PRICE ANALYSIS IN THE STOCKER INDUSTRY

by

EMILY MOLLOHAN

B.S., Agribusiness, Kansas State University, 2013
B.S., Animal Sciences & Industry, Kansas State University, 2013

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Agriculture Economics
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2014

Approved by:

Major Professor
Glynn T. Tonsor

Abstract

The purpose of this analysis is to examine two aspects of price analysis in the stocker industry in order to better assist producers making purchasing decisions. One analysis looks at forecasting value of gain, while the second looks at drivers of price differentials between calves and yearlings.

When analyzing forecasts on value of gain, weekly data was collected to compare a naïve approach and futures market implied basis-adjusted approaches that include one to five years of historical average basis. This allowed for the assessment of five different models for nine scenarios. The conclusions from this were inconsistent with what was hypothesized and the naïve approach was either worse or no better when compared to using the futures market implied basis-adjusted approaches to forecast value of gain. The drawback to this analysis was that it was solely influenced by error on forecasting the selling price and in future work a forecasting horizon will be incorporated on the buying price.

In order to analyze the price premiums and discounts between calves and yearlings, a confirmation, update and expansion were completed following monthly models by Marsh (1985). Three elements are considered when predicting price premiums and discounts between two weight classes; cost of gain (proxied by corn price), slaughter price, and seasonality. Estimated models in the confirmation for years 1972 to 1982 and the update for years 1973 to 2013, show that premiums and discounts are influenced by expected changes in corn price and/or slaughter price, but not highly affected by seasonality. However, in the expansion for years 1993 to 2013, corn price, slaughter price, and seasonality were all significant to the models and in higher magnitude when compared to those results in the confirmation and update. Understanding

the relationships between all variables in these models allows producers in the cattle-feeding industry to make management decisions based on current marketing conditions and trends.

Table of Contents

List of Figures

List of Tables

Acknowledgements

I would like to acknowledge my major professor, Dr. Glynn Tonsor, for all of his guidance and patience during my time in graduate school. I would especially like to thank him for making my graduate school career a great learning experience and most of all, for putting up with me on days where my brain was on another planet. I would like to thank Dr. Ted Schroeder for pushing me to think deeper about my research and what was actually happening behind the numbers. Another thank you to Dr. Gregg Ibendahl for being on my committee.

I want to thank God for putting here and always knowing what is best for me. This opportunity has taught me more than just about agricultural economics and for those experiences I am extremely grateful.

When I think about how I made it here, it would be a lie to say I did it all on my own, because when I look at the path I took, there are many people that saw more potential than I did. Mr. Wagner was not only the best high school agricultural education teacher, but was an admirable mentor. Mrs. Lora Boyer changed my life when I applied to the McNair Scholars Program and the support she has given is phenomenal, I wouldn't be here without her and the other McNair staff. Dr. John Leatherman was gracious when employing me as a student research assistant and I greatly appreciate all of his support these last five years. My dad has been there from day one and stood beside me no matter what. His unending support, listening skills, and "good morning" texts are something to be cherished.

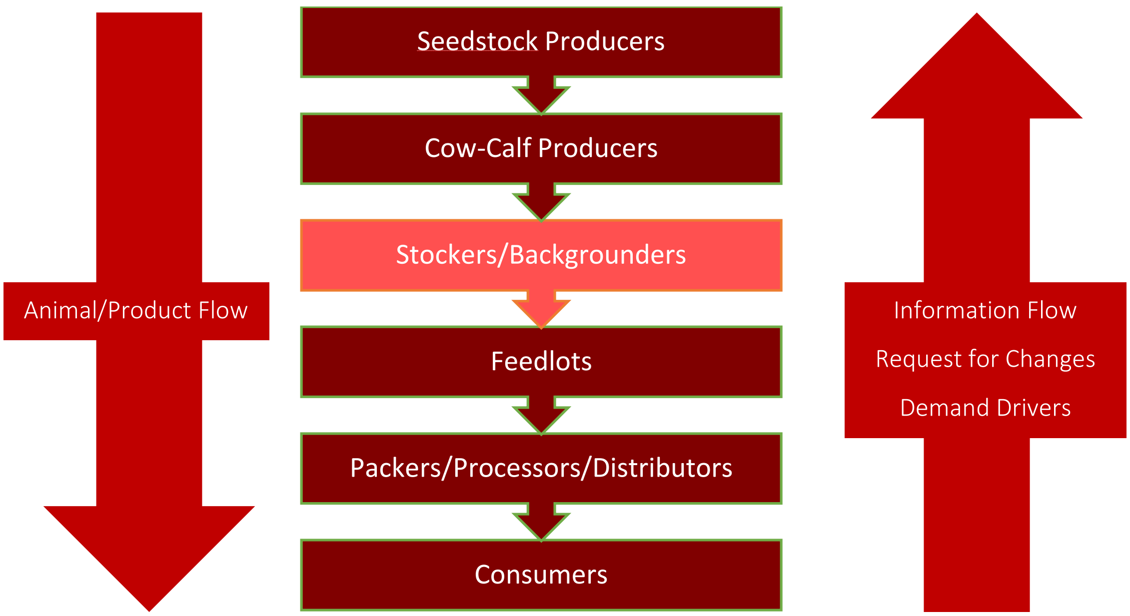
To all of my friends that supported me, both those in graduate school with me and those not, you know who you are! For those of you that live close, I wouldn't have been able to do it without the endless hours of conversation, GSAE events, trips to Radina's, games of Sorry!, making you sit through my presentation "just one more time", and your understanding of what I

was going through. For those of you far away, the pick-me-up notes, letters, flowers, and packages I received in the mail meant so much to me. The large amounts of texts or the occasional phone calls are something I appreciate more than you will ever know. Thank you so much!

Chapter 1 - Overview of the Stocker Industry and Review of Previous Literature

The beef industry is comprised of many different levels that are outlined in Figure 1.1.

Figure 1.1 Beef Supply Chain



This research focuses on the stocker industry because it is a facet of agriculture that is not extensively researched. A stocker operator is a producer that purchases cattle after weaning and has a goal to capitalize on adding extra weight before selling the animal to a feedlot operation. A cow/calf operator can background their weaned calves in order to capitalize on this revenue margin as well. In this research we assume that the cow/calf producer is open to backgrounding.

During weaning, beef producers face an important management decision of whether to sell their calves or retain ownership. This decision is usually made by analyzing current market conditions or price forecasting using either futures markets or historical data.

Benefits of retained ownership for calves after weaning include, but are not limited to, increased animal value by adding weight, documenting post-weaning performance, and capitalizing on superior genetics and preventative health programs (White, et al., 2007). A few options for cow/calf producers and stocker operators during this time are highlighted by Marsh (1985). Fall-weaned calves can either be marketed during the late fall/early winter or be fed through the winter with light to moderate rates of gain. If retained, options at this point are to either sell or again retain for spring/summer grazing. However, another common practice is for calves to be backgrounded with higher rates of gain during the winter months and then either be marketed to feedlots or placed on direct feed in the spring (Marsh, 1985).

A producer must understand the current beef industry structure, possible risks (price, health, performance), and their own risk preferences when making these decisions (White, et al., 2007). This research contains two chapters that focus on the stocker industry and are both driven by the prices of two different weight classes. The first looks at forecasts of value of gain and the second looks at the drivers of price differentials between calves and yearlings.

Using futures market implied basis-adjusted forecasts has long been a method for cattle producers making management decisions. This is highlighted in the article titled *"Improving Cattle Basis Forecasting"* by Tonsor, Dhuyvetter and Mintert (2004). Their research touched on the number of optimal years to include in forecasting feeder cattle and live cattle basis. It was concluded that it would be beneficial for a basis forecaster to use a 3-year average for feeder cattle and a 4-year average for live cattle. These results are the motivation behind this continued research on forecasting value of gain, which was completed by using historical cash and futures market data to compare different approaches used by producers. These two approaches were the naïve approach and the futures market implied basis-adjusted approach that includes a 1-year average, 2-year average, 3-year average, 4-year average and 5-year average of the basis added back to the futures price to predict value of gain. This allowed for the comparison of all six approaches in nine different scenarios.

Drivers of price premiums and discounts are also important to understand. Marsh (1985) led the motivation of this topic in his paper titled "*Monthly Price Premiums and Discounts between Steer Calves and Yearlings."* This research focuses on confirming, updating and expanding his research, which used data spanning from January 1972 to December 1982, to better understand how factors such as cost of gain and price of slaughter cattle affect the price of a calf, as well as, yearling and the price differential between the two classes of cattle.

Another large motivator of this research is that about three-fourths of the difference in net return between high- and low-profit producers is due to cost differences, while the other one-fourth is due to differences in gross income per cow (Dhuyvetter and Herbel, 2013). This implies that the differentiation of profit between high- and low-profit farms is largely due to cost management. Due to this and the fact that cattle producers are largely price-takers, producers have much to gain from understanding value of gain, and drivers of price differentials in the feeder cattle market. The research that has been conducted in these areas is minimal and outdated given the current market situation.

Chapter 2 - Forecasting Value of Gain

2.1 Introduction

As a stocker operator, the main goal is to capitalize on adding extra weight to weaned cattle before they are sold or placed in a feedyard. As mentioned before, producers forecast prices using futures market prices, historical data, or a combination of both to guide herd management decisions. Value of gain is sometimes confused with the cost of gain. However, value of gain is the margin between how much the animal is worth at selling less the purchasing price then divided by the amount of weight added. This yields the revenue gained per pound. Whereas, the cost of gain is defined as "the average cost of each additional pound of weight gained by an animal after it has been placed on feed" (Anderson and Trapp, 2000). The reason for focusing on value of gain is due to the fact that the stocker industry is a minimally researched sector and the research that has been done is outdated. Also, stocker operators are considered price-takers since supply and demand in the stocker industry are derived from the cow/calf sector and up-stream (feedlots, packers, and consumers) sectors (Dhuyvetter and Herbel, 2013). Therefore, it is extremely important to understand the market and the drivers on value of gain as critical factors in profitability realized by stocker producers.

