RISK MANAGEMENT CASH REQUIREMENTS AND OPTIMAL MARKETING STRATEGIES FOR WINTER GRAZED STOCKER CATTLE

By

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-Blayne Horn

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Abstract:

Some agricultural producers use futures contracts and put options as a means of managing price risk. Producers who do not use risk management strategies might be turned away from them due to the margin requirements or the options premiums. They also may need further information in order to evaluate the choice not to pursue risk management strategies. This study uses historical data to determine the optimal risk management strategy (futures contracts or put options). A Monte Carlo simulation is used to simulate the production period of Oklahoma winter grazed stocker steers and heifers and stocker steers from Georgia grazed on winter forage. End of the period wealth is computed across the all three groups of calves for each risk management strategy given a static initial wealth and accounting for the costs associated with purchasing, producing, and hedging cattle. Next, ending wealth is converted into a utility value using a constant relative risk aversion (CRRA) utility function. Next, the producer's certainty equivalent is derived from the utility function to determine the optimal marketing alternative for each group of calves and a non-pooled t-test was conducted to determine the significance between each strategy.

A calculation of the margin requirements for a producer who markets their cattle using futures contracts was calculated for all three groups of calves to determine how often and approximately how much money a producer might need during a production period.

Results concluded that producers who market their cattle using put options have more to gain in terms of revenue per contract, end of period wealth, and certainty equivalent for all three groups of calves followed by futures and cash markets.

Keywords: Options, Futures, Cattle, Risk, Production, Wealth

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CHAPTER I

INTRODUCTION

Agricultural producers occasionally use futures markets to manage price risks and to aid in the sale of their products. However, recent increased volatility of agricultural prices across most all markets have left many more producers wondering what actions they can take to better manage their risk. Specifically, increased fluctuations of the price in cattle markets over the past five years have made risk management strategies and price protection more of a necessity for cattle producers. Figure 1 depicts the three-month, rolling standard deviation of Oklahoma City 700 to 800 pound steers from 1992 to 2016. While price fluctuations have been present since the early 2000's, the figure highlights the increased price variability since 2012, with even greater volatility since 2014. However, in spite of the need for price risk management, many cattle producers fear the rigidness and unknown aspects of using futures markets to hedge price risk.

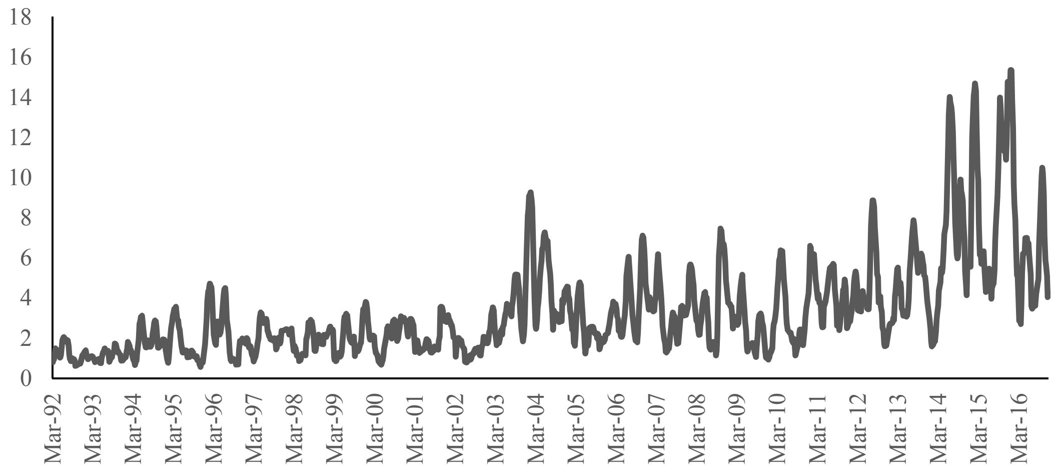

Figure 1. Stocker cattle three-month rolling standard deviation of prices, January 1992 to December 2016, Oklahoma City, OK, 700-800 pound steers.

Multiple studies have reported that few producers utilize futures contracts and options (Turvey and Baker, 1990; Arias, Brorsen, and Harri 2000; Riley and Anderson, 2000). However, there are instances where producers do recognize the value and importance of managing price risks. For example, Brad James, a cattle producer from Colorado, had this to say about marketing with options, "When I started to hedge years ago, my Grandpa didn't think it was a good idea. I told him I'd like to at least break even. I'm gambling less hedging than I am pouring feed to them" (Stalcup, 2014).

Stockers are cattle not used for production that have been weaned from their mothers. Typically they weigh between 400-700 pounds and are placed on forage to promote growth. In Oklahoma, winter grazing stocker cattle are generally bought in mid-September and spend about one month of confinement on a diet of grain and dry, harvested forage before they are put on winter pasture where they remain until late February or early March and then are sold as feeder cattle.

Two common risk management protocols for the seller of a commodity, and more specifically the seller of livestock, are futures contracts and put option contracts. The seller of a commodity desiring to manage price risk with futures would sell a futures contract for a specific month that coincides closely with the anticipated sale month. This requires producers to maintain a margin account balance, which are set by the exchange with minimum margin amounts that are predicated on the volatility of the futures contract price (Kastens and Schroeder, 1994). A put option provides a producer the right, but not the obligation, to sell the underlying futures contract at a specific price, known as the strike price. The added flexibility afforded by options requires a premium, similar to an insurance premium and the premium will fluctuate depending on the volatility of the underlying futures price.

Of course, there are producers who don't pursue any risk management strategies and chose to sell on a cash market. This is often the most common form of selling a commodity however, it also carries the most risk as the final price is uncertain. Many producers indicate concern that the expenses related to risk management strategies, such as a put option or taking a position in the futures market, have increased faster relative to the cost of other inputs (Riley and Anderson, 2010) and are not worth the premium or margin requirements they carry. Producers often find themselves looking at short term cash flow constraints throughout the production period, rather than long term end of the production period outcomes. Producers find themselves under the impression that purchasing risk management strategies, be it options or a futures contract, is not worth the cost when in reality producers are hedging much less than theory would suggest (Arias, Brorsen, and Harri, 2000).

Objective

This study uses simulation to determine the within period cash flow requirements of hedging with futures relative to no cash outflows when not hedging and a single, one-time outflow when hedging with put options (i.e., the option premium). Furthermore, end of period wealth is used to measure a risk averse producer's preferred marketing strategy when considering cash marketing, cash marketing when hedging with futures, and cash marketing when hedging with put options. Historical futures price changes and end of period basis are used to calibrate the simulation outcomes.

