.3251	1.1138
	(0.43)	(0.35)	(0.17)	(0.19)	(0.17)	(0.17)	(0.36)	(0.46)	(0.15)	(0.23)	(0.19)	(0.24)	(0.19)	(0.21)
August	0.8982	0.9726	0.6859	1.4264	0.7148	1.0867	0.6689	0.7601	0.1205	1.0095	0.3758	1.5736	0.1483	0.8374
	(0.40)	(0.31)	(0.16)	(0.17)	(0.16)	(0.14)	(0.00)	(0.40)	(0.14)	(0.20)	(0.18)	(0.21)	(0.18)	(0.18)
September	0.8352	1.2398	0.7655	1.5802	0.6272	0.8122	0.6745	1.0150	0.2546	1.2716	0.5039	1.9553	0.2251	0.8247
	(0.45)	(0.37)	(0.18)	(0.20)	(0.18)	(0.17)	(0.38)	(0.48)	(0.16)	(0.24)	(0.20)	(0.25)	(0.20)	(0.22)
October	0.8083	1.7912	0.6849	1.0491	0.4707	0.1356	0.4754	1.4013	0.3000	0.7466	0.5019	1.6749	0.1528	-0.1923
	(0.61)	(0.57)	(0.22)	(0.31)	(0.23)	(0.27)	(0.47)	(0.75)	(0.19)	(0.37)	(0.25)	(0.39)	(0.25)	(0.34)
November	0.3781	0.7751	0.6197	-0.0930	0.5283	0.0042	0.7169	2.0251	0.3177	0.2855	0.4160	0.7440	0.0970	0.0290
	(0.64)	(0.58)	(0.23)	(0.31)	(0.24)	(0.27)	(0.48)	(0.75)	(0.20)	(0.37)	(0.25)	(0.39)	(0.25)	(0.34)
December	0.3409	0.8140	0.5471	-0.1487	0.7827	0.7534	0.8156	2.7335	0.3023	-0.0673	0.2087	-0.2760	0.0335	-0.1782
	(0.58)	(0.50)	(0.21)	(0.27)	(0.22)	(0.23)	(0.44)	(0.65)	(0.18)	(0.32)	(0.23)	(0.34)	(0.23)	(0.30)
R-Square	0.1941	0.5116	0.2065	0.5810	0.3121	0.6694	0.1517	0.5771	0.0641	0.2834	0.0849	0.5168	0.0634	0.4357
Total R-Square	0.7638		0.9201		0.9086		0.939		0.9294		0.9296		0.8904	
Estimates of Autoregressive Parameters	-0.67453		-0.85721		-0.80721		-0.87913		-0.92718		-0.88451		-0.8629	

Standard Errors are in Parentheses

N=315

Table 5.6 Choice Primal Hedge Ratios-8 Week Lagged Basis

	Choice Rib		Choice Chuck		Choice Round		Choice Loin		Choice Brisket		Choice S. Plate		Choice Flank	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	1.1188	2.0537	-0.1900	-0.5486	0.3832	0.3510	1.1011	2.9082	0.0923	0.5193	0.4283	0.8189	0.1788	0.0382
	(0.62)	(0.59)	(0.23)	(0.26)	(0.24)	(0.25)	(0.50)	(0.62)	(0.22)	(0.30)	(0.27)	(0.31)	(0.25)	(0.36)
February	1.4839	1.8199	1.0047	1.3546	1.1574	1.4927	1.1015	1.0651	0.2871	0.5331	0.8570	1.4399	0.3745	0.8245
	(0.52)	(0.54)	(0.20)	(0.24)	(0.20)	(0.24)	(0.43)	(0.57)	(0.19)	(0.27)	(0.23)	(0.28)	(0.22)	(0.33)
March	1.3409	1.4015	0.6741	1.0863	0.9753	1.4064	0.6611	0.7917	0.1545	0.9615	0.5326	1.0893	0.2414	0.8218
	(0.47)	(0.38)	(0.18)	(0.17)	(0.18)	(0.16)	(0.40)	(0.40)	(0.18)	(0.20)	(0.21)	(0.20)	(0.21)	(0.23)
April	0.7909	0.4163	0.6901	0.8883	0.9698	0.8349	0.5512	0.6318	0.3568	1.4208	0.6598	1.3042	0.3180	0.9220
	(0.41)	(0.36)	(0.16)	(0.15)	(0.16)	(0.15)	(0.35)	(0.37)	(0.15)	(0.18)	(0.18)	(0.18)	(0.18)	(0.21)
May	0.5018	0.4725	0.8728	1.3318	0.9472	1.0537	0.3934	-0.0212	0.2328	0.8878	0.5131	1.1208	0.0863	0.9306
	(0.47)	(0.39)	(0.18)	(0.17)	(0.18)	(0.16)	(0.39)	(0.40)	(0.17)	(0.19)	(0.21)	(0.20)	(0.21)	(0.23)
June	0.9768	1.0469	0.8012	0.9161	0.8736	0.9583	0.7592	0.8410	0.2739	0.6677	0.6205	0.8317	0.1953	0.6296
	(0.40)	(0.33)	(0.15)	(0.14)	(0.15)	(0.14)	(0.34)	(0.34)	(0.15)	(0.16)	(0.18)	(0.17)	(0.18)	(0.19)
July	1.3624	1.9165	1.0280	1.4035	1.1616	1.5676	1.3156	2.1220	0.5249	1.2148	0.7210	1.3321	0.3473	1.1302
	(0.42)	(0.35)	(0.16)	(0.15)	(0.16)	(0.15)	(0.36)	(0.37)	(0.16)	(0.17)	(0.19)	(0.18)	(0.19)	(0.21)
August	0.8980	0.9297	1.0434	1.4725	0.8736	1.0926	0.7736	0.9889	0.4790	1.3389	0.8789	1.5468	0.1738	0.9294
	(0.39)	(0.31)	(0.15)	(0.13)	(0.15)	(0.13)	(0.34)	(0.32)	(0.15)	(0.15)	(0.18)	(0.16)	(0.18)	(0.18)
September	0.8145	1.1233	1.0891	1.4364	0.7146	0.6472	0.7830	0.6378	0.5993	1.2696	1.0205	1.6524	0.2350	0.7637
	(0.45)	(0.37)	(0.17)	(0.16)	(0.17)	(0.15)	(0.38)	(0.38)	(0.17)	(0.18)	(0.20)	(0.19)	(0.20)	(0.22)
October	0.8080	1.8329	0.9019	1.0495	0.4780	0.2796	0.7062	1.6333	0.6157	1.2210	0.9724	1.5532	0.1598	-0.1053
	(0.61)	(0.57)	(0.22)	(0.25)	(0.23)	(0.24)	(0.49)	(0.60)	(0.21)	(0.28)	(0.26)	(0.29)	(0.25)	(0.34)
November	0.3505	0.6613	0.4866	0.0065	0.4442	0.3356	0.7932	1.6132	0.3896	0.6154	0.5684	0.6827	0.0721	0.2132
	(0.64)	(0.58)	(0.24)	(0.25)	(0.24)	(0.24)	(0.52)	(0.60)	(0.22)	(0.28)	(0.27)	(0.30)	(0.26)	(0.34)
December	0.3415	0.7237	0.3090	0.3701	0.7143	1.0627	0.9269	1.7296	0.3204	0.9297	0.2652	0.4245	-0.0085	0.1223
	(0.58)	(0.50)	(0.22)	(0.22)	(0.22)	(0.21)	(0.48)	(0.53)	(0.21)	(0.25)	(0.25)	(0.26)	(0.24)	(0.31)
Lagged Basis	0.0463	0.1127	0.1893	0.4931	0.1169	0.4488	0.3027	0.6048	0.1715	0.7007	0.2654	0.6473	0.0346	0.2016
Estimates	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)	(0.06)
R-Square	0.1856	0.4848	0.3648	0.7267	0.4259	0.7421	0.3026	0.7350	0.1277	0.5981	0.251	0.7093	0.0614	0.4417
Total R-Square	0.7514		0.9106		0.9015		0.9293		0.9132		0.9113		0.8877	
Estimates of Autoregressive Parameters	-0.67072		-0.72429		-0.68813		-0.77119		-0.79617		-0.75441		-0.85306	