The purpose of this chapter's analysis is to assess the accuracy of two common approaches used by producers to predict value of gain when looking at buying or retaining ownership of weaned calves. The two approaches addressed are: naïve approach (NA) and futures market-implied basis-adjusted approach (FMI), as described below.

2.2 Data

Data for this research was collected from the Livestock Marketing Information Center (LMIC). The first data set reports the weighted average summary for Kansas auctions. The information utilized for this research was the weekly price information classified by weight in 50 pound increments for feeder cattle steers, medium and large frame #1. The weighted average for Kansas auctions utilized data ranging from the 500 to 850 weight classes. The first week reported in this data set is June 11, 1999. The second data set reports the weekly value of feeder cattle futures by monthly contract. The first week reported in this data set is November 3, 1989. When running the models for this research all data was excluded except for weekly data ranging from January 7, 2005 to December 28, 2012. The reason for ending at this date is when the data was collected it ended on September 20, 2013. As seen in Table 2.1 the longest forecasting horizon used in this research is 25 weeks. In order to capture the entire 25 week horizon, placing a calf on December 23, 2012 allows for utilization of the entire data set.

In both of the data sets there were missing values. In order to fill in the blanks there were multiple steps that were taken.

For the combined Kansas auction data, there were three stages used to impute the missing observations. The first stage consisted of multiple steps. If there was not missing data in the table, the value was left the same. If a value was missing, the first step in calculating the replacement was to average the cash value from the week before and the cash value of the next week. A separate process was required for instances in which either the previous or following week's data, or both, was not available. An average was calculated for the entire data set for each set of weight classes. These values were then used to yield carry values[1]. The given values from the preceding weight classes were used and carry values were subtracted to obtain approximate cash values. An average of nine percent of data was adjusted for the data ranging from the 500 to 850 weight classes and this accounted for all the missing values for these weights being used.

[1] A carry value is the difference between the average of one weight class and the next.

Although, this adjusted all blanks for the weight classes used in this research, two more steps were taken to fill blanks in the entire data set. This allows for the use of this data in future research projects and for any future research that considers lighter or heavier weights. For stage two of imputing missing observations the process was repeated using the data generated in stage one. The cash value from the prior week was averaged with the cash value from the next week. When those values were not available, averages were calculated for the entire data set and then used to yield carry values. These carry values were subtracted from the preceding weight classes to yield approximate cash values.

After stage one and stage two, there was a minimal amount of missing data. To adjust these values, another method was utilized. Using cash values from one year prior and feeder futures data from that date, a basis[2] was calculated. This was then added to the futures price of the missing date to obtain a cash value. This concluded all stages of imputing missing observations and yielded a data set with no missing values.

To impute the missing values in the feeder futures data there was only one stage needed. If there was not missing data, the value was left the same. If the prior and following week's data were available, these two values were averaged together to fill the missing week's data. When these were not available, another step was utilized. An average was calculated for the entire data set of monthly contracts. These averages were then used to yield carry values[3]. These carry values were then subtracted from given values of the preceding contracts in order to obtain approximate futures contract values. An average of three percent of data was adjusted.

---

[2] Basis, in this research is the difference between cash and futures price.

[3] Carry values are the difference between the average of one contract and the next.

2.3 Procedure

There were two different approaches used to predict value of gain in this research, the naïve approach and the FMI basis-adjusted approach. The naïve approach, simply reflects the price of two different weight classes in the current cash market. For example, buying a 525 pound calf on a certain date was compared with the price of selling a 725 pound calf on the same day in the same cash market. The approach ignores the amount of time it takes to add a set amount of weight, but is used by producers because of its simplicity. For the FMI basis-adjusted approach, data from the combined Kansas auctions and the feeder cattle futures market were utilized. This approach is forward-looking, whereas the naïve approach is not. A 1-year, 2-year, 3-year, 4-year and 5-year average historical basis was calculated. It is important to note that basis, in this instance, is calculated as cash minus futures. These average basis values were then added back to the futures contract used, in order to predict selling price. The futures contract used is tied to the timing of the planned sale at the heavier weight. Using these values, the process above was repeated to calculate predicted value of gain and then using cash values from the combined Kansas auctions an actual or realized value of gain was used.

Using the prices for each weight class, the expected value of gain per hundred weight (cwt) was calculated:

$$(1)\ \ Exp\_VOG_t^i = \frac{[Exp_{t-j}(SP_t^i) * SW_t^i] - [BP_{t-j}^i * BW_{t-j}^i]}{[(SW_t^i) - BW_{t-j}^i]}$$

where $Exp\_VOG_t^i$ is the expected value of gain in time, *t*, for scenario *i;* $Exp_{t-j}(SP_t^i)$ is the expected selling price in time, *t,* for scenario, *i,* being predicted at time of placement, denoted by *t-j*; BP_{t-j}^i is the buying price at placement; SW_t^i is the expected selling weight at time, *t*, for scenario, *i*,; and BW_{t-j}^i is the buying weight at time of placement.

It is important to note that in this equation, buying price, selling weight and buying weight are all assumed as known variables, while selling price is being forecasted. In order to be more realistic about producers' decision-making processes, future work will also include forecast horizons on the buying price. This forward-looking research may incorporate four, eight, and twelve week buying horizons to pattern a producer making purchasing decisions for the future.

Using the historical data, actual selling price was then pulled to coincide with the number of weeks it would take to add the desired weight at a specified daily rate of gain. Actual buying price was subtracted from actual selling price (adjusted by weights) in order to obtain the actual dollar gain per head per cwt and then divided by pounds gained to yield actual value of gain per cwt:

$$(2)\ Actual\_VOG_t^i = \frac{[(SP_t^i)*SW_t^i] - [BP_{t-j}^i*BW_{t-j}^i]}{[(SW_t^i) - BW_{t-j}^i]}$$

where $Actual\_VOG_t^i$ is the actual value of gain in time, *t*, for scenario, *i*; SP_t^i is the actual selling price at time, *t*, for scenario *i*; SW_t^i is the actual selling weight at time, *t*, for scenario *i*; all other variables are the same as equation (1).

Using these two formulas allows us to evaluate the error in value of gain forecasting by subtracting the expected value of gain from the actual value of gain:

$$(3)\ ErrorVOG = [(Actual\_VOG_t^i) - (Exp\_VOG_t^i)].$$

It is important to note that in this instance we are assuming that buying price, buying weight and selling weight are known. Therefore, the error in the forecast of value of gain is solely based on error of predicting the selling price and takes on no performance risk or an error on the buying price, which is highly unlikely in most producer's decision making process. We start with this to reflect a producer that purchased cattle from the cash market yesterday and is planning to put a certain amount of weight on before selling. Even though it would be more realistic to have a forward-looking buying scenario, this was a much simpler situation for this research to begin.

Using this, the absolute percentage errors were calculated:

$$(4)\ AE\% = ABS\left(\frac{ErrorVOG}{ActualVOG}\right).$$

The reasons for using the absolute percentage error include the ever-increasing cattle prices from year to year, as well as, the fact that as cattle weigh more; they are worth less per pound. Also, when incorporating the absolute value of the percentage error, it allows us to analyze the accuracy of the forecast on an absolute basis. However, if stocker or feedlot operators were forecasting value of gain they would not benefit from using the absolute value. For example, a stocker operator would want an error that under-predicts the value of gain meaning that they had greater profit than predicted. On the contrary, a feedlot operator would benefit from an error that over-predicts the value of gain because that would mean they paid less to increase the weight of the animal. In this research we are solely interested in knowing the amount of error on the estimate and that is the reason for using the absolute percentage error.

There are nine different scenarios (Table 2.1) used in this research to allow for three total pounds of weight gain and three different rates of gain. This allowed for a clear observation of changes in the model when adding different weights at various rates of gain. From this point on scenarios will be referred to by scenario name. Each scenario is outlined in Table 2.1 below to indicate how many weeks it would take to put on each amount of weight at the specified rate of gain. It is important to know that when calculating weeks of gain, rounding was used and that is why the numbers do not double when adding another 100 pounds at a certain rate of gain. As specified, scenario G is the shortest time frame with the least total gain and fastest rate, while scenario C is the longest with the most total weight gain and the slowest rate. In all scenarios, placement weight is assumed to be 525 pounds.

Table 2.1 Scenarios

Scenario Name	Pounds of Gain (lbs)	Average Daily Gain (lbs/day)	Weeks of Gain
A	100	1.75	9
B	200	1.75	17
C	300	1.75	25
D	100	2.00	8
E	200	2.00	15
F	300	2.00	22
G	100	2.25	7
H	200	2.25	13
I	300	2.25	20

In order to assess the absolute percentage error values, histograms were constructed for the values calculated using the naïve approach in all scenarios. The data found in the histograms for all scenarios is detailed in Table 2.2. Looking at scenario A, the majority of absolute percentage errors are between zero and ten percent, most of these being below five percent error. More narrowly, three-quarters of the values show less than one percent error. This scenario yields a large variance, but also has three outliers greater than 100% that most likely drive the variance of the data set. When analyzing the histograms across all scenarios, the majority of the absolute percentage errors are between zero and one percent which shows low variability. However, when calculating the variance for the data analyzed, some scenarios produce large variances. This can most likely be explained by large outliers having a large impact on the variability of the data. Therefore, in this research, absolute percentage errors exclude values greater than 95% to control for any strong interference by the outliers.