Specific Objectives

(1) Determine the distribution of margin requirements from hedging cattle using futures contracts and options, relative to marketing only through the cash market for Oklahoma steers, Oklahoma heifers, and Georgia steers,

(2) determine the marketing outcome that provides the greatest gain in end of the production period wealth between cash only, futures contract hedging, or option hedging,

(3) determine the marketing outcome that minimizes variation of end of period wealth between cash only, futures contract hedging, and option hedging, and

(4) using end of period wealth determine the optimal marketing outcome for a utility maximizing, risk averse livestock producer.

CHAPTER II

LITERATURE REVIEW

There has been much research done to better understand the reasoning behind the low use of risk management strategies among agricultural producers in the United States. Many have suggested that agricultural producers are not hedging as much as theory would suggest (Arias, Harri, and Brorsen, 2000; Riley and Anderson, 2010) and other have sought out what other strategies producers are currently using (Goodwin and Schroeder, 1994; Musser, Patrick, and Eckman, 1996; Schroeder et al., 1998; Sartwelle et al., 2000; Riley and Anderson, 2010).

Surveys of Agricultural Hedging

This study determines optimal marketing strategy of winter grazed stocker cattle by marketing with futures contracts and options or selling on a cash market. Studies have suggested that producers are not hedging as much as they say they are and this study shows that producers have much to gain by hedging.

Musser, Patrick, and Eckman (1996) conducted a survey of Midwestern corn and soybean farmers to determine risk and farm characteristics of pre-harvesting techniques. They found that 53.4 percent of the farmers said they would use futures or options to market their crops however, only 34.5 percent of that 53.4 percent said they actually used futures and options. Schroeder et al. (1998) conducted a survey of Kansas crop and cattle producers primarily about futures markets, price forecasting, and market risk management. They determined 45.0 percent and 56.0 percent of crop producers said they hedged using futures contracts and options, respectively. For cattle producers only 22.0 percent said they used similar strategies like futures and options but out of all the respondents of that 22.0 percent, only 16 individuals were either stocker cattle producers or feeders and of those 16 individuals, 37.0 percent hedged with options and 32.0 percent used futures. Sartwelle et al. (2000) used survey results to determine that 96.0 percent of Kansas, Iowa, and Texas grain producers sold on cash markets. It is not uncommon for producers to use both cash along with futures, forwards[1], or options as a collective risk management protocol and Sartwell et al. found that 70 percent of the cash market users also use forward contracts while 52 percent also use futures.

Theoretical Factors Influencing Hedging Decisions

Johnson (1960) provided the framework for hedging theory when a hedger desires to minimize price risk, given that spot (or cash) market prices are not always perfectly aligned with futures market prices. He derived the minimum variance approach, which in essence, minimizes the variance of the return to hedging when a hedger participates in both spot and futures markets. The minimum variance result defined by Johnson shows that the greater the correlation between spot market and futures market prices, the more effective hedging with futures becomes as price risk is reduced to zero.

Stein (1961) developed a geometric technique for determining the simultaneous determination of spot and futures prices in commodity markets. The technique was used

[1] Forward contracts are similar to futures in that both offer a set price for a future transaction, however forward contracts are often tailored to the specific desires of the buyer and seller whereas futures contracts are specified by the futures exchange.

to explain the allocation between holding hedged and unhedged stocks. Given that this study deals with cattle, Stein's study is still relevant since he looks at the comparison between hedging and not hedging on the futures market. His results concluded that a positive correlation between the change in the spread between futures price and cash price and the change in price suggests that the market has expected spot and futures prices to move together. When the correlation was negative the change in price spread and the change in price results in a excess supply of production, however, if the change is price and the change in stocks were negatively correlated but the change in price and the change in stocks were positively correlated then this resulted due to a change in spot price but no change in expected futures price.

Lence (1995) conducted a theoretical model that focused on the assumptions that yield minimum variance hedges (MVH) consistent with expected utility maximizations. Using Bayesian decision theory to define the opportunity cost of hedging, which he considered an equivalent to MVH, and assuming constant absolute risk aversion, Lence used simulation to determine the optimal hedge ratio and the benefit of increased precision of MVH models. Among the findings be Lence, were that direct hedges – hedges where spot markets and futures markets matched – without diversification in production practices yield a hedge ratio of 0.85 or 85 percent. His overall results concluded that the value of a "better" MVH estimate is insignificant and that there is a substantial difference between optimal hedges and MVH's when the normal MVH restrictions are relaxed.

Futures Adoption by Agricultural Producers

This study examined the outflow of cash requirements in the form of margin calls when marketing with futures contracts to determine how much and how often producers are faced with such requirements. Recent studies have suggested that perhaps these cash outflows, as well as costs associated with these outflows (i.e., interest rates, tax, etc.) are what limits producers from using futures contracts as a hedging vehicle. Some of the arguments associated with the use of marketing with futures and options compared to that of forward contracting or even selling on a cash market is that the price associated with them, such as option premiums or margin requirements, exceeds the value they offer as a risk management tool. Arias, Brorsen, and Harri (2000) found that to encourage a producer to hedge using futures contracts or options as a means of managing risk you must first reduce tax liabilities, bankruptcy costs, borrowing costs, and liquidity costs. Even then the cost associated with hedging had a congruent effect on optimal hedging ratios. Reductions of producer liquidity may be considered an important deterrent of risk management tools according to Hall et al. (2003).

Riley and Anderson (2010) determined in a study of wheat and corn production in Kansas, corn and soybean production in Illinois, and cotton and soybean production in Mississippi that hedging costs typically account for 10.0 percent or less of the overall cost of production after factoring in all other inputs such as fertilizer, chemicals, seed, labor, and rent/land.

Hall et al. (2003) reports that Texas and Nebraska cattle producers rank output price risk variability as an important risk factor, with the topic receiving an average of 4.3 on a 5.0 Likert scale ranking and being the second most important factor of the 1,313 survey respondents from the two states. However, the same survey respondents did not view forward contracts, or futures and options contracts, as a potential risk management strategy, with the average Likert ranking of 2.2 and 2.0, respectively, out of a possible 5.0. The respondents from the survey conducted by Hall et al. did indicate though, maintaining financial/credit reserves was a potential risk management strategy, with a 3.6 Likert average.

These studies examined many factors that influence a producer's decision to hedge including borrowing costs and input costs and suggests that some producers are not hedging because they do not want to reduce cash reserves at the beginning of the production period via margin requirements or option premium expenses. This study measured the frequency and total dollar amount of cash outflows in the form of margin calls to determine the overall margin balance requirements relative to cash only marketing and option premium requirements.