Standard Errors are in Parantheses

N=307

In both models, seasonal differences and discrepancies between OLS and Autoregressive estimation techniques are pronounced. Hedge ratios differ significantly between primal cuts as well. Figures 5.13 and 5.14 illustrate the differences in hedge ratios for primals throughout the year. The cutout hedge ratio is included to illustrate the relationship between the primals and the cutout.

Figure 5.13 All Choice Primal Hedge Ratios-No Lagged Basis

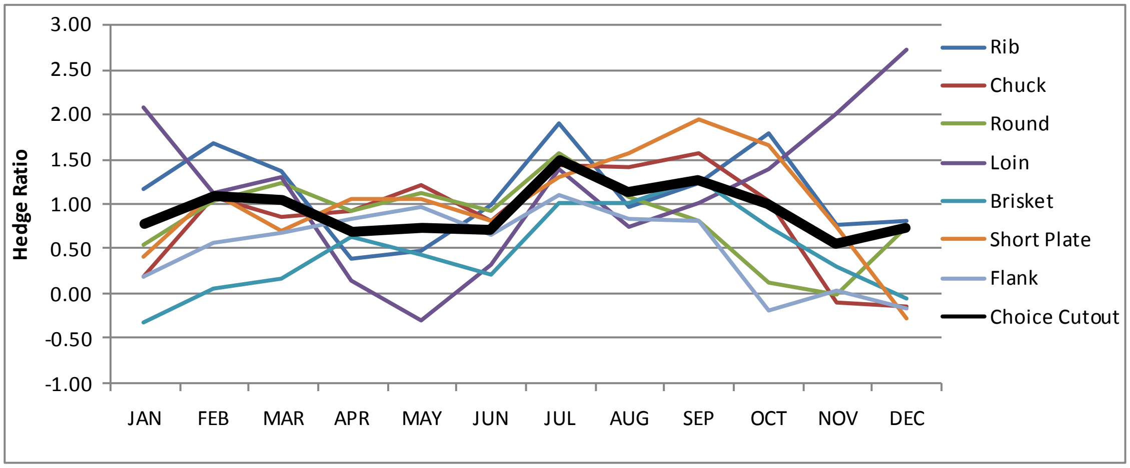
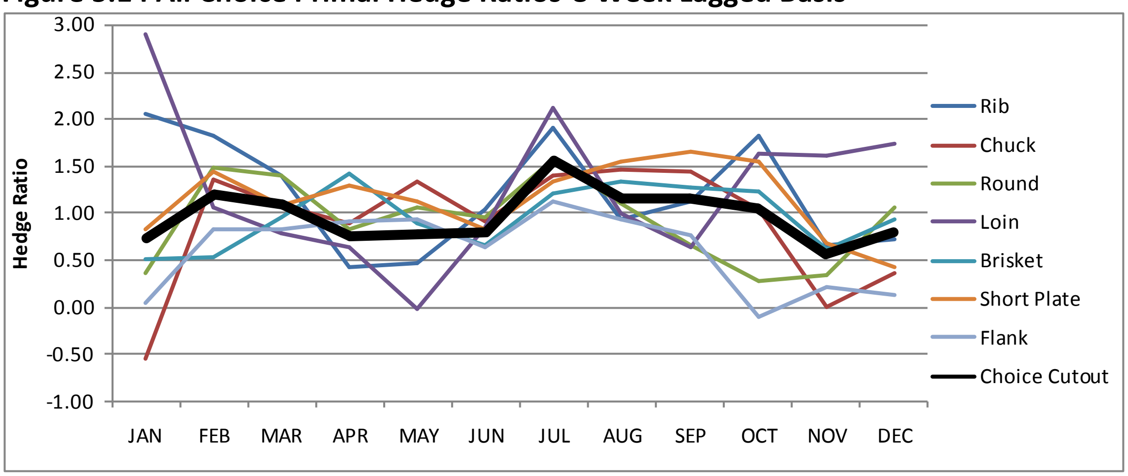