Table 2.2 Histograms for Absolute Percentage Error, Naïve Approach

	Frequency by Scenario								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
0	0	0	0	0	0	0	0	0	0
1	312	352	367	312	355	373	321	364	379
2	32	25	42	36	21	34	26	23	30
3	13	10	3	23	11	7	23	9	5
4	17	4	3	9	10	1	11	3	1
5	11	5	0	10	5	1	7	3	0
6	5	5	0	3	4	0	6	4	1
7	4	3	0	5	1	1	0	1	1
8	0	2	0	2	1	0	2	3	0
9	3	0	1	1	1	0	2	1	0
10	1	1	0	2	0	0	1	0	0
11-20	13	7	1	5	0	0	10	5	0
21-30	0	0	0	3	3	0	2	0	0
31-40	2	1	0	2	0	0	0	1	0
41-50	0	0	0	3	0	0	2	0	0
51-60	0	0	0	0	1	0	1	0	0
61-70	0	0	0	0	1	0	1	0	0
71-80	1	0	0	0	0	0	1	0	0
81-90	0	0	0	0	0	0	0	0	0
91-100	0	0	0	0	0	0	0	0	0
More than 100	3	2	0	1	3	0	1	0	0
Average	2.856	2.154	0.495	2.080	3.343	0.455	2.913	0.847	0.439
Variance	204.531	288.487	0.903	58.181	905.623	0.329	384.662	6.401	0.328

2.4 Models

In order to analyze patterns on drivers of percentage error, we considered five different models for all nine scenarios. It should also be noted that absolute percentage errors greater than 95% were excluded in these models in order to avoid strong interference from outliers (Table 2.2). The base model (B) shown in equation (5) focuses on the FMI basis-adjusted and naïve approaches without any other variables. The naïve approach is omitted, leaving the 1-year average, 2-year average, 3-year average, 4-year average, and 5-year average in the FMI basis-adjusted approach to be analyzed in comparison with the naïve approach. The model (BS) shown in equation (6) adds in monthly dummy variables to account for seasonality. The next two models shown in equations (7) and (8), add in year trend variables, one linear variable (BSY) and the other quadratic (BSY^2). The last model shown in equation (9) takes a different approach to adding in yearly data and uses the years as dummy variables (BSA) instead of using a trend like in models shown in equations (7) and (8).

Model 1 Base (B)

$$(5)\quad AE\% = \beta_0 + \beta_1 1YrDum + \beta_2 2YrDum + \beta_3 3YrDum + \beta_4 4YrDum + \beta_5 5YrDum + \varepsilon$$

Model 2 Base + Seasonality (BS)

$$(6)\quad AE\% = \beta_0 + \beta_1 1YrDum + \beta_2 2YrDum + \beta_3 3YrDum + \beta_4 4YrDum + \beta_5 5YrDum + \beta_6 February + \beta_7 March + \beta_8 April + \beta_9 May + \beta_{10} June + \beta_{11} July + \beta_{12} August + \beta_{13} September + \beta_{14} October + \beta_{15} November + \beta_{16} December + \varepsilon$$

Model 3 Base + Seasonality + Year Trend (BSY)

$$(7)\quad AE\% = \beta_0 + \beta_1 1YrDum + \beta_2 2YrDum + \beta_3 3YrDum + \beta_4 4YrDum + \beta_5 5YrDum + \beta_6 February + \beta_7 March + \beta_8 April + \beta_9 May + \beta_{10} June + \beta_{11} July + \beta_{12} August + \beta_{13} September + \beta_{14} October + \beta_{15} November + \beta_{16} December + \beta_{17} YrTrend + \varepsilon$$

Model 4 Base + Seasonality + Year Trend + Year Trend^2 (BSY^2)

$$(8)\quad AE\% = \beta_0 + \beta_1 1YrDum + \beta_2 2YrDum + \beta_3 3YrDum + \beta_4 4YrDum + \beta_5 5YrDum + \beta_6 February + \beta_7 March + \beta_8 April + \beta_9 May + \beta_{10} June + \beta_{11} July + \beta_{12} August + \beta_{13} September + \beta_{14} October + \beta_{15} November + \beta_{16} December + \beta_{17} YrTrend + \beta_{18} YrTrend^2 + \varepsilon$$

Model 5 Base + Seasonality + Annual Dummies (BSA)

$$(9)\quad AE\% = \beta_0 + \beta_1 1YrDum + \beta_2 2YrDum + \beta_3 3YrDum + \beta_4 4YrDum + \beta_5 5YrDum + \beta_6 February + \beta_7 March + \beta_8 April + \beta_9 May + \beta_{10} June + \beta_{11} July + \beta_{12} August + \beta_{13} September + \beta_{14} October + \beta_{15} November + \beta_{16} December + \beta_{17} Yr2006Dum + \beta_{18} Yr2007Dum + \beta_{19} Yr2008Dum + \beta_{20} Yr2009Dum + \beta_{21} Yr2010Dum + \beta_{22} Yr2011Dum + \beta_{23} Yr2012Dum + \varepsilon$$

where *AE%* is the absolute percentage error on the forecast of value of gain; *1YrDum*, *2YrDum*, *3YrDum*, *4YrDum*, and *5YrDum* are binary variables referring to the different number of years used to complete the FMI basis-adjusted forecast (*Naïve* omitted); *February*, *March*, *April*, etc.

are seasonal dummy variables that are defined by the eleven months, (*January* omitted); *YrTrend* is equal to 0 for 2005, 1 for 2006, 2 for 2007, etc.; $YrTrend^2$ refers to *YrTrend* squared; *Yr2006Dum*, *Yr2007Dum*, *Yr2008Dum*, *Yr2009Dum*, *Yr2010Dum*, *Yr2011Dum*, *Yr2012Dum* are dummy variables that refer to the year that the cattle are placed (*Yr2005Dum* omitted). It is important to note that time subscripts have been omitted when presenting these models.

2.5 Results and Discussion

As mentioned before, a limitation of this research is that the absolute percentage error on the forecast of value of gain is based solely on the error of forecasting the selling price. In the beginning it was hypothesized that using the basis-adjusted approach of the 1-year, 2-year, 3-year, 4-year or 5-year basis average would be more accurate than using the naïve approach, however, that was not the yielded result.

Table 2.3 through Table 2.11 represent the estimated coefficients and statistical results for the nine scenarios (A-I) for all five of the regression models. For each scenario, the R-squared increased when adding information from the BS model to the BSA model; however, these values were still very low. P-values are given under each estimate and are shown in parentheses. In this research we use the five percent level to indicate if an estimate is significant.

When looking at scenario A (Table 2.3), the base model (B) yielded coefficient estimates with no significance. This concludes that under the assumptions stated above, the naïve approach is neither better nor worse at predicting value of gain for a 100 pound gain at the rate of gain of 1.75 pounds per day than using each of the FMI basis-adjusted approaches. This same conclusion was seen with all five models under Scenario A. Looking at the BS model that incorporates seasonality for the month of placement, there did not seem to be many significant variables except when looking at the months of February, June, and September. Therefore, showing that these months differed when compared to the month of January, while the other months did not significantly differ. February yielded the lowest AE% and was the month with most accurate predictions. June had the largest estimated coefficient at a value of 5.1376, which means that June, compared to January, yields the highest AE% and is the month with the least accurate forecasts. Under the BSY and BSY^2 models, the year trend and year trend squared variables were not significant, meaning that there is not a linear or quadratic yearly trend for absolute percent error on predicting value of gain. The coefficient estimates in the BSA model using annual dummy variables, showed significance on the years 2006, 2007, and 2012, meaning that these years each had larger forecasting errors than 2005.

Scenario B (Table 2.4) (200 pound gain at the rate of 1.75 pounds per day) showed similar results in regards to the naïve approach being neither better nor worse than that of using the FMI basis-adjusted approaches in all five models. When looking at the seasonality in this model; February, March, April, May, June, July, September, October and November showed significance in differing from the month of January, which shows there is more seasonality in this scenario than in scenario A. All of these months yielded negative coefficients, which means during these months, forecasting value of gain is more accurate when compared with forecasting in January. The year trend did not yield significance in the BSY model, and the BSY^2 model yielded the result that incorporating a linear and quadratic year trend was also insignificant in this scenario. Under the BSA model, the years 2006, 2007, 2008, and 2012 were shown to yield significance when adding in the annual dummy variables. These years had larger forecasting errors when compared to that of 2005.

More differences were seen when looking at scenario C (Table 2.5) (300 pound gain at 1.75 pounds per day). This model yielded significance on the dummy variables signifying the use of the 1-year average, 2-year average and 3-year average FMI basis-adjusted approaches. These estimated coefficients were all positive values, which led to the conclusion that using these averages under the FMI basis-adjusted approach is less accurate than using the naïve approach to predict value of gain. This result was not hypothesized since scenario C is the longest time horizon and this is inconsistent with the hypothesis that the more weight you add, the less accurate the naïve approach will be due to the fact there is a longer time frame to add more weight and is at a lower rate of gain. Seasonality was seen to hold for this scenario, with significant coefficient estimates on ten out of the eleven dummy variables (February, April, May, June, July, August, September, October, November, and December). All of these estimated coefficients were negative, except those on February and December, leading us to believe that those are months with more accurate forecasts of value of gain when compared to January. The year trend (BSY) did not add significance; however, the linear and quadratic year trends (BSY^2) did yield significance. The annual dummies (BSA) were seen to yield significance as detailed in scenario B.

The base model (B) under scenario D (Table 2.6) yielded no significance on any of the coefficient estimates, which concludes results similar to those in scenarios A and B. In the BS model, when adding in seasonality, only five of the eleven months yielded significance, of which all were positive and were months with less accurate forecasts of value of gain when compared to forecasting in the month of January. When looking at the BSY model, the yearly trend variable yielded significance and was a positive value, meaning that as the year increased, the accuracy of predicting value of gain decreased. However, in the BSY^2 model the yearly trend variables deemed to be insignificant, while the year trend squared variable was significant, meaning that when predicting value of gain for a 100 pound gain at 2.00 pounds per day, there could be a quadratic yearly trend. The results for the BSA model showed that the years 2006, 2007, 2008, 2010, and 2012 were years with the less accurate forecasts when compared with those in 2005.