Simulation of Agricultural Marketing

This study simulated the production of winter grazed stockers that were sold on cash markets as well as hedged using futures contracts and options. Simulations used in this study are similar to those done in previous studies that looked at optimal marketing strategies for agricultural producers. Furthermore, this study used the expected utility framework similar to Moschini and Lapan (1995) and Harri et al. (2009) to determine the optimal marketing strategy.

Turvey and Baker (1990) used a farm level discrete stochastic programming model to look at a producer's use of futures and options under alternative farm programs, the influence of price and financial risk, and liquidity constraints, to determine how the financial characteristics of the farm and alternative farm programs influenced a producers hedging strategies. They implied that farms with high debt have the most to gain from hedging and suggest that lenders may want to encourage high-debt farms to hedge.

Anderson, Harri, and Coble (2009) compared the Iman and Conover (IC) and the Phoon, Quek, and Huang procedures used for simulating correlated variables. The comparison of the two resulted in significantly different rates depending on the use of the procedure based on t-test which were run to determine the significance of the difference in values between both procedures. Results suggested the PQH yields a more accurate rate, and while these were statistically significant, the difference in rates are not considered to be economically significant.

Moschini and Lapan (1995) constructed a model to analyze the simultaneous choice of futures and options when there are production risks. The solution for futures and options were derived using a CARA (Constant Absolute Risk Aversion) utility function and multivariate normal distribution of hedging variables then the mean-variance approximation for futures and options were derived to consider the optimal use of futures and options for a risk-averse producer. Results concluded that there is a distinct role for options even when the production and price risks are independently distributed.

Harri et al. (2009) conducted a study to estimate the optimal hedge ratios for fed cattle placed on value-based marketing (VBM or grid pricing) and average live basis to reveal how grid pricing affects the effectiveness of the live cattle futures contracts as a risk management strategy using simulation resulting from the Cholesky decomposition of the variance-covariance matrix of the simulated variables. Results from this study suggested that the effectiveness of existing instruments in managing a producers' price risk on fed cattle associated with a given grid depend on the base price used by the grid.

Collectively, these studies suggest that agricultural producers are not hedging as much as they might suggest even though they are highly concerned with their output prices, even though they still use cash markets to market their cattle as opposed to using futures contracts or option.

CHAPTER III

DATA AND METHODS

This study simulated the production period of winter grazed stocker calves, both steers and heifers from Oklahoma as well as steers from Georgia. All results are based on a Monte Carlo simulation. The data generating process used in the Monte Carlo simulated is estimated using historical data. Production periods are considered to be between the beginning of September, when the calves are purchased, through the middle of March, when the calves are taken off of wheat pasture. Oklahoma City (OKC) steers and heifers are used in the study given that OKC is centrally located in the region that the CME Group feeder cattle futures contract price is derived from[2]. Also, OKC has historically been on of the nation's largest markets for stocker and feeder cattle. Georgia steers are included for spatial diversity as Georgia is outside the CME Group's defined feeder cattle price determination region.

Data

To simulate the weekly variability of output prices and marketing outcomes, cash prices for each location and feeder cattle futures prices are used to define the parameters for a Monte Carlo simulation. Cash price data for Oklahoma City, OK are obtained for 700-750 pound steers and heifers reported by the United States Department of Agriculture, Agricultural Marketing

[2] The CME Group feeder cattle futures contract is cash settled and cannot be delivered on, meaning that the contract settlement price is determined from a group of cash market locations.

Service (USDA-AMS, KO_LS795) and compiled by the Livestock Marketing Information Center (LMIC). Cash price data for Georgia steers are obtained for 700-750 pound steers reported by USDA-AMS (USDA-AMS, TV_LS145) and compiled by LMIC. Oklahoma City cash prices are specific to that auction market, while cash prices from Georgia are compiled by USDA-AMS from multiple auctions across the state. Oklahoma City prices are reported weekly, with the sale in Oklahoma City occurring on each Monday. Georgia prices are reported each week on Friday with multiple sales occurring throughout the week. Futures prices are obtained by the CME Group (formerly the Chicago Mercantile Exchange) and compiled by LMIC. Daily settlement futures prices are recorded by LMIC and a weekly simple average is computed to comprise weekly price. It should be noted that by using a simple average of each trading day's closing price for each week rather than using a price specific to a certain day of the week in the simulation may introduce autocorrelation which might influence the simulated output price outcomes.

Cash prices were used from 1991/1992 to 2015/2016[3] providing twenty-five years of historical data to use to calibrate the simulation parameters. The cash prices used in the study for the end of the production period were compiled from the final three weeks of March (typically weeks 10-12, except when there were 53 weeks in a year). Futures prices from 1991/1992 to 2015/2016 were also used in this study, using weekly averages from the beginning of September (week 36, except when there were 53 weeks in a year; beginning of the production period) through the third week in March (week 12, except when there were 53 weeks in a year; end of the production period).

[3] This study analyzes winter grazing production, which involves the latter portion of one year and beginning portion of the following year, thus the use of the mutli-year notation.

Methods

Ending basis and weekly futures price changes are simulated assuming both are normally distributed. Weekly futures price changes were included to calculate the margin account balance throughout the production period so that additional margin requirements could be assessed[4].

First, futures price changes for each week of the production period, starting in week 36, and continuing through the third week in March were calculated based on the outcomes of the simulated price changes. The change in futures price was calculated from the available data as:

$$\Delta F_t = F_t - F_{t-1} \qquad [1]$$

where, F_t is the average futures price for week t and F_{t-1} is the average futures price from the previous week. End of period cash price is determined using simulated basis values. Basis for the simulation was calculated from the available data as:

$$B_t = \frac{C_t}{F_t} \qquad [2]$$

where, B_t is the basis value at time period t, C_t is cash price at time period t, and F_t is futures price at time period t. In this study basis is the ratio of cash and futures as opposed to the difference to account for the price level differences over the timeframe of the data. To overcome possible irregularities for a single week's basis value a simple average for the first three weeks of March is used to calculate the final basis value. As a result end of period cash price is calculated as:

[4] Margin account balances are marked-to-market each trading day, however, this study evaluates them on a weekly basis.

$$C_t = B_t \times F_t \quad [3]$$

Simulation Procedures

For a producer grazing stocker cattle on winter pasture[5] who purchases a pre-determined number of head of cattle, output price was considered as the cash price received when the cattle are sold at the end of the production period. End of period futures price is derived from a static, pre-determined beginning of period futures price at $140 per hundredweight (cwt.). Proceeding weekly futures prices are determined from simulated weekly price changes (equation [1]). Cash price stems from the simulated end of the period ending basis using equation [3] combined with the end of period futures price described previously.