Figure 5.14 All Choice Primal Hedge Ratios-8 Week Lagged Basis



5.2.2 Select Primal Hedge Ratios

Hedge ratios are calculated and reported in Tables 5.7 and 5.8 for Select grade primal cuts. Table 5.7 includes hedge ratios for models estimated with no lagged basis information.

OLS R-Square statistics for these models range from 0.27 for Briskets to 0.76 for Loins. The R-Square for the Select cutout reported in section 5.1.4 is 0.75.

Like the corresponding Choice primal model, autocorrelation is evident. Briskets (0.93), Short Plates (0.88), Flanks (0.88), and Chucks (0.86) exhibit the highest degree of autocorrelation.

Hedge ratios estimated with 8-week lagged basis information are presented in Table 5.8. OLS R-Square values for this method are lowest for Flanks (0.43) and highest for Loins (0.80). The R-Square statistic for the Select cutout model reported in 5.1.4 is 0.76. For the Chuck, Round, Brisket, and Short Plate, goodness of fit statistics are improved substantially by the inclusion of conditioning basis information. Once again, hedge ratios vary widely based on seasonality, estimation technique and primal cut. Figures 5.15 and 5.16 illustrate the differences in hedge ratios for primal cuts throughout the year.

Table 5.7 Select Primal Hedge Ratios, No Lagged Basis

	Select Rib		Select Chuck		Select Round		Select Loin		Select Brisket		Select S. Plate		Select Flank	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	0.6241	0.4677	0.3119	0.0950	0.5634	0.6501	0.7622	1.1135	0.0852	-0.2754	0.4134	0.4134	0.3531	0.1672
	(0.32)	(0.26)	(0.18)	(0.20)	(0.18)	(0.17)	(0.27)	(0.25)	(0.15)	(0.23)	(0.20)	(0.25)	(0.17)	(0.20)
February	1.0607	1.3161	0.6905	1.0283	1.0017	1.1833	0.7288	0.6739	0.2746	0.2060	0.4594	1.1245	0.4105	0.7011
	(0.29)	(0.24)	(0.16)	(0.19)	(0.16)	(0.16)	(0.25)	(0.23)	(0.13)	(0.22)	(0.18)	(0.23)	(0.15)	(0.18)
March	0.9139	1.2343	0.4101	0.8246	0.8005	1.1650	0.5324	1.1148	0.1661	0.2706	0.2109	0.7076	0.2370	0.7949
	(0.33)	(0.28)	(0.18)	(0.21)	(0.19)	(0.18)	(0.28)	(0.26)	(0.14)	(0.25)	(0.20)	(0.26)	(0.17)	(0.21)
April	0.7676	0.8913	0.4188	0.9055	0.7946	1.0771	0.7001	1.1405	0.1081	0.6267	0.3142	1.0705	0.2528	0.8767
	(0.29)	(0.26)	(0.16)	(0.20)	(0.17)	(0.17)	(0.25)	(0.24)	(0.13)	(0.23)	(0.18)	(0.24)	(0.15)	(0.19)
May	1.0163	1.3097	0.5732	1.2126	0.8900	1.3909	0.7739	1.1900	0.0926	0.4283	0.1374	1.0576	0.0669	0.9531
	(0.33)	(0.28)	(0.19)	(0.21)	(0.19)	(0.19)	(0.29)	(0.26)	(0.15)	(0.25)	(0.20)	(0.26)	(0.17)	(0.21)
June	1.1554	1.4094	0.5068	0.8179	0.7103	1.0161	0.7603	1.3233	0.0140	0.2100	0.2842	0.8174	0.1252	0.5632
	(0.28)	(0.23)	(0.16)	(0.18)	(0.16)	(0.16)	(0.25)	(0.22)	(0.13)	(0.21)	(0.18)	(0.22)	(0.15)	(0.18)
July	1.4306	1.8745	0.6810	1.4124	0.9711	1.6222	1.0460	1.6389	0.2015	0.9521	0.3165	1.3169	0.2363	0.6376
	(0.30)	(0.25)	(0.17)	(0.19)	(0.17)	(0.17)	(0.26)	(0.24)	(0.14)	(0.23)	(0.19)	(0.24)	(0.16)	(0.19)
August	1.0391	1.2667	0.6398	1.3783	0.7645	1.1581	0.6771	0.9513	0.0801	0.9531	0.3757	1.5738	0.1323	0.5515
	(0.28)	(0.22)	(0.17)	(0.17)	(0.17)	(0.15)	(0.25)	(0.21)	(0.13)	(0.20)	(0.18)	(0.21)	(0.15)	(0.17)
September	1.1544	1.6340	0.7798	1.5464	0.7582	0.9046	0.7281	0.8467	0.3053	1.2866	0.5038	1.9553	0.2648	0.6027
	(0.32)	(0.26)	(0.18)	(0.20)	(0.19)	(0.18)	(0.28)	(0.25)	(0.15)	(0.24)	(0.20)	(0.25)	(0.17)	(0.20)
October	0.5746	0.7030	0.6941	0.9577	0.5846	0.2069	0.7303	0.4927	0.3271	0.6429	0.5019	1.6749	0.1315	-0.2669
	(0.43)	(0.41)	(0.23)	(0.31)	(0.24)	(0.27)	(0.36)	(0.39)	(0.18)	(0.37)	(0.25)	(0.39)	(0.21)	(0.31)
November	0.5071	0.1030	0.6052	-0.1660	0.5281	-0.0522	0.8995	1.0209	0.3837	0.2509	0.4160	0.7440	0.2853	-0.0867
	(0.45)	(0.41)	(0.23)	(0.32)	(0.25)	(0.28)	(0.38)	(0.39)	(0.18)	(0.37)	(0.25)	(0.39)	(0.21)	(0.31)
December	0.2678	0.5416	0.6201	-0.0872	0.6584	0.5754	1.1277	1.7611	0.3768	-0.1056	0.2087	-0.2760	0.3137	0.0714
	(0.40)	(0.36)	(0.21)	(0.27)	(0.22)	(0.24)	(0.34)	(0.34)	(0.17)	(0.32)	(0.23)	(0.34)	(0.19)	(0.27)
R-Square	0.2394	0.5975	0.2057	0.563	0.3043	0.6886	0.3059	0.7607	0.1063	0.2712	0.0849	0.5167	0.0782	0.4008
Total R-Square	0.8162		0.9167		0.9131		0.9172		0.9372		0.9296		0.9008	
Estimates of Autoregressive Parameters	-0.6956		-0.86007		-0.80684		-0.75515		-0.93337		-0.88451		-0.87629	