Results for scenario E (Table 2.7) yielded the same results in respect to the approach used to predict value of gain. Only the month of December was significant when adding in seasonality and showed it was much less accurate to forecast value of gain in this month, when compared to January. Neither of the added variables in the BSY and BSY^2 models were significant and when adding in annual dummies in the BSA model, 2006, 2007, 2008, and 2012 were years that were less accurate at predicting VOG than predicting in the year 2005.

Forecasting value of gain for the 300 pound gain at 2.00 pounds per day in scenario F (Table 2.8) produced very similar results to those in scenario C. There was significance on the dummy variables that represent using the 1-year average, 2-year average, and 3-year average to predict value of gain. However, just like in scenario C, these coefficient estimates were positive, meaning that it is worse to use these averages to predict VOG when compared to using the naïve approach. All eleven monthly dummies yielded significance. November deemed to be the month with the most accurate forecasts, with a value of -0.4654, while February was the month with the least accurate forecasts, with a value of 0.1976. When adding in the year trend and year trend squared variables, they yielded no significance. In the BSA model, 2006, 2007, 2008, 2009, and 2012 were all significant and years with less accurate predictions, when compared to 2005.

Modeling scenario G (Table 2.9) (100 pound gain at 2.25 pounds per day) produced results that state that using the averages are neither better nor worse than using the naïve approach to predict VOG. When adding in seasonality, there was significance on five of the eleven dummy variable coefficient estimates. Of these, October was the month with the least accurate predictions, while September had the most accurate forecasts. Under the BSY model, the yearly trend variable was not significant. However, under the BSY^2 model, the year trend was more significant than the year trend squared variable. The BSA model showed that only 2006 and 2011 were significant in the model when compared to 2005.

The coefficient estimates in the base model for scenario H (Table 2.10) (200 pound gain at 2.25 pounds per day) yielded results consistent with those of the base model in scenario G, that using the averages are neither better nor worse than using the naïve approach to predict VOG. Only three of the eleven coefficient estimates for the monthly dummy variables were significant (July, August, and December).These three months were months with less accurate forecasts when compared to predicting in January. Of these, August had the least accurate forecasts and December had the most accurate. In both the BSY and BSY^2 the year trend and year trend squared variables yielded significant coefficient estimates. In the BSA model, the annual dummy variables for 2006, 2007, 2008, and 2012 had significant coefficient estimates that were years with less accurate predictions of VOG, than those in 2005.

Scenario I (Table 2.11) (300 pound gain at 2.25 pounds per day) yielded similar results to those of the other scenarios that include 300 pounds of gain. The coefficient estimates on the dummy variables for the 1-year average and 2-year average were both significant however, were worse at predicting VOG than using the naïve approach. Adding in seasonality in the BS model, all eleven coefficient estimates were significant, all of which are negative. Looking at the BSY and BSY^2 the coefficient estimates on the year trend and year trend squared variables were insignificant. The BSA model showed that the annual dummies for the years of 2006, 2007, 2008, 2009, and 2012 were all significant when compared to 2005.

Table 2.3 Scenario A - 100 pound gain at 1.75 pounds per day

A (100 lb gain @ 1.75 lbs/day)					
	B	**BS**	**BSY**	**BSY^2**	**BSA**
Constant	1.7184	1.5925	1.6004	1.9534	0.9294
	(0.0000)	(0.0013)	(0.0024)	(0.0005)	(0.1092)
Yr1Dum	0.3751	0.3880	0.3880	0.3880	0.3932
	(0.3805)	(0.3474)	(0.3476)	(0.3473)	(0.3342)
Yr2Dum	0.4460	0.4580	0.4580	0.4594	0.4634
	(0.2972)	(0.2674)	(0.2675)	(0.2658)	(0.2552)
Yr3Dum	0.6119	0.6124	0.6124	0.6116	0.6087
	(0.1524)	(0.1379)	(0.1380)	(0.1383)	(0.1348)
Yr4Dum	0.5405	0.5418	0.5418	0.5401	0.5396
	(0.2059)	(0.1890)	(0.1891)	(0.1903)	(0.1847)
Yr5Dum	0.5001	0.5014	0.5014	0.4997	0.4992
	(0.2418)	(0.2242)	(0.2243)	(0.2256)	(0.2197)
Feb		-1.4518	-1.4519	-1.4560	-1.5029
		(0.0144)	(0.0144)	(0.0141)	(0.0102)
March		-1.1244	-1.1245	-1.1430	-1.2819
		(0.0543)	(0.0543)	(0.0504)	(0.0262)
April		-0.3365	-0.3366	-0.3550	-0.3086
		(0.5645)	(0.5645)	(0.5432)	(0.5921)
May		0.4375	0.4374	0.4403	0.4080
		(0.4570)	(0.4573)	(0.4541)	(0.4820)
June		5.1376	5.1374	5.1222	4.9946
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
July		-0.1940	-0.1939	-0.2006	-0.1566
		(0.7389)	(0.7390)	(0.7303)	(0.7849)
Aug		-0.0884	-0.0886	-0.0937	-0.2082
		(0.8801)	(0.8799)	(0.8730)	(0.7188)
Sept		-1.4008	-1.4011	-1.4251	-1.4173
		(0.0165)	(0.0165)	(0.0147)	(0.0140)
Oct		0.1574	0.1574	0.1585	0.1413
		(0.7887)	(0.7889)	(0.7873)	(0.8074)
Nov		-0.4788	-0.4788	-0.4960	-0.6254
		(0.4157)	(0.4158)	(0.3991)	(0.2813)
Dec		0.7281	0.7279	0.7083	0.7405
		(0.2094)	(0.2097)	(0.2220)	(0.1957)
YrTrend			-0.0022	-0.3437	
			(0.9659)	(0.0701)	
$YrTrend^2$				0.0488	
				(0.0613)	
Yr2006Dum					1.1911
					(0.0114)
Yr2007Dum					2.2786
					(0.0000)
Yr2008Dum					0.6441
					(0.1712)
Yr2009Dum					-0.0200
					(0.9662)

Yr2010Dum					-0.3603
					(0.4416)
Yr2011Dum					-0.3315
					(0.4808)
Yr2012Dum					2.3256
					(0.0000)
N	2489	2489	2489	2489	2489
R^2	0.0010	0.0732	0.0732	0.0745	0.1013

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.4 Scenario B – 200 pound gain at 1.75 pounds per day

B (200 lb gain @ 1.75 lbs/day)					
	B	**BS**	**BSY**	**BSY^2**	**BSA**
Constant	1.0114	2.2160	2.1648	2.3550	1.3623
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)
Yr1Dum	0.3700	0.3671	0.3672	0.3674	0.3664
	(0.1402)	(0.1350)	(0.1350)	(0.1346)	(0.1232)
Yr2Dum	0.3589	0.3589	0.3589	0.3589	0.3589
	(0.1528)	(0.1443)	(0.1443)	(0.1442)	(0.1313)
Yr3Dum	0.3064	0.3064	0.3064	0.3064	0.3064
	(0.2222)	(0.2125)	(0.2126)	(0.2124)	(0.1976)
Yr4Dum	0.2520	0.2520	0.2520	0.2520	0.2520
	(0.3154)	(0.3052)	(0.3053)	(0.3051)	(0.2893)
Yr5Dum	0.1992	0.1992	0.1992	0.1992	0.1992
	(0.4274)	(0.4176)	(0.4177)	(0.4175)	(0.4022)
Feb		-1.6237	-1.6214	-1.6194	-1.7104
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
March		-1.8047	-1.8024	-1.8083	-1.9432
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
April		-1.8403	-1.8384	-1.8444	-1.8231
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
May		-1.5476	-1.5456	-1.5397	-1.6152
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
June		-1.7669	-1.7646	-1.7706	-1.9055
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
July		-0.8736	-0.8719	-0.8740	-0.8412
		(0.0128)	(0.0130)	(0.0127)	(0.0133)
Aug		-0.4593	-0.4578	-0.4591	-0.5915
		(0.1932)	(0.1947)	(0.1933)	(0.0839)
Sept		-1.7288	-1.7254	-1.7344	-1.7667
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Oct		-1.6331	-1.6316	-1.6237	-1.6743
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Nov		-1.6838	-1.6826	-1.6879	-1.7949
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dec		0.5036	0.5065	0.4999	0.4906
		(0.1510)	(0.1488)	(0.1540)	(0.1486)
YrTrend			0.0140	-0.1744	
			(0.6502)	(0.1214)	
YrTrend^2				0.0269	
				(0.0818)	
Yr2006Dum					1.9269
					(0.0000)
Yr2007Dum					1.1778
					(0.0000)
Yr2008Dum					1.7027
					(0.0000)
Yr2009Dum					0.2886
					(0.2930)

Yr2010Dum					-0.0004
					(0.9989)
Yr2011Dum					-0.0546
					(0.8422)
Yr2012Dum					2.2931
					(0.0000)
N	2491	2491	2491	2491	2491
R^2	0.0012	0.0467	0.0468	0.0480	0.1101

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.5 Scenario C – 300 pound gain at 1.75 pounds per day