First, the simulation procedure follows Anderson, Harri, and Coble (2009) which uses the Phoon, Quek, and Huang (PQH) simulation methodology where price changes and basis values are assumed normal. The PQH procedure uses a Karhunen-Loeve (KL) expansion technique to simulate correlated standard normal deviates. The deviations are used as probabilities in the desired distribution. In this study the deviations have a mean of zero and standard deviation of one, N(0,1). The mean and standard deviations of weekly futures price change and ending basis ratio from the historical data, which are used in the simulation outcomes are provided in table 1.

[5]Wheat is the primary forage in Oklahoma but any winter annual such as rye, ryegrass, or clover are possible and defined forage systems are not specific to this study.

Table 1. Summary Statistics of Historical Futures Price Changes and Basis, 1991/1992 to 2015/2016

Variable		Mean	Standard Deviation	Minimum	Maximum
Futures Price Changes					
Time Relative to End of Period	Approximate date in production period				
t-27	3-Sep	0.323	1.651	-1.665	7.306
t-26	10-Sep	0.400	1.279	-2.196	3.211
t-25	17-Sep	-0.225	1.861	-6.206	2.619
t-24	24-Sep	-0.307	1.920	-7.565	3.190
t-23	1-Oct	0.131	2.458	-5.180	8.290
t-22	8-Oct	0.402	2.199	-4.250	5.630
t-21	15-Oct	0.030	1.561	-4.485	4.480
t-20	22-Oct	0.044	1.290	-3.560	2.895
t-19	29-Oct	-0.456	0.932	-3.040	1.102
t-18	5-Nov	-0.453	2.053	-5.375	3.340
t-17	12-Nov	-0.354	2.738	-11.645	3.824
t-16	19-Nov	0.071	1.941	-6.170	2.936
t-15	26-Nov	0.275	1.491	-4.719	3.134
t-14	3-Dec	0.016	1.772	-4.577	2.997
t-13	10-Dec	-1.185	2.537	-8.260	4.780
t-12	17-Dec	-0.406	2.580	-10.165	4.630
t-11	24-Dec	0.915	2.622	-1.773	11.429
t-10	31-Dec	0.001	2.286	-9.431	3.050
t-9	7-Jan	0.330	1.287	-2.275	3.494
t-8	14-Jan	-0.684	3.127	-9.880	4.054
t-7	21-Jan	-0.135	1.528	-4.974	2.005
t-6	28-Jan	0.127	1.512	-1.671	5.194
t-5	4-Feb	-0.485	1.831	-4.980	3.345
t-4	11-Feb	-0.237	2.107	-6.820	3.305
t-3	18-Feb	-0.015	2.580	-6.741	5.748
t-2	25-Feb	0.269	1.595	-2.999	5.140
t-1	3-Mar	0.478	1.885	-3.550	7.500
t	10-Mar	0.289	2.030	-2.750	6.795
Ending Basis (Cash/Futures)					
Oklahoma Citiy Steers		1.022	0.014	0.992	1.050
Oklahoma Citiy Heifers		0.945	0.020	0.909	0.975
Georgia Steers		0.921	0.026	0.870	0.970

From Anderson, Harri, and Coble (2009) the PQH procedure is:

$$\omega_k = \bar{\omega}_k + \sum_k \sqrt{\lambda_k} \xi_k(\theta) f_k(x) \qquad [4]$$

where, ω_k, is the KL expansion of a Gaussian process with a mean $\bar{\omega}_k$. Eigenvalues and eigenvectors of the Pearson correlation matrix are represented by λ_k and $f_k(x)$, and $\xi_k(\theta)$ is a matrix of randomly generated standard normal deviates of size k x n, where k is the number of simulated variables (28 weeks and 1 basis) – i.e., the number of variables in the correlation matrix- and n is the number of simulated variables (1,000) – i.e., the number of simulated outcomes. The simulated variables for this study are used to simulate 28 random weekly futures price changes and a final ending basis throughout the production period for 1,000 different outcomes. The simulated variables are each week's futures price change, from equation [1], which occurs at the beginning of the production period to the third week of March the following year, as well as ending basis from equation [2]. The production period was set at 28 weeks. Both futures price changes and basis are assumed to follow a normal distribution.

Next, end of period wealth was calculated from the simulated outcomes and used in an expected utility framework. End of period wealth is defined as:

$$\bar{W}_E = W_S + Q_c P_c - \bar{C} + Q_F^*(F_0 - F_1) + Q_O^*[\max(0, F_0 - F_1)] \qquad [5]$$

where, $\bar{W}_E$ is the ending total wealth, W_S is starting wealth and static at $150,000, Q_C is the quantity of cattle sold and static at 70 head, P_C is the cattle price, $\bar{C}$ is the input cost amount, Q_F* and Q_O* are, respectively, the amount of cattle hedged using a futures contract or option on futures, F_0 is the futures price at the onset of the hedge, week 36, where this represents the selling price since this is a short hedge, and F_1 is the end of period futures price. If a producer chooses to market his/her cattle through a spot market only, ending wealth collapses to $\overline{W}_E = W_S + Q_c P_c - \bar{C}$, since both Q_F* and Q_O* equal zero.

Within this framework, the producer maximizes expected utility according to von Neumann-Morgenstern utility function defined over ending wealth, W_E, which is strictly increasing, concave, and twice differentiable. To account for the variability in weekly futures price changes, which provide ending futures price, and basis, these variables are simulated using the process outlined previously.

Next, an ending wealth value is calculated for each hedging decision across 1,000 correlated futures price changes for each week, for 28 consecutive weeks, and ending basis outcomes. Ending wealth is then converted into utility values using a constant relative risk aversion (CRRA) utility function. The general form of the CRRA utility function follows:

$$E(U)_r = \sum_{i=1}^{n} \frac{1}{n} \frac{W_i^{1-r}}{1-r}, r \neq 1 \qquad [6]$$

Or

$$E(U)_r = \sum_{i=1}^{n} \frac{1}{n} \ln(W_i), r = 1 \qquad [7]$$

where, W_i is ending wealth for period i, r is a risk aversion coefficient, and n is the total number of simulated outcomes (1,000). Utility values are calculated for risk aversion coefficient of 0.5, 1.0, 2.0, 3.0, and 4.0, which follows Hardaker, Huirne, and Anderson (1997). These measures indicate a slightly risk averse producer (0.5) to an extremely risk averse producer (4.0). For this study, initial wealth is static and is set at $150,000 and cost are constant at $980.77 per head for Oklahoma cattle (Oklahoma State University, 2017) and $830.28 per head for Georgia cattle (Russel and Steward, 2006). Number of head is static at 70 head.