Standard Errors are in Parantheses
N=315

Table 5.8 Select Primal Hedge Ratios, 8-Week Lagged Basis

	Select Rib		Select Chuck		Select Round		Select Loin		Select Brisket		Select S. Plate		Select Flank	
	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS	AutoReg	OLS
January	0.5222	1.2004	-0.2458	-0.5912	0.2806	0.3434	0.6800	1.8922	0.0303	0.4100	0.4284	0.8189	0.1488	0.0808
	(0.43)	(0.42)	(0.23)	(0.27)	(0.24)	(0.25)	(0.36)	(0.36)	(0.21)	(0.29)	(0.27)	(0.31)	(0.21)	(0.32)
February	1.2269	1.7087	1.0364	1.3383	1.2109	1.5279	0.7160	1.1221	0.3299	0.6819	0.8570	1.4399	0.4562	0.9931
	(0.37)	(0.38)	(0.20)	(0.25)	(0.20)	(0.23)	(0.30)	(0.33)	(0.18)	(0.26)	(0.23)	(0.28)	(0.19)	(0.29)
March	0.9620	1.2730	0.6614	1.0703	0.9768	1.2962	0.5222	1.1393	0.2890	0.9400	0.5326	1.0893	0.2540	0.9712
	(0.33)	(0.27)	(0.18)	(0.17)	(0.18)	(0.16)	(0.28)	(0.24)	(0.17)	(0.19)	(0.21)	(0.20)	(0.18)	(0.20)
April	0.7776	0.8826	0.6532	0.8822	0.9273	0.9435	0.7878	1.3162	0.3009	1.2882	0.6598	1.3042	0.2820	0.9646
	(0.29)	(0.25)	(0.16)	(0.16)	(0.16)	(0.15)	(0.24)	(0.22)	(0.15)	(0.17)	(0.18)	(0.18)	(0.15)	(0.19)
May	0.9975	1.2623	0.8547	1.3151	1.0638	1.2863	0.7851	1.0718	0.2789	0.8415	0.5130	1.1208	0.0852	0.8635
	(0.33)	(0.28)	(0.18)	(0.17)	(0.18)	(0.16)	(0.27)	(0.24)	(0.16)	(0.19)	(0.21)	(0.20)	(0.17)	(0.20)
June	1.1374	1.3940	0.7650	0.9333	0.9043	0.9960	0.8177	1.2562	0.2273	0.6508	0.6203	0.8316	0.1451	0.5030
	(0.28)	(0.23)	(0.15)	(0.14)	(0.15)	(0.13)	(0.23)	(0.20)	(0.14)	(0.16)	(0.18)	(0.17)	(0.15)	(0.17)
July	1.4085	1.8427	0.9813	1.4057	1.1937	1.5411	1.1223	1.5272	0.4747	1.2110	0.7208	1.3321	0.2462	0.6424
	(0.30)	(0.25)	(0.16)	(0.16)	(0.16)	(0.14)	(0.25)	(0.22)	(0.15)	(0.17)	(0.00)	(0.18)	(0.00)	(0.18)
August	1.0268	1.2460	0.9966	1.4456	0.9612	1.1584	0.7732	0.9491	0.4311	1.2692	0.8790	1.5469	0.1660	0.7017
	(0.28)	(0.22)	(0.15)	(0.14)	(0.15)	(0.12)	(0.23)	(0.19)	(0.14)	(0.15)	(0.18)	(0.16)	(0.15)	(0.16)
September	1.1286	1.5913	1.0834	1.4266	0.8285	0.6796	0.7581	0.7684	0.6356	1.3165	1.0206	1.6524	0.2867	0.6850
	(0.31)	(0.26)	(0.17)	(0.16)	(0.17)	(0.15)	(0.26)	(0.23)	(0.16)	(0.17)	(0.20)	(0.19)	(0.17)	(0.19)
October	0.5499	0.6887	0.8938	0.9903	0.5790	0.3231	0.7645	0.5398	0.5901	1.1209	0.9725	1.5530	0.1497	-0.0492
	(0.42)	(0.41)	(0.23)	(0.25)	(0.23)	(0.23)	(0.35)	(0.35)	(0.20)	(0.27)	(0.26)	(0.29)	(0.21)	(0.30)
November	0.4673	0.0604	0.4595	-0.0406	0.4557	0.3661	0.8586	1.0459	0.4494	0.6382	0.5685	0.6827	0.2471	0.1453
	(0.44)	(0.41)	(0.24)	(0.25)	(0.25)	(0.24)	(0.37)	(0.35)	(0.21)	(0.27)	(0.27)	(0.30)	(0.22)	(0.31)
December	0.1995	0.5679	0.3435	0.4166	0.5818	0.9613	1.1032	1.7193	0.3951	0.9317	0.2652	0.4245	0.2408	0.3944
	(0.41)	(0.35)	(0.22)	(0.23)	(0.22)	(0.21)	(0.34)	(0.31)	(0.20)	(0.25)	(0.25)	(0.26)	(0.20)	(0.27)
Lagged Basis	0.0406	0.0824	0.1791	0.4994	0.1897	0.497	0.2609	0.3557	0.1593	0.7099	0.2654	0.6473	0.0807	0.2752
Estimates	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.06)
R-Square	0.2386	0.5906	0.3479	0.7148	0.4565	0.7751	0.4155	0.8021	0.1327	0.6095	0.251	0.7093	0.0791	0.4274
Total R-Square	0.8189		0.9085		0.9052		0.9205		0.9175		0.9113		0.8984	
Estimates of Autoregressive Parameters	-0.70293		-0.72979		-0.67195		-0.71095		-0.79623		-0.75441		-0.86115	