	C (300 lb gain @ 1.75 lbs/day)				
	B	**BS**	**BSY**	**BSY^2**	**BSA**
Constant	0.4949	0.6881	0.6968	0.5533	0.4402
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Yr1Dum	0.1665	0.1665	0.1665	0.1665	0.1665
	(0.0201)	(0.0166)	(0.0166)	(0.0162)	(0.0129)
Yr2Dum	0.1710	0.1710	0.1710	0.1710	0.1710
	(0.0171)	(0.0139)	(0.0139)	(0.0135)	(0.0107)
Yr3Dum	0.1470	0.1470	0.1470	0.1470	0.1470
	(0.0402)	(0.0344)	(0.0344)	(0.0337)	(0.0282)
Yr4Dum	0.1239	0.1239	0.1239	0.1239	0.1239
	(0.0837)	(0.0745)	(0.0745)	(0.0734)	(0.0643)
Yr5Dum	0.1040	0.1040	0.1040	0.1040	0.1040
	(0.1466)	(0.1344)	(0.1344)	(0.1329)	(0.1204)
Feb		0.2886	0.2884	0.2901	0.2663
		(0.0039)	(0.0040)	(0.0036)	(0.0058)
March		0.0504	0.0502	0.0578	0.0385
		(0.6090)	(0.6103)	(0.5565)	(0.6852)
April		-0.3099	-0.3101	-0.3026	-0.2912
		(0.0017)	(0.0017)	(0.0021)	(0.0022)
May		-0.4604	-0.4605	-0.4617	-0.4846
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
June		-0.5086	-0.5088	-0.5013	-0.5205
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
July		-0.3982	-0.3983	-0.3937	-0.3824
		(0.0000)	(0.0000)	(0.0001)	(0.0001)
Aug		-0.2030	-0.2030	-0.1989	-0.2301
		(0.0396)	(0.0396)	(0.0429)	(0.0156)
Sept		-0.2850	-0.2854	-0.2757	-0.2746
		(0.0039)	(0.0038)	(0.0050)	(0.0039)
Oct		-0.3388	-0.3388	-0.3415	-0.3547
		(0.0006)	(0.0006)	(0.0005)	(0.0002)
Nov		-0.3935	-0.3935	-0.3865	-0.4049
		(0.0001)	(0.0001)	(0.0001)	(0.0000)
Dec		0.2524	0.2521	0.2601	0.2699
		(0.0100)	(0.0101)	(0.0077)	(0.0043)
YrTrend			-0.0025	0.1365	
			(0.7791)	(0.0000)	
$YrTrend^2$				-0.0198	
				(0.0000)	
Yr2006Dum					0.2749
					(0.0004)
Yr2007Dum					0.2852
					(0.0002)
Yr2008Dum					0.8062
					(0.0000)
Yr2009Dum					0.3328
					(0.0000)

Yr2010Dum					-0.0159
					(0.8361)
Yr2011Dum					-0.0758
					(0.3274)
Yr2012Dum					0.4205
					(0.0000)
N	2502	2502	2502	2502	2502
R^2	0.0031	0.0669	0.0669	0.0747	0.1352

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.6 Scenario D – 100 pound gain at 2.00 pounds per day

D (100 lb gain @ 2.00 lbs/day)					
	B	**BS**	**BSY**	**BSY^2**	**BSA**
Constant	1.8160	1.1971	0.7187	1.1453	-0.0841
	(0.0000)	(0.0194)	(0.1879)	(0.0480)	(0.8888)
Yr1Dum	0.5310	0.5292	0.5281	0.5271	0.5249
	(0.2218)	(0.2150)	(0.2155)	(0.2160)	(0.2131)
Yr2Dum	0.3953	0.3934	0.3923	0.3913	0.3891
	(0.3631)	(0.3566)	(0.3575)	(0.3583)	(0.3560)
Yr3Dum	0.3513	0.3495	0.3483	0.3473	0.3451
	(0.4189)	(0.4128)	(0.4139)	(0.4148)	(0.4129)
Yr4Dum	0.1771	0.1752	0.1741	0.1731	0.1709
	(0.6837)	(0.6814)	(0.6830)	(0.6845)	(0.6852)
Yr5Dum	0.2198	0.2180	0.2168	0.2158	0.2136
	(0.6131)	(0.6095)	(0.6110)	(0.6124)	(0.6123)
Feb		-0.8186	-0.8087	-0.8136	-0.8468
		(0.1828)	(0.1877)	(0.1847)	(0.1631)
March		-0.1594	-0.1496	-0.1719	-0.2739
		(0.7923)	(0.8046)	(0.7761)	(0.6472)
April		-0.1336	-0.1276	-0.1498	-0.1019
		(0.8254)	(0.8329)	(0.8042)	(0.8647)
May		1.3843	1.3923	1.3957	1.3803
		(0.0233)	(0.0223)	(0.0219)	(0.0220)
June		2.9213	2.9312	2.9089	2.8069
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
July		-0.5262	-0.5220	-0.5358	-0.4734
		(0.3815)	(0.3848)	(0.3720)	(0.4255)
Aug		1.3802	1.3846	1.3744	1.3148
		(0.0228)	(0.0223)	(0.0232)	(0.0283)
Sept		-0.9217	-0.9004	-0.9293	-0.9345
		(0.1279)	(0.1366)	(0.1243)	(0.1184)
Oct		2.2890	2.2911	2.2992	2.2891
		(0.0002)	(0.0002)	(0.0001)	(0.0001)
Nov		-0.0370	-0.0370	-0.0578	-0.1133
		(0.9516)	(0.9515)	(0.9243)	(0.8508)
Dec		1.9683	1.9837	1.9600	1.9599
		(0.0011)	(0.0010)	(0.0011)	(0.0010)
YrTrend			0.1347	-0.2777	
			(0.0123)	(0.1557)	
YrTrend^2				0.0589	
				(0.0284)	
Yr2006Dum					2.6962
					(0.0000)
Yr2007Dum					1.0758
					(0.0274)
Yr2008Dum					1.2803
					(0.0087)
Yr2009Dum					0.4930
					(0.3118)

Yr2010Dum					1.1420
					(0.0186)
Yr2011Dum					0.6708
					(0.1685)
Yr2012Dum					3.1536
					(0.0000)
N	2501	2501	2501	2501	2501
R^2	0.0007	0.0408	0.0432	0.0451	0.0668

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.7 Scenario E – 200 pound gain at 2.00 pounds per day

	E (200 lb gain @ 2.00 lbs/day)				
	B	**BS**	**BSY**	**BSY^2**	**BSA**
Constant	1.0657	1.1149	1.1767	1.1119	0.3730
	(0.0000)	(0.0006)	(0.0007)	(0.0026)	(0.3239)
Yr1Dum	0.1056	0.0959	0.0955	0.0950	0.0928
	(0.7022)	(0.7243)	(0.7253)	(0.7269)	(0.7269)
Yr2Dum	0.1624	0.1582	0.1579	0.1574	0.1590
	(0.5567)	(0.5609)	(0.5617)	(0.5629)	(0.5498)
Yr3Dum	0.1171	0.1128	0.1125	0.1121	0.1136
	(0.6719)	(0.6783)	(0.6792)	(0.6805)	(0.6691)
Yr4Dum	-0.1271	-0.1257	-0.1260	-0.1264	-0.1211
	(0.6459)	(0.6442)	(0.6435)	(0.6426)	(0.6490)
Yr5Dum	-0.1566	-0.1553	-0.1556	-0.1559	-0.1506
	(0.5712)	(0.5684)	(0.5677)	(0.5669)	(0.5712)
Feb		-0.4635	-0.4647	-0.4640	-0.5510
		(0.2351)	(0.2339)	(0.2347)	(0.1488)
March		-0.5930	-0.5943	-0.5908	-0.6797
		(0.1232)	(0.1224)	(0.1247)	(0.0708)
April		-0.4765	-0.4773	-0.4738	-0.4498
		(0.2154)	(0.2147)	(0.2182)	(0.2317)
May		-0.2200	-0.2210	-0.2215	-0.2878
		(0.5701)	(0.5684)	(0.5675)	(0.4472)
June		-0.3781	-0.3793	-0.3759	-0.4648
		(0.3256)	(0.3240)	(0.3286)	(0.2166)
July		0.2253	0.2218	0.2208	0.3118
		(0.5599)	(0.5661)	(0.5679)	(0.4093)
Aug		0.1852	0.1831	0.1831	0.1006
		(0.6326)	(0.6365)	(0.6366)	(0.7905)
Sept		-0.6624	-0.6652	-0.6607	-0.6812
		(0.0851)	(0.0839)	(0.0861)	(0.0702)
Oct		-0.0746	-0.0749	-0.0761	-0.1184
		(0.8462)	(0.8457)	(0.8431)	(0.7527)
Nov		-0.3441	-0.3441	-0.3408	-0.4092
		(0.3744)	(0.3745)	(0.3791)	(0.2800)
Dec		2.2401	2.2385	2.2439	2.3025
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
YrTrend			-0.0173	0.0466	
			(0.6155)	(0.7097)	
YrTrend^2				-0.0092	
				(0.5955)	
Yr2006Dum					1.5622
					(0.0000)
Yr2007Dum					0.7261
					(0.0179)
Yr2008Dum					2.2745
					(0.0000)
Yr2009Dum					0.1582
					(0.6055)

Yr2010Dum					-0.0324
					(0.9154)
Yr2011Dum					-0.0374
					(0.9029)
Yr2012Dum					1.6127
					(0.0000)
N	2478	2478	2478	2478	2478
R^2	0.0010	0.0362	0.0363	0.0364	0.0822

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.8 Scenario F – 300 pound gain at 2.00 pounds per day