At the onset of the production period a producer knows the margin requirements and option premium, therefore these were held constant across all simulated outcomes[6]. Options strike price and options premium were static at $140/cwt. and $5.25/cwt. (or $2,625 per option contract), respectively, which utilizes an at the money option strike price. Initial margin and maintenance margin for futures contracts were static at $3,712.50 and $3,375, respectively. Given how small the amount is relative to the costs reported commission and transaction costs are not taken into consideration for this study[7].

Next, the certainty equivalent (CE) was derived from the utility function used for equation [6] or [7] for W_i given a certain risk coefficient. The CE represents the highest sure payment a decision maker would be willing to endure to avoid a risky outcome. For any two alternatives, *i* and *j*, if $CE_i > CE_j$ then alternative *i* is preferred to *j*. Therefore, the optimal marketing strategy can be taken to be that which results in the highest CE. The equations for calculating the CE from CRRA utility function used here are:

$$CE_{\gamma} = [\bar{U}(1-r)]^{(\frac{1}{1-r})} - W_0, r \neq 1 \qquad [8]$$

Or

$$CE_{\gamma} = e^{\bar{U}} - w_0, r \neq 1 \qquad [9]$$

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[6] Black (1976) defines the theoretical formula for commodity futures option premiums, which are dependent on the underlying volatility of the futures market price. Futures price volatility was assumed to be the same for all simulated outcomes at the onset of the production period and the option premium was constant. This may influence the option hedging results since option premiums are not allowed to vary with market volatility.

where, $\bar{U}$ is a value for utility calculated from equation [6] or [7]. The process of calculating the CE is repeated for each marketing alternative. Once the CE's are reported, a search for the highest CE value determines the optimal marketing alternative. It should be noted that this study does not take options premiums or margin calls into account when determining a producers' certainty equivalent though theory and real world practice might suggest that a producer who is risk averse might choose not to market their cattle using futures or options out of fear of having to pay more money to hedge.

After deriving certainty equivalent from the end of period wealth a non-pooled t-test was conducted to determine the significance between each strategy. The t-test was conducted by dividing the difference of two strategies by the square root of the sum of the variance divided by the number of observations of the two strategies. A t-distribution was then used to determine the level of significance. Next, the standard deviation was calculated by taking the square root of the variance for each marketing strategy.

Based on the objectives, the hypotheses for the study are as follows:

<u>*Hypothesis 1:*</u> End of period wealth, $\bar{W}_E$ outcomes are similar across all marketing strategies, (cash, futures, and options) or specifically:

$H1_0$: $\bar{W}_{E,Cash} = \bar{W}_{E,Fut} = \bar{W}_{E,Opt}$

$H1_A$: $\bar{W}_{E,Cash} \neq \bar{W}_{E,Fut} \neq \bar{W}_{E,Opt}$

where, $\bar{W}_E$ is the mean ending wealth for cash, futures (Fut), and options (Opt) marketing alternatives.

Hypothesis 2: The variability of ending wealth (i.e., marketing alternatives) is greatest for cash and smallest for futures, with options exhibiting ending wealth variability greater than futures but lower than cash marketing, or specifically:

H2$_0$: $\sigma_{W_E,Cash} > \sigma_{W_E,Opt} > \sigma_{W_E,Fut}$
H2$_A$: $otherwise$

where σ_{W_E} is the standard deviation of ending wealth for cash, futures, and options.

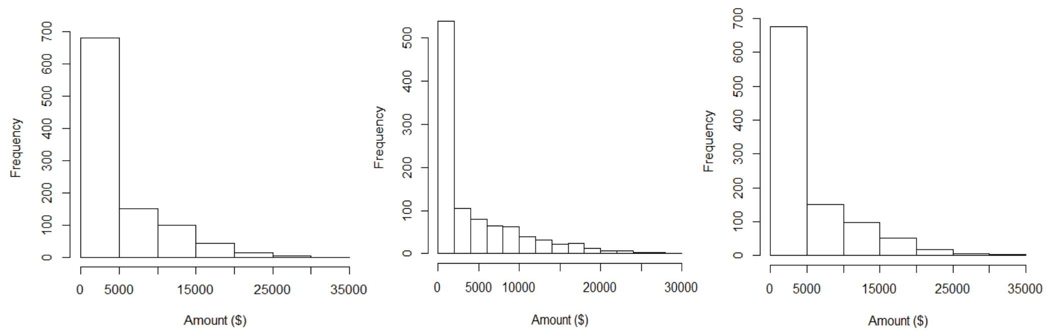
To accomplish objective (1) additional margin requirements from the initiation of the production period until the end of the period were determined. Margin account balances are marked-to-market each trading day, but the methods here calculate this on a week-to-week basis. Thus, margin balances were checked relative to the maintenance margin requirements established by the CME Group in September of 2016. When the end of week margin balance for each simulated outcome falls below the maintenance margin a margin call was instituted to replenish the account to the initial margin level. Total additional margin needs (cash outflows) were summed for each simulated outcome.

CHAPTER IV

RESULTS

Mean prices received for cash markets, futures contracts gains/losses, and options gains/losses were, respectively, $142.14 per hundredweight (cwt.), $0.98/cwt., and $1,913/cwt. for Oklahoma City steers; $139.89/cwt., $1.06/cwt., and $1,787 for Oklahoma City heifers; and $139.81/cwt., $1.11/cwt., and $2,100 for Georgia steers.

Simulation outcomes for each production practice, Oklahoma steers, Oklahoma heifers, and Georgia steers were conducted independently. Total additional margin account needs (i.e., margin calls) which result in producer cash outflows for Oklahoma steers averaged $4,425 with 229 occurrences (22.9 percent) of receiving no margin calls out of the 1,000 simulated outcomes and 66 occurrences (6.6 percent) of additional margin needs of $15,000 or higher. Oklahoma heifers averaged $4,176 with 318 occurrences (31.8 percent) of receiving no margin calls and 67 occurrences (6.7 percent) of total margin calls greater than $15,000. Georgia steers averaged $4,575 with 264 occurrences (26.4 percent) of receiving no margin calls while there were 78 occurrences (7.8 percent) of total additional margin needs about $15,000. The distribution of cash, outflows for each production practice is provided in Figure 2.



(a) (b) (c)

Figure 2. Distribution of cash outflows for Oklahoma steers (a), Oklahoma heifers (b), and Georgia steers (c).

End of period wealth for cash marketing only, cash marketing with futures hedging, and cash marketing with put options were calculated at $153,481, $153,970, and $155,394, respectively, for Oklahoma steers. Oklahoma heifers had end of period wealth values of $152,228, $152,868, and $154,125 for cash markets, futures hedging, and options hedging, respectively. End of period wealth for Georgia steers were $162,833, $163,389, and $164,933 for cash markets, futures hedging, and options hedging respectively. Across all three groups of calves, when comparing the optimal marketing strategy, using a put option to hedge yielded the highest end of period wealth, relative to cash only and futures hedging. Figure 3 shows the results for end of the period wealth of each marketing strategy for each group of calves.