Standard Errors are in Parantheses

N=307

Figure 5.15 All Select Primal Hedge Ratios, No Lagged Basis

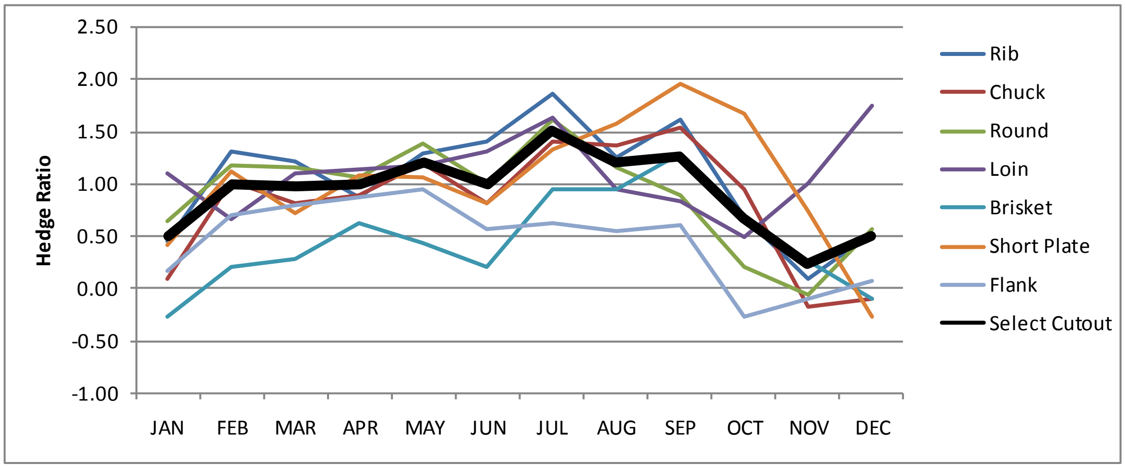
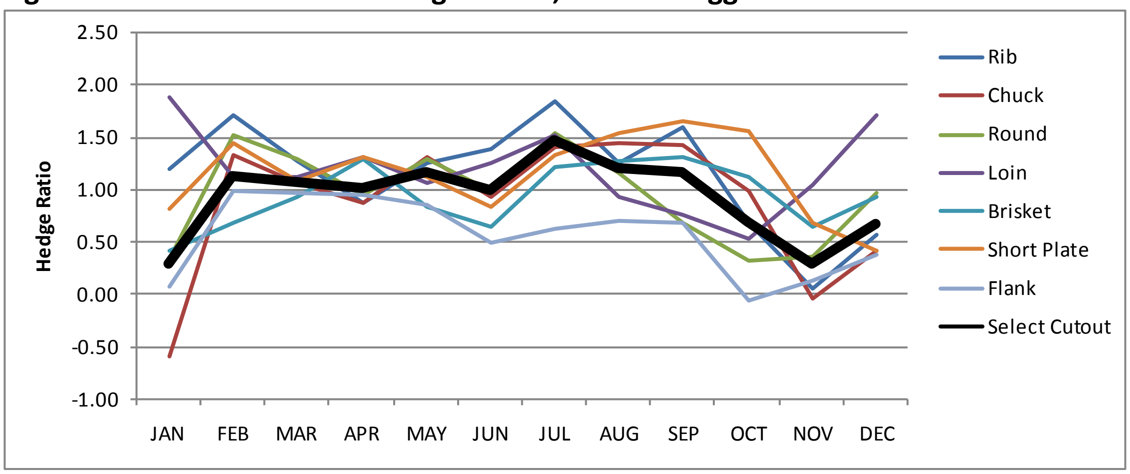


Figure 5.16 All Select Primal Hedge Ratios, 8-Week Lagged Basis



5.3 Cross-Hedging Example

To clarify how these estimated hedge ratios can be applied, this section will provide an example of how a meat packer might use the information provided in this chapter to lock in an expected future price.