F (300 lb gain @ 2.00 lbs/day)					
	B	**BS**	**BSY**	**BSY²**	**BSA**
Constant	0.4554	0.6940	0.7028	0.6714	0.4798
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Yr1Dum	0.1312	0.1312	0.1312	0.1312	0.1312
	(0.0069)	(0.0052)	(0.0052)	(0.0052)	(0.0033)
Yr2Dum	0.1288	0.1288	0.1288	0.1288	0.1288
	(0.0080)	(0.0061)	(0.0061)	(0.0061)	(0.0039)
Yr3Dum	0.1034	0.1034	0.1034	0.1034	0.1034
	(0.0331)	(0.0275)	(0.0275)	(0.0275)	(0.0205)
Yr4Dum	0.0750	0.0750	0.0750	0.0750	0.0750
	(0.1220)	(0.1097)	(0.1097)	(0.1096)	(0.0926)
Yr5Dum	0.0508	0.0508	0.0508	0.0508	0.0508
	(0.2955)	(0.2792)	(0.2792)	(0.2791)	(0.2552)
Feb		0.1976	0.1974	0.1977	0.1823
		(0.0035)	(0.0035)	(0.0034)	(0.0046)
March		-0.1467	-0.1469	-0.1452	-0.1677
		(0.0276)	(0.0275)	(0.0292)	(0.0082)
April		-0.2631	-0.2632	-0.2615	-0.2486
		(0.0001)	(0.0001)	(0.0001)	(0.0001)
May		-0.4125	-0.4127	-0.4129	-0.4279
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
June		-0.4359	-0.4361	-0.4344	-0.4569
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
July		-0.3198	-0.3199	-0.3189	-0.3063
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Aug		-0.1390	-0.1390	-0.1381	-0.1627
		(0.0369)	(0.0369)	(0.0381)	(0.0103)
Sept		-0.3384	-0.3388	-0.3366	-0.3361
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Oct		-0.3534	-0.3534	-0.3540	-0.3612
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Nov		-0.4654	-0.4654	-0.4639	-0.4818
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dec		-0.1658	-0.1661	-0.1644	-0.1567
		(0.0122)	(0.0121)	(0.0130)	(0.0128)
YrTrend			-0.0025	0.0279	
			(0.6774)	(0.1955)	
YrTrend²				-0.0043	
				(0.1429)	
Yr2006Dum					0.3904
					(0.0000)
Yr2007Dum					0.2873
					(0.0000)
Yr2008Dum					0.4869
					(0.0000)
Yr2009Dum					0.2331
					(0.0000)

Yr2010Dum					-0.0356
					(0.4882)
Yr2011Dum					-0.0585
					(0.2568)
Yr2012Dum					0.4681
					(0.0000)
N	2502	2502	2502	2502	2502
R^2	0.0043	0.0739	0.0739	0.0747	0.1646

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.9 Scenario G – 100 pound gain at 2.25 pounds per day

G (100 lb gain @ 2.25 lbs/day)					
	B	**BS**	**BSY**	**BSY²**	**BSA**
Constant	2.0137	1.7056	2.0256	2.4233	1.6868
	(0.0000)	(0.0021)	(0.0006)	(0.0001)	(0.0100)
Yr1Dum	0.1782	0.1839	0.1844	0.1845	0.1880
	(0.7084)	(0.6913)	(0.6903)	(0.6900)	(0.6824)
Yr2Dum	0.1151	0.1208	0.1213	0.1215	0.1249
	(0.8091)	(0.7942)	(0.7932)	(0.7929)	(0.7857)
Yr3Dum	0.4464	0.4400	0.4407	0.4398	0.4386
	(0.3481)	(0.3415)	(0.3405)	(0.3413)	(0.3393)
Yr4Dum	0.3062	0.2998	0.3005	0.2996	0.2983
	(0.5199)	(0.5169)	(0.5157)	(0.5168)	(0.5157)
Yr5Dum	0.2755	0.2690	0.2698	0.2689	0.2676
	(0.5626)	(0.5608)	(0.5596)	(0.5607)	(0.5599)
Feb		-1.3242	-1.3309	-1.3355	-1.3296
		(0.0468)	(0.0457)	(0.0448)	(0.0444)
March		-0.3299	-0.3365	-0.3573	-0.3829
		(0.6151)	(0.6079)	(0.5858)	(0.5568)
April		2.9827	2.9794	2.9608	3.0143
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
May		-0.9327	-0.9380	-0.9347	-0.9141
		(0.1582)	(0.1558)	(0.1570)	(0.1636)
June		2.6807	2.6710	2.6539	2.6327
		(0.0000)	(0.0000)	(0.0001)	(0.0001)
July		1.1380	1.1352	1.1223	1.1717
		(0.0808)	(0.0815)	(0.0849)	(0.0701)
Aug		-1.2252	-1.2266	-1.2380	-1.2255
		(0.0619)	(0.0616)	(0.0591)	(0.0601)
Sept		-1.3768	-1.3911	-1.4182	-1.3999
		(0.0359)	(0.0340)	(0.0307)	(0.0317)
Oct		3.1225	3.1211	3.1286	3.1247
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Nov		-1.1186	-1.1186	-1.1381	-1.1211
		(0.0906)	(0.0905)	(0.0849)	(0.0876)
Dec		-0.0350	-0.0453	-0.0674	-0.0729
		(0.9572)	(0.9445)	(0.9176)	(0.9103)
YrTrend			-0.0901	-0.4753	
			(0.1229)	(0.0252)	
YrTrend²				0.0551	
				(0.0592)	
Yr2006Dum					1.7874
					(0.0008)
Yr2007Dum					-0.7141
					(0.1786)
Yr2008Dum					-0.0567
					(0.9149)
Yr2009Dum					-0.7901
					(0.1366)

Yr2010Dum					0.5751
					(0.2761)
Yr2011Dum					-1.1769
					(0.0265)
Yr2012Dum					0.5831
					(0.2733)
N	2497	2497	2497	2497	2497
R^2	0.0004	0.0595	0.0604	0.0618	0.0764

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.10 Scenario H – 200 pound gain at 2.25 pounds per day

H (200 lb gain @ 2.25 lbs/day)					
	B	**BS**	**BSY**	**BSY²**	**BSA**
Constant	0.8467	0.5669	0.3712	0.8543	-0.1020
	(0.0000)	(0.0331)	(0.1908)	(0.0044)	(0.7382)
Yr1Dum	0.1952	0.1952	0.1952	0.1952	0.1952
	(0.3841)	(0.3784)	(0.3782)	(0.3761)	(0.3614)
Yr2Dum	0.3059	0.3059	0.3059	0.3059	0.3059
	(0.1726)	(0.1675)	(0.1673)	(0.1654)	(0.1527)
Yr3Dum	0.2332	0.2332	0.2332	0.2332	0.2332
	(0.2984)	(0.2927)	(0.2924)	(0.2903)	(0.2756)
Yr4Dum	0.1680	0.1680	0.1680	0.1680	0.1680
	(0.4538)	(0.4484)	(0.4481)	(0.4461)	(0.4322)
Yr5Dum	0.1543	0.1543	0.1543	0.1543	0.1543
	(0.4913)	(0.4862)	(0.4859)	(0.4840)	(0.4705)
Feb		-0.1503	-0.1462	-0.1518	-0.1980
		(0.6378)	(0.6468)	(0.6327)	(0.5207)
March		-0.2520	-0.2480	-0.2732	-0.3626
		(0.4231)	(0.4303)	(0.3828)	(0.2327)
April		0.4109	0.4133	0.3880	0.4327
		(0.1916)	(0.1887)	(0.2152)	(0.1543)
May		0.4598	0.4631	0.4670	0.4304
		(0.1468)	(0.1438)	(0.1386)	(0.1595)
June		0.0932	0.0972	0.0720	-0.0174
		(0.7670)	(0.7572)	(0.8182)	(0.9543)
July		1.0568	1.0585	1.0428	1.0940
		(0.0007)	(0.0007)	(0.0008)	(0.0003)
Aug		1.3545	1.3554	1.3416	1.2677
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sept		-0.3888	-0.3801	-0.4130	-0.4194
		(0.2165)	(0.2268)	(0.1873)	(0.1675)
Oct		-0.3284	-0.3275	-0.3185	-0.3373
		(0.2965)	(0.2976)	(0.3090)	(0.2667)
Nov		0.2723	0.2723	0.2487	0.1921
		(0.3902)	(0.3899)	(0.4303)	(0.5302)
Dec		0.7659	0.7722	0.7453	0.7553
		(0.0143)	(0.0135)	(0.0166)	(0.0123)
YrTrend			0.0550	-0.4126	
			(0.0491)	(0.0000)	
YrTrend²				0.0668	
				(0.0000)	
Yr2006Dum					1.8140
					(0.0000)
Yr2007Dum					0.4918
					(0.0471)
Yr2008Dum					0.9793
					(0.0001)
Yr2009Dum					0.0958
					(0.6986)

Yr2010Dum					-0.0218
					(0.9295)
Yr2011Dum					-0.0013
					(0.9959)
Yr2012Dum					2.3088
					(0.0000)
N	2502	2502	2502	2502	2502
R^2	0.0008	0.0285	0.0300	0.0390	0.0977

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.11 Scenario I – 300 pound gain at 2.25 pounds per day