Transaction costs were not captured by the reported ending wealth values. Typical transaction costs for futures markets participants are $30 to $70 per round turn ($0.06/cwt. to $0.14/cwt.) for a single feeder cattle futures contract trade, which represents 50,000 pounds per contracts. Option commission and transactions costs are typically $25 per trade ($0.05/cwt.) plus any additional transactions if the option contract is exercised. When considering these, assuming a futures transaction cost of $50 per turn, average ending wealth for futures would be $153,920, $152,818, and $163,339 for Oklahoma steers, Oklahoma heifers, and Georgia steers, respectively. A producer using options would see an average ending wealth of $155,343.10, $154,073.95, and $164,882 for each production practice. The ranking of end of the period wealth for each risk management strategy does not change across the three groups of calves after taking into consideration transaction costs. Options still yields the highest end of the period wealth followed by futures and then cash.

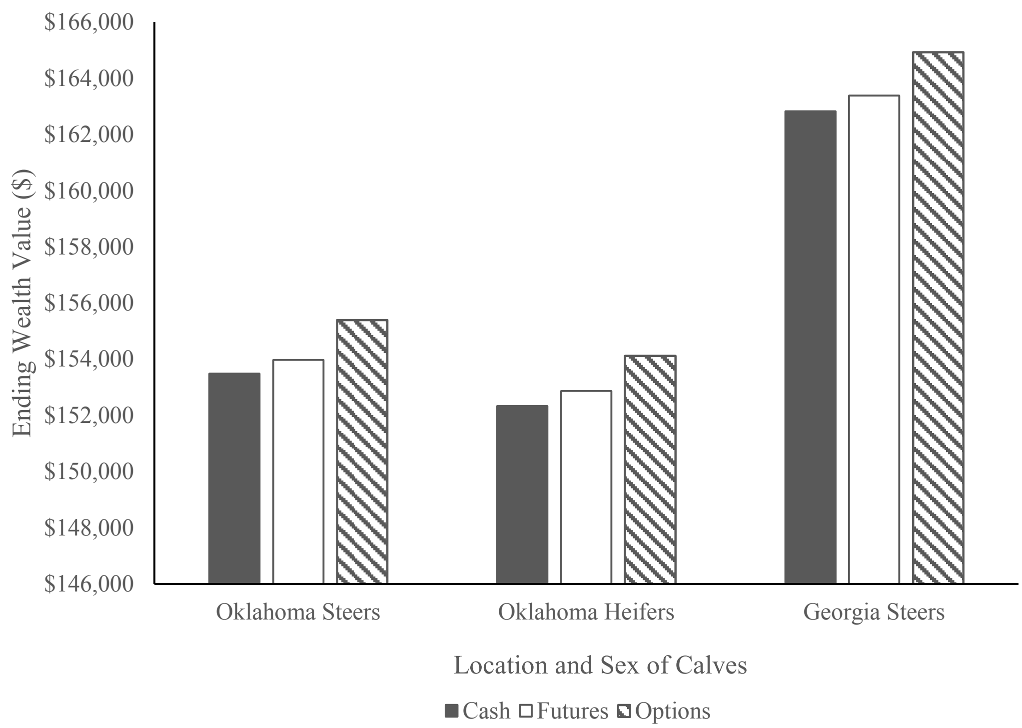


Figure 3. Mean end of period wealth values for Oklahoma steers, Oklahoma heifers, and Georgia steers marketed via cash markets, futures contracts, and options.

Table 2 reports the mean and standard deviation of the end of period wealth for each simulated outcome for end of period wealth for each marketing strategy across all three production practices. Using a non-pooled t-test to determine the significance of the mean simulated ending wealth outcomes within each production practice indicates that cash only marketing ending wealth values for each production practice are statistically different from ending wealth when futures are used to hedge and when options are used to hedge at the 10% level. The mean ending wealth of simulated outcomes for futures hedging and option hedging are not significantly different from each other at the 1% level. Therefore, the null hypothesis for hypothesis one is rejected and the alternative is accepted with respect to cash only marketing and futures hedging as well as cash only marketing and options hedging.

The variance of simulated end of period wealth outcomes were measured using an F-test. Standard deviations of $11,269, $685, and $6,442 for cash, futures, and options were computed for Oklahoma steers, respectively. Cash for Oklahoma heifers had standard deviations of $10,451 while futures were $159 and options were $5,836. For Georgia steers, there was a standard deviation of $11,277 for cash, $170 for futures, and $6,336 for options.

Table 2. Results of Simulated Ending Wealth and Ending Wealth Standard Deviation for Each Marketing Alternative and Production Scenario

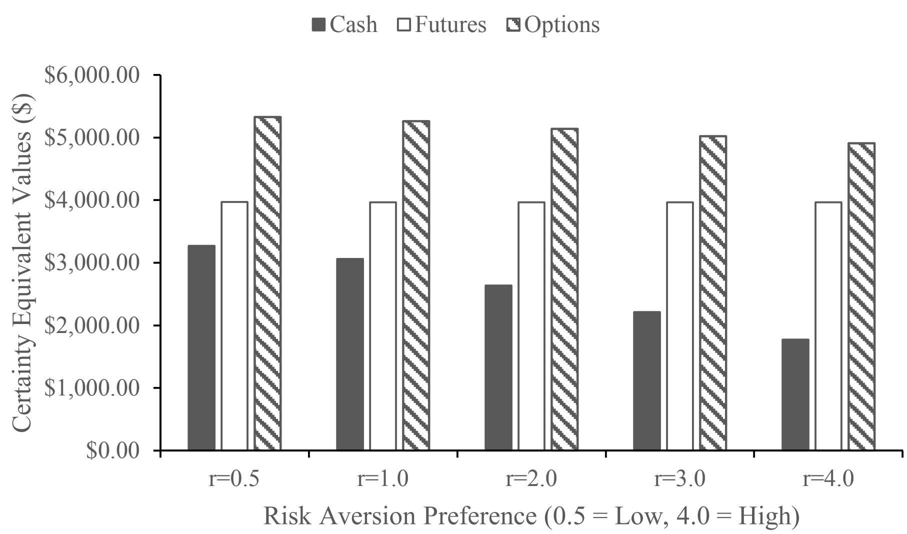
	Cash			Futures			Options		
Calf Grouping	Mean Ending Wealth	Standard Deviation	D.F	Mean Ending Wealth	Standard Deviation	D.F	Mean Ending Wealth	Standard Deviation	D.F
OK Steers	$153,4801[a,b]	$11,269[x]	1006	$153,970[a*]	$685[y]	999	$152,534[b]	$8,6,442[z]	999
OK Heifers	$152,338[a,b]	$10,451[x]	1997	$152,868[a]	$159[y]	999	$151,265[b]	$5,836[z]	1572
GA Steers	$162,833[a,b]	$11,278	1021	$163,389[a]	$170[y]	1000	$162,007[b]	$6,337[z]	1000