Consider a meat packer who on September 1 would like to cross-hedge 100,000 pounds of Choice Loins to be delivered November 1. A risk manager must know which hedge ratio to use, what expected price he can lock in, and how many Live Cattle contracts must be opened to cover the price risk on 100,000 pounds of Choice Loin.

Since the product is to be delivered in approximately 8 weeks, a model for Choice Loins with 8-week lagged basis information should be used (Table 5.6). The appropriate hedge ratio For a November cross-hedge is 1.61. Table 5.6 also provides a lagged basis estimate for Choice Loins of 0.6. These two estimates, along with the current Live Cattle futures price and current Loin basis [Basis = Cash Loins – Nearby (October) Live Cattle futures] are used to determine the expected price for Choice Loins on November 1. [1] The formula used to calculate this expected price is:

$$\text{EP}=\text{Intercept}+(\text{Hedge Ratio}*\text{Current LCF})+(\text{Basis Estimate}*\text{Current Basis}). \quad (7)$$

Given a December Live Cattle futures price of $100.00/cwt and a Choice Loin basis of $132.00/cwt (Cash Loin trading at $230.00/cwt minus October Live Cattle trading at $98.00/cwt), the expected Loin price is [-16.24 + (1.61*$100) + (0.6*$132)] or $223.96.

To cover the price risk on 100,000 pounds of Loin, 161,000 pounds of Live Cattle futures will need to be sold. This is calculated by multiplying the amount of product to be hedged by the hedge ratio (1.61*100,000).

From Table 5.6, the standard error for the November hedge ratio is 0.60. If the actual cash-futures price relationship is within the standard error of the predicted hedge ratio of 1.61 when the hedge is lifted, the expected Loin price will be between $163.96 and $288.96.

5.4 Summary

Predicting the appropriate cross-hedge ratio for wholesale beef is a difficult task to accomplish with a high level of confidence. This is illustrated in the previous section. Models

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[1] The intercept term, which has been omitted from this report, is also necessary to calculate an expected cash price.

for Choice Loins have goodness of fit measures that are some of the highest calculated in this thesis, but as the example in Section 5.3 shows, the cash price that can be achieved might be much higher or lower than expected.

Deriving cross-hedge ratios for boxed beef cutouts demonstrates that estimation techniques and conditioning information will significantly impact the predicted hedge ratios. Seasonality and demand elasticities dictate the use of unique hedge ratios for every month to adjust for changes in the cash-futures price relationship.

Elaborating on the cutout level analysis to calculate primal level cross-hedge ratios shows that variations in hedge ratios at the cutout level are the result of wide fluctuations in hedge ratios at the primal level. Standard errors for all cross-hedging scenarios are highest in the last quarter of the year.

Risk managers who intend to cross-hedge wholesale beef will face a great deal of basis risk. The findings presented in this chapter do not preclude the use of Live Cattle futures to cross-hedge wholesale beef. Levels of risk aversion and expectations regarding price movements for individual managers will determine the efficacy of cross-hedging. Lessening the amount of basis risk inherent with cross-hedging would enhance the practicality and usefulness of this activity.

CHAPTER 6 - Bundling Wholesale Primals

The previous chapter shows that basis risk is significant for managers who wish to cross-hedge wholesale beef in Live Cattle futures. In this chapter we seek to determine if basis risk associated with cross-hedging wholesale beef can be reduced by bundling certain primal cuts together. Bundling scenarios for Choice graded primals conditioned with 8-week lagged basis information are constructed to evaluate the impact on basis risk. For a bundled cross hedge to offer a reduced level of basis risk, errors for the regression of cash on futures should offset each other to some degree. A correlation matrix (Table 6.1) for the residuals of each primal regression serves as a guide for determining which cuts to bundle.

Table 6.1 Correlation Matrix: Primal Cross-Hedge Regression Residuals

	Rib Errors	Chuck Errors	Round Errors	Loin Errors	Brisket Errors	Short Plate Errors	Flank Errors
Rib Errors	1	0.04519	0.08618	0.49255	0.12014	0.27428	0.21695
Chuck Errors	0.04519	1	0.75450	0.09782	0.62594	0.61524	0.37351
Round Errors	0.08618	0.75450	1	0.24963	0.41952	0.42694	0.36723
Loin Errors	0.49255	0.09782	0.24963	1	0.07256	0.21153	0.31455
Brisket Errors	0.12014	0.62594	0.41952	0.07256	1	0.65194	0.31674
Short Plate Errors	0.27428	0.61524	0.42694	0.21153	0.65194	1	0.53468
Flank Errors	0.21695	0.37351	0.36723	0.31455	0.31674	0.53468	1

6.1 Rib-Loin Bundle

The first bundle evaluated consists of Ribs and Loins. These cuts were paired together because they are high quality cuts that are popular with foodservice. Based on their relative proportion of the composite cutout (Table 3.1), the bundle will be comprised of 35 percent Rib and 65 percent Loin. The new variable yielded by this weighting is regressed on futures prices and 8-week lagged basis information in a manner identical to that in the previous section. The variance of the residual errors for this regression is compared to the combined variance of residuals for Ribs and Loins. The variance of the error terms for the bundle is 35.74. For an equal proportion of Ribs and Loin cross-hedged independently, the variance of residuals is 36.55. This indicates that a bundle of Ribs and Loins results in less cross-hedging basis risk than if the primals were hedged independently. However, an F-test statistic of 1.0227 reveals that the two methods yield results that are statistically indifferent.