I (300 lb gain @ 2.25 lbs/day)					
	B	**BS**	**BSY**	**BSY^2**	**BSA**
Constant	0.4394	0.7495	0.7609	0.7490	0.5429
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Yr1Dum	0.1108	0.1108	0.1108	0.1108	0.1108
	(0.0160)	(0.0138)	(0.0138)	(0.0139)	(0.0091)
Yr2Dum	0.1062	0.1062	0.1062	0.1062	0.1062
	(0.0210)	(0.0183)	(0.0183)	(0.0183)	(0.0125)
Yr3Dum	0.0745	0.0745	0.0745	0.0745	0.0745
	(0.1055)	(0.0981)	(0.0981)	(0.0982)	(0.0798)
Yr4Dum	0.0463	0.0463	0.0463	0.0463	0.0463
	(0.3136)	(0.3031)	(0.3031)	(0.3032)	(0.2755)
Yr5Dum	0.0272	0.0272	0.0272	0.0272	0.0272
	(0.5546)	(0.5460)	(0.5460)	(0.5461)	(0.5225)
Feb		-0.1472	-0.1474	-0.1473	-0.1641
		(0.0233)	(0.0231)	(0.0232)	(0.0074)
March		-0.2083	-0.2086	-0.2080	-0.2308
		(0.0011)	(0.0011)	(0.0012)	(0.0001)
April		-0.3366	-0.3367	-0.3361	-0.3240
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
May		-0.4618	-0.4620	-0.4621	-0.4776
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
June		-0.4245	-0.4247	-0.4241	-0.4469
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
July		-0.2843	-0.2844	-0.2840	-0.2715
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Aug		-0.2830	-0.2831	-0.2827	-0.3073
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sept		-0.4058	-0.4064	-0.4055	-0.4068
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Oct		-0.4155	-0.4156	-0.4158	-0.4238
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Nov		-0.5338	-0.5338	-0.5332	-0.5503
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dec		-0.2160	-0.2163	-0.2157	-0.2100
		(0.0007)	(0.0007)	(0.0007)	(0.0005)
YrTrend			-0.0032	0.0084	
			(0.5707)	(0.6858)	
YrTrend^2				-0.0017	
				(0.5602)	
Yr2006Dum					0.4318
					(0.0000)
Yr2007Dum					0.2329
					(0.0000)
Yr2008Dum					0.4942
					(0.0000)
Yr2009Dum					0.1834
					(0.0002)

Yr2010Dum					-0.0416
					(0.3951)
Yr2011Dum					-0.0491
					(0.3176)
Yr2012Dum					0.4692
					(0.0000)
N	2502	2502	2502	2502	2502
R^2	0.0037	0.0502	0.0503	0.0504	0.1554

Note: p-values are given under each coefficient estimate and are shown in parentheses

Hypothesis testing was completed using F-tests to analyze the seasonality and time trend aspects of these models. As seen in Table 2.12, hypothesis tests yielded that seasonality holds for each model under each scenario. Thus, meaning that there is seasonality in the time of placement that needs to be incorporated when predicting value of gain.

The hypothesis tests done for the year trend variables yielded varying results, with only four of the nine scenarios showing that these yearly variables hold true to the models. Five of the scenarios (A, B, E, F, I) were not significant at the five percent level (Table 2.13).

When using the model with annual dummies (Table 2.14), annual effects were jointly significant for all scenarios. Thus, meaning that the year in which the forecast of value of gain is made plays a significant role.

Table 2.12 Hypothesis Testing for Seasonality

	Seasonality								
	H_0 : Feb = Mar = Apr = ... = Dec = 0								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
B	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BS	17.49	10.74	15.44	9.44	8.18	16.96	14.17	6.44	11.05
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
BSY	17.48	10.73	15.43	9.45	8.18	16.95	14.19	6.43	11.05
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
BSY^2	17.50	10.73	15.57	9.50	8.18	16.93	14.23	6.46	11.04
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
BSA	17.64	12.12	16.81	9.46	9.35	18.81	14.45	7.18	12.94
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.13 Hypothesis Testing for Yearly Trend

Year Trend									
H_0: YrTrend = $YrTrend^2$ = 0									
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
B	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BS	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BSY	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BSY^2	1.75	1.62	10.38	5.55	0.27	1.16	2.97	13.48	0.33
	(0.1735)	(0.1984)	(0.0000)	(0.0039)	(0.7656)	(0.3135)	(0.0513)	(0.0000)	(0.7186)
BSA	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-

Note: p-values are given under each coefficient estimate and are shown in parentheses

Table 2.14 Hypothesis Testing for Annual Dummies

Year Dummies									
H_0: Yr2006Dum = ... = Yr2012Dum = 0									
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
B	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BS	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BSY	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BSY^2	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BSA	11.04	25.11	27.94	9.84	17.56	38.43	6.46	27.15	44.11
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: p-values are given under each coefficient estimate and are shown in parentheses

2.6 Conclusions and Implications

It was hypothesized that the naïve approach would be less accurate than the FMI basis-adjusted approaches. However, the results from all nine scenarios did not conclude this. Although there is no definite explanation for these conclusions, there are some important points to be made. The first being that in this exact research, the calculation in the error on the forecast of value of gain is solely based on the forecast of the selling price and takes on no performance risk or an error in the forecast of the buying price. This research also includes short time horizons when forecasting the value of gain, which could heavily influence the accuracy of the naïve approach. This thought is influenced by the hypothesis that the longer the time horizon, the worse the forecast is when using the naïve approach compared to the FMI basis-adjusted approach. This short time horizon is highly unlikely for some producer's decision-making process.

The R-squared in each scenario is low. This could be due to the fact that after excluding the absolute percentage errors that are greater than 95%, there is little variability in the data to explain. The histograms showed that three-quarters of the forecasts had an error that was less than one percent. This low variability in the data could possibly influence the fact that the results were inconsistent with the hypothesis since this research is forecasting value of gain that has an error of less than one percent most of the time.

Even though the results were not consistent to what was hypothesized, there are still major conclusions from this research given the hypothesis tests for seasonality and yearly dummies. These tests concluded that seasonality and annual dummies hold for all scenarios and show that the placement month and year have strong significance on forecasting value of gain.

As discussed above, this research was conducted as a producer that made purchasing decisions yesterday. In the future research, a buying horizon will be implemented to better represent the producer's decision-making. This will lengthen the forecasting horizon on both the buying and the selling price.

Chapter 3 - A Confirmation, Update and Expansion of "Monthly Price Premiums and Discounts between Steer Calves and Yearlings" Marsh (1985)

3.1 Introduction

A major factor that is taken into consideration during the producer's management decision-making process is the monthly price premiums and discounts between steer calves and yearlings. This chapter focuses on these premiums and discounts to provide an updated assessment of past research.

The objective of this chapter's research is to confirm, update and expand results generated by Marsh in an article titled *Monthly Price Premiums and Discounts between Steer Calves and Yearlings* (1985). Although Marsh published this paper in 1985, the cow/calf, stocker, and cattle-feeding industries still rely heavily on price premiums and discounts between calves and yearlings. Cow/calf producers take this information into account when making their decision of whether to sell or retain ownership of their weaned calves. Moreover, stocker operators and feedyard managers find this same information useful when making purchasing decisions between weight classes. Whether a cow-calf producer, stocker operator, or feedyard owner, knowing how cost of gain and slaughter price affect the price of calves or yearlings and the price differential between the two, is important when making certain management decisions. One example discussed later, is when cow-calf producers are looking at a market where either slaughter prices are decreasing or feed costs are increasing and they are faced with either selling their calves or retention.

Marsh (1985) focuses on cost of gain, slaughter price and seasonality. Since they are large inputs and outputs of the cattle-feeding industry, they are used to estimate the variability in price differences. As discussed by Marsh, other variables (i.e. inventories and grazing conditions) that play a key role in modeling prices and price differences were not available for monthly periods of time when completing this analysis and therefore were not included.

The motivation behind this confirmation is illustrated in four main points made by Tomek (1993). First, the confirmation of results links one model to another and can highlight differences or improvements from the previous work. Second, the writer that is conducting the confirmation attempt has the potential to learn from the paper and allows the writer to analyze the strengths and weaknesses of the work already done. There is also room for the scholar to update and improve upon what has already been completed. Third, in this case, these results are important for producers in the cattle-feeding industry and must be kept as accurate and up-to-date as possible. Confirmation allows for this. Lastly, Tomek states that if an article is to be confirmed, it should increase the accuracy and honesty that the publisher puts into his/her work and allows for more scholarly publications of higher quality.

However, there are difficulties associated with confirmation including, actual data not being available, vagueness in model specification, and not obtaining identical results due to obscurities in computer codes used in statistical software (Tomek, 1993). All benefits and difficulties were encountered in the attempts to confirm this research.

In addition to confirming this article, there is also much to be gained by completing an update and expansion using these models constructed by Marsh. Conducting an update using a longer time series data set provides for the opportunity to observe and analyze structural change in the model over time. This analysis will examine if structural change occurs in the markets as prices change through the time period. Moreover, an expansion allows for the chance to add different variables to the model that could have more relevance in the current market. As presented in this chapter, both an update and expansion of Marsh's article are completed in this research.

3.2 Model

Based on Marsh's paper, the model includes three equations:

$$(1)\ P400 = f_1\left[D, COSTG_{t-j}, PSL_{t-j}, P400_{t-i}, e_{1t}\right]$$

$$(2)\ P600 = f_2\left[D, COSTG_{t-j}, PSL_{t-j}, P600_{t-i}, e_{2t}\right]$$

$$(3)\ P400 - P600 = f_3[D, COSTG_{t-j}, PSL_{t-j}, (P400 - P600)_{t-i}, e_{3t}]$$

$$j = 0, 1, \dots, p \quad i = 1, 2, \dots, p \ \leq k$$

where *P400* is the price of Medium No. 1 steers calves, Kansas City, \$/cwt; *P600* is the price of Medium No. 1 feeder steers, 600 to 700 pounds, Kansas City, \$/cwt; *P400 – P600* is the price premium/discount between steer calves and yearlings, \$/cwt; *D* are seasonal dummy variables that are defined by the eleven months, January (*D1*) omitted, February = *D2*, March = *D3*, etc.; *PSL* is the price of Choice slaughter steers, 900 to 1100 pounds, Omaha, \$/cwt; *COSTG* is feed cost per pound of gain in feedlot represented by the price of corn received by farmers, Nebraska[4], \$ per bushel; *t* represents a specific month in the data; *j* and *i* represent specific lags on certain variables; *p* is the amount of months to be lagged; *k* is the maximum amount of months to be lagged; e_{1t}, e_{2t}, e_{3t} are random disturbance terms, assumed to be normally distributed with mean zero, constant variance, and serial independence.