Note: A non-pooled t-test was used to determine the significance of mean end of period wealth where a, b, and c denotes the mean end of period is different at the 1% level ($P < 0.01$)
An F-test was used to determine the significance of the variance, reported here as standard deviation, of end of period wealth where x, y, and z denotes the variance is different at the 1% level ($P < 0.01$)

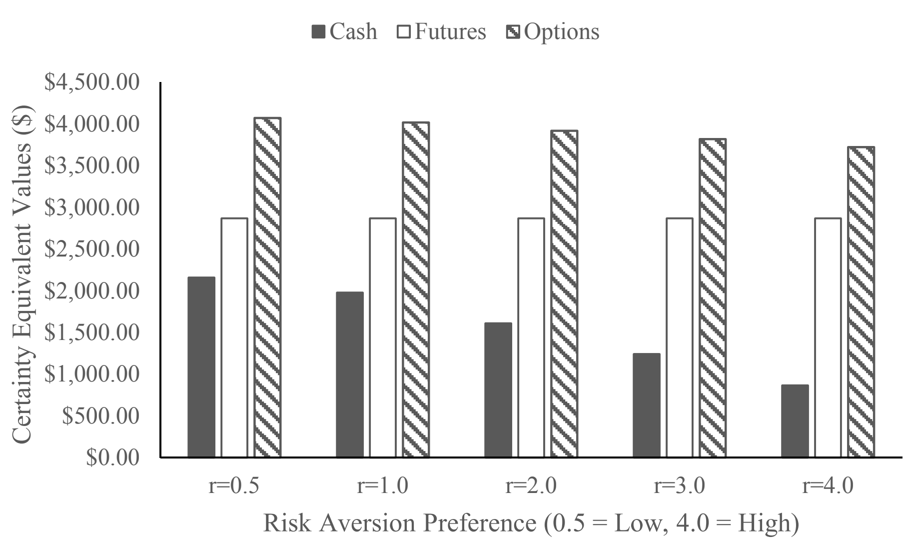
Given the results of the F-test the variability of ending wealth is greatest for cash and smallest for futures, with options exhibiting ending wealth variability greater than futures but lower than cash marketing. Therefore, the null hypothesis from hypothesis two is accepted.

The price a producer would be willing to accept to avoid a risky outcome is known as the certainty equivalent (Hardaker, Hurine, and Anderson; 1997). The certainty equivalent (CE) value is calculated by equations [8] and [9]. CE's were figured for producers with five different levels of risk aversion (0.5 = Extremely Low, 1.0 = Low, 2.0 = Reasonable, 3.0 = High, 4.0 = Extremely High). CE values for Oklahoma steer producers that sold on cash markets were figured at $3,272, $3,063, $2,639, $2,210, and $1,775 for producers with low to high risk aversion levels, respectively. Oklahoma heifer producers CE's were figured at $2,158, $1,976, $1.611, $1,241, and $867 for producers with low to high risk aversion levels, respectively. Similarly, Georgia steer producers had CE prices of $12,622, $12,424, $12,025, $11,622, and $11,214 for producers with low to high risk aversion levels, respectively.

Certainty equivalents for producers who marketed their steers using futures contracts were generally equal across all levels of risk aversion for each production practice, which is a valid outcome based on the standard deviations reported in table 2. Figure 4 depicts the certainty equivalents for the varying levels of risk aversion used across the three different production practices analyzed. From figure 4 hedging with options yielded the highest CE's for each level of risk aversion across each production practice. Oklahoma steer producers had CE values of $3,969, $3,968, $3,967, $3,965, and $3,964, respectively. Heifer producers had CE's of $2,867.47, $2,867.43, $2,867.34, $2,867.26, and $2,867.18, respectively. And Georgia steer producers had CE values of $13,388.90, $13,388.86, $13,388.77, $13,388.68, and $13,388.59, respectively. Much like producers who sold their calves on cash markets, producers who marketed their steers using options saw a decrease in CE as the risk aversion level increased. Oklahoma steer producers received CE values of $5,329, $5,266, $5,142, $5,024, and $4,910, respectively. Heifer producers received CE values of $4,071, $4,019, $3,916, $3,818, and $3,723 and Georgia producers received CE values of $14,874, $14,816, $14,703, $14,596, and $14,490, respectively. Based on the values of the CE values for each group of calves and producers it can be determined that producers who marketed their calves using options received a higher CE. Cash had more variability and lower CE values while options had less variability and higher CE values. The significant difference in CE values for Georgia steers is due to the differences in price per head for Georgia steers relative to Oklahoma calves. Figure 4 shows the results for each group of calves.



(a)



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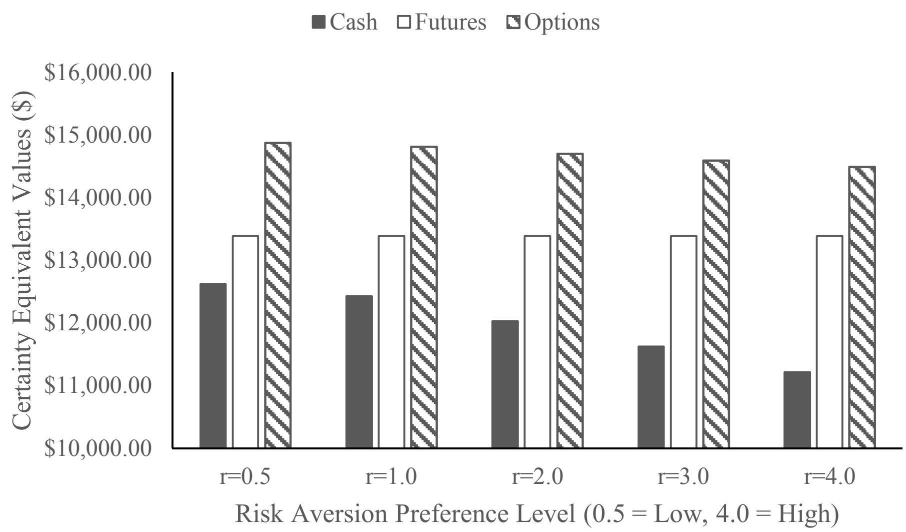

(c)

Figure 4. Certainty equivalent results for various risk aversion levels under constant relative risk aversion for each production practice, Oklahoma steers (a), Oklahoma heifers (b), and Georgia steers (c).