To evaluate the amount of risk reduction that would be associated with the bundle, a 90 percent confidence interval can be constructed for the predicted cash price for each method. These results are shown in Table 6.2. The forecast error, evaluated at the means for all variables, shows that bundling will reduce basis risk by $1.72/cwt ($20.73-$19.01). This is about an 8 percent risk reduction. Because the variance of error terms for the two methods are statistically the same, the analysis of basis risk reduction is included solely for illustrative purposes.

Table 6.2 Comparison of Basis Risk for Bundled and Un-Bundled Ribs and Loins

Cash Product	Predicted Cash Price/CWT	90% Confidence Interval		Forecast Error at Mean
Rib	$224.89	$204.73	$245.04	$20.15
Loin	$211.08	$190.05	$232.11	$21.03
Rib w/ Loin Un-Bundled	$215.91	$195.19	$236.64	$20.73
Bundle	$216.20	$197.19	$235.21	$19.01

6.2 Loin-Brisket Bundle

From Table 6.1, it is evident that residuals for Loin and Brisket regressions have a relatively low correlation coefficient. Pairing these cuts together results in a bundle comprised of 81 percent Loin and 19 percent Brisket. Regressing this bundle on futures and basis data yields residuals with a variance of 27.37. Hedging a proportionate amount of Loins and Briskets independently results in a combined variance of 26.85. Testing the difference between these two variances shows that these variances are statistically indifferent given an F statistic of 1.019.

6.3 Chuck-Round Bundle

Unlike the last bundle evaluated, residuals for Chuck and Round primals are more closely related with a correlation coefficient of 0.75. This bundle would consist of 57 percent Chuck and 43 percent Round. The variance of the error terms from the regression of this bundle on futures prices and basis information is 8.06. The combined variance of residuals for a proportionate amount of Chucks and Rounds hedged independently is 7.72. When these variances are tested, the F-Statistic of 1.043 shows the two methods will have statistically indistinguishable levels of basis risk.

6.4 Loin-Brisket-Round Bundle.

In Section 6.2, a bundle of Loins and Briskets was evaluated. In that scenario, the Loin made up over 80 percent of the bundle. This would likely dilute any basis reduction offered by the addition of the Brisket. In this scenario, the Round primal is included in the bundle. Residuals for Loin and Round models are weakly correlated (0.25) and the addition of the Round will reduce the amount of Loin necessary to complete the bundle.

This bundle will consist of 43.6 percent Loin, 10.2 percent Brisket and 46.2 percent Round. The variance of the residuals for this model is 12.50. The combined variance for cross-hedging a similar amount of Loin, Brisket, and Round independently is 11.97. An F-Statistic of

1.045 indicates that there is no statistically significant difference in basis risk between the two methods.

6.5 Loin-Round Bundle

Modifying the bundle in the previous section, a package of Loins and Rounds is evaluated. These primals are very similar in proportion to the wholesale cutout and would create a bundle of 48.6 percent Loin and 51.4 percent Round. The variance of the residuals yielded by this cross-hedge regression is 14.77. Cross-hedging a similar proportion of Loins and Rounds independently would result in a variance of errors equal to 14.23. Testing the difference between these variances results in an F-Statistic of 1.038. Again, basis risk will be indifferent when using a bundled or independent hedging strategy.

6.6 Rib-Chuck Bundle

A Rib-Chuck bundle also represents two primals that exhibit a weak positive correlation (see section 6.2). This bundle is comprised of 27.7 percent Rib and 72.3 percent Chuck. The variance of the error terms for cross-hedging this bundle is 10.27. When hedging a proportionate amount of Rib and Chuck independently, the combined variance of residuals is 9.98. The F-Statistic determined by testing for differences between these variances is 1.029. Bundling Ribs and Chucks will have no effect on basis risk.

6.7 Rib-Flank Bundle

In Section 6.6, the Rib Chuck bundle is evaluated. The majority of that bundle is comprised of Chuck. In this scenario, Rib is bundled with Flank which creates a bundle more heavily weighted to Ribs. 77 percent Rib and 23 percent Flank is used to make up this bundle.

A regression of this bundle yields residuals with a variance of 41.96. The combined variance for a similar proportion of Ribs and Flanks hedged independently is 41.77. Testing for differences between these two variances gives an F-Statistic of 1.005 which indicates that basis risk is statistically indifferent between the two methods.

6.8 Summary

Bundling appears to have a neutral effect on basis risk for cross-hedging wholesale beef in Live Cattle futures. Correlations of residuals for primal cross-hedge regressions did not have an identifiable positive or negative effect on basis risk reduction. As described in previous sections, the correlation between cash and futures prices will determine cross-hedging effectiveness. At least for the bundles evaluated here, a better correlation for cash and futures prices is not obtained by bundling.

CHAPTER 7 - Conclusions

Three main objectives were addressed in this research. The first objective was to examine wholesale cash beef prices. The second objective was to replicate previous research regarding cross-hedging wholesale beef in Live Cattle futures. The final objective addressed in this research was to assess the impact of bundling wholesale primal cuts on cross-hedging basis risk. Conclusions, implications and suggestions for further research are provided in this chapter.

7.1 Objective 1- Examining Wholesale Cash Prices

Previous research indicates that much variability exists in wholesale cash beef prices. Data used for this analysis indicates that Choice cutout prices ranged from a low of $124.41/cwt to a high of $170.44/cwt. For Select quality grade cutout, prices ranged from $119.27 to $163.91/cwt. Primal prices exhibit similar levels of variability. This indicates a need to manage price risk for those who wish to procure or sell wholesale beef. Cross-hedging in Live Cattle futures provides a means for reducing price risk. However, the performance of cross-hedging programs has decreased since the first research was conducted in the early 1980s. This is likely the result of changes in beef marketing practices over the last 30 years.

Since early research on cross-hedging was conducted, the Live Cattle futures contract specifications have changed from 100 percent Choice steers to 55 percent Choice and 45 percent Select steers. To the extent that the correlation between Choice beef and Live Cattle futures was eroded with this change, cross-hedging has become more difficult.

The inclusion of price information for Branded boxed beef in April, 2003 may have also had an effect on the Choice cutout. The Branded cutout includes all branded product grading Choice or higher. The prevalence of programs like Certified Angus Beef that include only upper 2/3 Choice graded beef increases the mix of lower 1/3 Choice product included in the Choice cutout. If procurement managers do not place incremental value on lower 1/3 Choice beef over Select beef, the Choice cutout price may have undergone a structural shift. Analyzing the Choice-Select spread indicates that the difference in prices for these cutouts has narrowed. The decrease in the Choice- Select spread has not led to an increase in Branded Select spread, however. It is important to point out that the Branded cutout includes many branding programs. As a composite, the Branded cutout is closely correlated with the Choice cutout, but certain branded programs may be outperforming the Choice and Select cutouts substantially.

At any rate, for the data used in this thesis, the Choice cutout is less positively correlated with Live Cattle futures than the Select cutout. This research does not seek to determine the cause of this shift in price relationships, but product differentiation and the increase of branding programs has likely played a role.

Variability present in wholesale cash beef prices makes effective cross-hedging a significant challenge. Changes in the price relationships between quality grades and between the Live Cattle futures contract price compound this challenge.

7.2 Objective 2- Traditional Cross-Hedge Analysis

To address the second objective of this research, cross hedging ratios for cutouts and primals were analyzed. The inclusion of current nearby basis information improves the performance of hedging ratios for shorter hedging horizons. However as the time the hedge is held increases, current nearby basis information becomes less useful.

Substantial differences in hedge ratios are noted between AutoReg and OLS estimation techniques. Estimates of autoregressive parameters indicate that autocorrelation is prevalent in wholesale cash prices. Because different estimation techniques can yield much different hedge ratios, users should keep their end goal in mind when selecting the appropriate ratio. For practicing cross-hedgers who intend to hold their hedge position for a long period of time (generally over one month) an OLS hedge ratio is more appropriate. If hypothesis testing is desired, a hedge ratio calculated through an autoregressive framework would offer more efficient standard errors.

At the cutout level, hedge ratios can differ a great deal between quality grades. Reflective of their closely correlated price patterns, Choice and Branded product generally have similar hedge ratios. Prime and Select quality graded product hedge ratios can vary substantially. Managers need to pay close attention to the type of product to be cross-hedged and select the appropriate hedge ratio accordingly. As discussed previously, Select graded beef will be cross-hedged with less basis risk than Choice, Prime or Branded beef.

Replicating previous studies of wholesale beef cross-hedging re-iterates the findings of earlier researchers who found that the relationship between wholesale cash prices and Live Cattle futures has weakened. Since modeling techniques and primal specifications have evolved a great deal since the earliest cross-hedging research was conducted, direct comparisons are difficult to draw. Hayenga, Jiang, and Lence (1996) use modeling techniques and data somewhat similar to that used in this thesis. This allows for a comparison of a Choice

Chuck model with 8-week lagged basis information to a comparable model from Hayenga, Jiang, and Lence. Comparing results shows that R-square values from the earlier study ranged from 0.74 to 0.95 depending on the month.[2] R-Square statistics from this study are 0.73 for Choice Chuck and 0.71 for Select Chuck. Hedge ratios calculated in this study are in a similar range to those calculated previously; however the seasonal pattern seems to have shifted.

Cross-hedging wholesale beef is challenging at best, however cross-hedging efficacy is not ruled out by this study. Managers who anticipate a large price movement may still be motivated to place cross-hedges. However, the significant basis risk associated with these hedges make cross-hedging wholesale beef a largely speculative endeavor.

7.3 Objective 3- Evaluating the Impact of Bundling Wholesale Primals

To decrease the amount of basis risk associated with cross-hedging wholesale beef, this research assessed the impact of bundling primals together into a single hedgeable unit. For the bundles evaluated here, bundling has neither a positive or negative effect on basis risk. This result appears to be independent of the relationship between the underlying primal prices. While beef wholesalers will not be able to offer reduced basis risk through a bundling program, the use of such a program seems to be plausible.

7.4 Suggestions for Further Research

Four quality grades and seven primal cuts make the options for bundling plentiful. This research evaluates only a small portion of these bundles. Although bundling was not found to offer reduced basis risk in this analysis, certain combinations of primals may exist that do offer

[2] Hayenga, Jiang, and Lence (1996) calculate 12 separate regressions to deal with seasonality and therefore report 12 different R-Square statistics.

more appealing risk levels. This research did not attempt to bundle between quality grades. Bundles that include cuts from different quality grades may provide interesting results.

As differentiation has increased in the beef segment, it becomes increasingly difficult to draw conclusions from commodity price information. Beef wholesalers with in-house price data may find results that differ from the results obtained here using USDA-AMS reported prices.

As structural shifts continue to take place in the beef industry, price relationships are constantly changing. Future work in this field may uncover new data or methods that could improve the performance of wholesale beef cross hedging. Given the price risk faced by wholesale beef traders, methods to relieve some of this risk would be met with open arms.

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