CHAPTER V

CONCLUSION

This study was conducted to measure cash outflows and determine the optimal marketing strategy for selling winter grazed stocker cattle. Previous studies have suggested that agricultural producers do not hedge as much as theory would suggest (Arias, Brorsen, and Harri, 2000; Riley and Anderson, 2010). The results from this study indicate that concerns of cash flow requirements when hedging with futures – which require minimum margin account levels – is valid as approximately 6 to 8 percent of the 1,000 simulated outcomes had total margin call amounts greater than $15,000. Relative to cash only marketing and options, the average additional cash requirements for futures are notably large.

Additionally, across all three production practices analyzed, hedging with options yielded the highest ending wealth value followed by futures contracts and then cash. This result is likely due to the underlying historical data that the simulation outcomes were based on exhibiting a downward trend. This would lead to a net gain for both the futures and options strategies (where the option strategy used a strike price equal to the initial futures price). This outcome is not typical under the assumptions of efficient futures markets as well as the increased cost to reduce risk and is specific to the underlying parameters used in the simulation.

End of period wealth was statistically lower for cash only marketing relative to hedging with futures and hedging with options and, once again, is likely a result of the parameters used in the simulation. Even so, the lower trending outcome of the data supports the result of futures hedging yielding a higher ending wealth than cash only marketing and options hedging offering the highest ending wealth when the option strike price is at the money. Furthermore, the end of wealth outcomes from the simulation matched expectations that hedging with futures had the smallest variability of final wealth, while marketing only in the cash market had the highest variability of ending wealth. This provides additional evidence that hedging reduces risk for producers.

Price variability continues to be of concern to producers. Hedging with futures and options allows producers to minimize price risk. However, concerns related to margin calls as well as high option premium rates hinder the adoption of these tools. This study confirmed previous results that hedging reduces price variability for winter grazing of steers and heifers in Oklahoma as well winter grazing steers in Georgia. This study also measured to additional margin requirements, within the production period, when hedging with futures. The average margin requirement, approximately $4,400, exceeded the known option premium amount, $2,625, as well as an expected risk management cash outflow of $0 for cash only marketing. When taking the margin requirement into account, it is understandable that producers continue to avoid hedging using futures, and options to a lesser degree, considering the results of Hall et al. (2003) that cattle producers consider cash/financial reserves as a better risk management tool.

REFERENCES

Anderson, J.D., A. Harri, and K.H. Coble 2009. "Techniques for Multivariate Simulation from Mixed Marginal Distributions with Application to Whole-Farm Revenue Simulation." *Journal of Agricultural and Resources Economics* 4(1):53-67.

Arias, J., B.W. Brorsen, and A. Harri. 2000. "Optimal Hedging Under Nonlinear Borrowing Cost, Progressive Tax Rates, and Liquidity." *The Journal of Futures Markets* 20(4):375-396

Black, F. 1976. "The Pricing of Commodity Contracts." *Journal of Financial Economics* 3(1-2):167-179.

Hall, D.C., T. O. Knight, K. H. Coble, A. E. Baquet, and G.F. Patrick. 2003. "Analysis of Beef Producers' Risk Management Perceptions and Desire for Further Risk Management Education." *Review of Agricultural Economics* 25(2):430-448.

Harri, A., J.M. Riley, J.D. Anderson, and K.H. Coble. 2009. "Managing economic risk in value-based marketing of fed cattle." *The Journal of the International Association of Agricultural Economists* 40(3):295-306.

Hardaker, J.B., R.B.M. Hurine, and J.R. Anderson. 1997. "Coping With Risk in Agriculture." New York: CABI Publishing.

Johnson, L.L. 1960. "The Theory of Hedging and Speculation in Commodity Futures." *The Review of Economic Studies* 27(3):139-151.

Kastens, T. and T.C. Schroeder. 1994. "A Trading Simulation Test for Weak-Form Efficiency in Live Cattle Futures." *Journal of Futures Markets* 15(6):649-676.

Lence, S.H. 1995. "The Economic Value of Minimum-Variance Hedges." *American Journal of Agricultural Economics* 77(2):353-364.

Mirsha, A.K. and J.E. Perry. 1999. "Forward Contracting of Inputs: A Farm-Level Analysis." *Journal of Agribusiness* 17(2):77-91.

Moschini, G. and H. Lapan. 1995. "The Hedging Role of Options and Futures under Joint Price, Basis, and Production Risk." *International Economic Review* 36(4):1025-1049.

Musser, W.N., G.F. Patrick, and D.T. Eckman. 1996. "Risk and Grain Marketing Behavior of Large-Scale Farms." *Review of Agricultural Economics* 18:65-77.

Oklahoma State University. 2017. "Stocker Enterprise Budget – 150 Steers." Oklahoma Agricultural Economics Enterprise Budget Software.

Riley, J.M. and J.D. Anderson. 2010. "Comparison of Hedging Cost with Other Variable Input Costs." *American Society of Farm Managers and Rural Appraisers* 73:145-153.

Russel, L. and L. Stewart. 2006. "Stockering Steers on Temporary Winter Grazing, Hay & Supplement." University of Georgia Cooperative and Extension Service.

Sartwelle, J., III, D. O'Brien, W. Tierney, Jr., and T. Eggers. 2000. "The Effect of Personal and Farm Characteristics upon Grain Marketing Practices." *Journal of Agricultural and Applied Economics* 32(1):95-111.

Stalcup, Larry. 2014. "Rancher Demonstrates the Benefit of Hedging for Cowmen." Beef Magazine. Available at http://www.beefmagazine.com/cattle-prices/rancher-demonstrates-benefits-hedging-cowmen.

Stein, J.L. 1961. "The Simultaneous Determination of Spot and Futures Prices." *The American Economic Review* 51(5):1012-1025.

Turvey, C.G. and T.G. Baker. 1990. "A Farm-Level Financial Analysis of Farmers' Use of Futures and Options under Alternative Farm Programs." *American Journal of Agricultural Economics* 27(4):946-957

United States Department of Agriculture, Agricultural Marketing Service. 2017. "Oklahoma National Stockyards – Oklahoma City. Feeder Cattle Weighted Average Report."KO_LS795. Oklahoma City, OK.

United States Department of Agriculture. Agricultural Marketing Service. 2017. "Georgia Cattle Auctions Weekly Summary." TV_LV145. Thomasville, GA.

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