Based on previous knowledge, signs on partial derivatives for the models are expected to be:

---

[4] Marsh uses corn prices received in Omaha, Nebraska. This information was not available in sources used to confirm, therefore, the Nebraska price was quoted instead.

$$(4)\ \frac{\partial P400}{\partial COSTG} = \beta_1 < 0 \text{ and}$$

$$\frac{\partial P600}{\partial COSTG} = \beta_2 < 0,\ \beta_1 \neq \beta_2$$

$$(5)\ \frac{\partial P400}{\partial PSL} = \beta_3 > 0 \text{ and}$$

$$\frac{\partial P600}{\partial PSL} = \beta_4 > 0,\ \beta_3 \neq \beta_4$$

$$(6)\ \frac{\partial P*}{\partial COSTG} = \beta_5 < 0 \text{ and}$$

$$\frac{\partial P*}{\partial PSL} = \beta_6 > 0,\ \beta_5 \neq \beta_6$$

where $P* = P400 - P600$ and the β coefficients are solely included to highlight signs and relationships. The negative correlations in equation (4) are expected because an increase in the cost of gain reduces cattle feeding margins, and consequently the derived demand for yearlings and calves. In equation (5) the positive relationship is anticipated because increases in the price of slaughter steers are expected to increase prices of both calves and yearlings. The coefficients are shown to be unequal because the two price groups will most likely respond differently to any changes that occur in the factors of supply and demand. This is because when calves are compared to yearlings, they do not necessarily yield a product with similar characteristics, such as biological finishing performance. There are also differences in beginning feed rations and the levels of concentrates used throughout the duration of the feeding program. According to Marsh (1985), there is also the time risk factor involved for each weight class to reach slaughter maturity that is significantly different. This allows for the differences in coefficients that come from an exogenous change in the market (Marsh, 1985).

In equation (6) the partial derivatives encompass the key focus of this research. This states that when the cost of gain increases, the difference in prices between calves and yearlings will narrow. This occurs because both of the prices will decrease (equation (4)), with a larger proportional decrease in price or demand of the 400 pound calf since there are more pounds to be added with a higher cost of gain. The next partial derivative states that when the slaughter price increases, the price difference between calves and yearlings widens. Increasing the price of slaughter steers increases the price of cattle in both weight classes. However, there is more of a proportional increase in the price of the 400 pound calves due to the fact that there are more pounds to be added in feedlots for lighter calves which leads to an increase in revenue. These partial derivative conditions assume that relative supplies between the two weight classes remain constant (Marsh, 1985). Agreeing with Marsh (1985), the absence of supply variables such as, "inventories of cattle and calves outside of feedlots" could account for some error in estimating the models, but at the time of his study this data was not available for the monthly time periods used.

3.3 Data

3.3a Confirmation

Monthly data was collected from January 1965 to December 1982, but when running the models all data was excluded except for the years 1972 to 1982 to match Marsh's time frame used. The data for this model were collected from two main sources. *U.S. Department of Agriculture Livestock and Meat Statistics, Supplement for 1982* was used to retrieve cattle prices and Agricultural Prices Summary annual reports were used to collect corn prices. Some of the data sources for this analysis varied from those indicated by Marsh (1985). He cites the *U.S. Department of Agriculture's Livestock and Meat Statistics* for all data; however, the issue used when completing this confirmation did not contain all information needed and could possibly differ from the original data. Therefore, another source was used to accumulate U.S. monthly corn prices, which is included as a proxy for the cost of gain. The price variables include only steers, the grade of Medium No. 1 frame for light and heavy feeder cattle, Choice Yield Grade No. 3 for slaughter steers, Kansas City price quotes for feeder cattle, and Omaha quotes for slaughter cattle. Using monthly observations accounts for any distributed lag relationships in the market, during a short-term period (Marsh, 1985).

3.3b Update

In order to update the results from Marsh's article through December 2013, new data was collected from the Livestock Marketing Information Center (LMIC, 2014). Changes to the data used in the update reflect the fact that the data used in the 1985 research was neither easily accessible nor consistent through the new time period used. In this instance, monthly data was collected from January 1973 to December 2013. The price variables still only include steers; however, locations differ from the data used in the confirmation. For the update, the price of weanlings and yearlings is represented by Oklahoma City price quotes of the simple average for weight classes ranging from 300 to 1000 pounds. The weight classes used in this update were 400 pounds to represent calves and 600 pounds to represent yearlings. The price of slaughter is the Nebraska price quote for Choice slaughter quotes, weighing 1100 to 1300 pounds. The proxy for cost of gain was also collected from the LMIC (2014), but compiled from *USDA-NASS Monthly Agricultural Prices* and is represented by the corn price received by farmers.

3.3c Expansion

When completing the expansion, monthly data was collected from the LMIC (2014) for the time period of January 1990 to December 2013. However, when regressing the models only the period of January 1993 to December 2013 was used because the prior years were used to calculate a 3-year average basis, which is explained later. The reason this time period was chosen is due to the fact that the variables collected and used in this expansion began in January 1990. However, there were changes in the data used to proxy the variables in the model. In today's market it is much more conducive for a producer to wean a calf at 500 pounds instead of 400 pounds. Therefore, the price variables used are those of Oklahoma City steer price quotes of 500 and 700 pound weights. Initially, an actual estimate for feedlot cost of gain was thought to be a better proxy for cost of gain than corn price. However, the cost of gain values from the Kansas State University Focus on Feedlot survey were highly correlated (0.95) with those of corn price values, so corn price was left as the proxy for cost of gain. Lastly, with data from the futures market now being available, a forward-looking live cattle future price was incorporated instead of current and lagged cash prices.

3.4 Procedure

3.4a Confirmation

Following Marsh (1985), all price variables (*P400*, *P600*, *COSTG*, *PSL*) are deflated by the consumer price index (1967 = 100); however, the price premium/discount variable (*P400 – P600)* is defined in nominal terms. The consumer price index (CPI) used was found on the Livestock Marketing Information Center (2014) website. This spreadsheet yielded CPI values (1982-1984 = 100), and was then used to calculate the CPI (1967 = 100). Since it was monthly data, the twelve values for 1967 were averaged together to calculate the denominator for converting the CPI. The author recognizes this may not be the method that Marsh (1985) used when adjusting price variables, however it was not specifically indicated in the original article what source was used to accumulate the monthly CPI.

In an effort to confirm the results that were produced by Marsh (1985), all data was collected, price variables were adjusted using the CPI, and then models were regressed using

Stata statistical software. All models were adjusted for first-order auto correlation[5]. To maintain consistency with Marsh (1985), distributed lags are included in all models. This consists of the price of slaughter being lagged one and two months for estimating the *P400* and *P600* models. The dependent variables were lagged one month for all models and then lagged two months for estimating the *P400* and *P600* models. This was done to account for the biological sequence, length of feeding period, and peaks in prices that were not within the specified month due to adjustments in feed price and slaughter price (Marsh, 1985). The first confirmation attempt was completed using real corn price values, but yielded extreme inconsistencies in the estimated coefficients for the *P400* and *P600* models. Therefore, a modification attempt was completed using nominal corn prices and was found to be more accurate for the two specified models. This information is further detailed below in the results section.

3.4b Update

Similar methods were used in analyzing the updated data. All data was collected and the monthly price variables were deflated using the calculated CPI (1967=100) that was derived during the confirmation. However, in the update the price premium/discount variable (*P400-P600*) is defined in real terms. These models were also adjusted for first-order auto correlation and regressed using Stata statistical software. The same distributed lags from the confirmation are used when regressing these models.

Due to the fact that only models including real corn price are deemed relevant in this research (even though there were inconsistencies in the confirmation until nominal corn prices

[5] This was done by using the “prais” command in Stata. This adjusts for first-order auto correlation. Results yielded are labeled as “Prais-Winsten AR”.

were used) the only models regressed in this section include real corn prices. These estimates for the 1973 to 2013 time period were compared to Marsh (1985) results.

To explore structural change in the model, two more regressions were run using data from two different time periods. A regression was run using the data from January 1973 to December 1983 in order to represent the original time frame analyzed by Marsh. Another regression was run using the rest of the data set from January 1983 to December 2013 to represent the time frame after Marsh's analysis. A Chow test was then completed using these models, as well as the combined model from 1973 to 2013 to determine if structural change has occurred over time.

3.4c Expansion

The procedure used in the expansion is very similar to those done in the confirmation and update. However, in order to incorporate the live cattle futures data as a forward-looking proxy for price of slaughter, there were multiple steps taken. First, it was important to incorporate a 3-year historical average basis using the cash values for price of slaughter that were collected in the update and the nearby live cattle futures contract for the same date collected from LMIC (2014). A 3-year average basis was used because of the findings by McElligott and Tonsor (2012) that confirmed that a 3-year average was still an acceptable method to use for a basis forecaster on fed cattle prices. This 3-year historical average also allowed us to use a time frame of 11 years which is the same amount of years included in the analysis completed by Marsh (1985). It is important to note that basis here is calculated as cash minus futures. This value was then added back to the live cattle futures price that was found in the next step.

Using Kansas State University Focus on Feedlot data (LMIC, 2014) for the 1990 to 2013 time frame, an average was calculated on both the final weight at slaughter values (1275 lbs) and the daily rate of gain values (3.4 lbs/day). These values were used to calculate the number of days it would take for an animal to reach the final weight at this specified rate of gain:

$$(7)\ \frac{Average\ Final\ Weight - Beginning\ Weight}{Average\ Daily\ Gain}$$

Using the date documented in the data set as the buying date, the amount of days found in equation (7) was added to the buying date to calculate a selling date. The month of the selling date was used to decide which contract would be used. It should be noted that live cattle futures has contracts for the months of February, April, June, August, October and December. Because of this, the closest following contract to the sell date was used. For example, if a 500 pound calf was placed in January 1993, it would take 228 days to add 775 pounds and would be sold in August 1993. Therefore, looking at the contract data in January 1993, the October contract price would be used. This was added to the 3-year historical average basis for the month of August to use as a forecast of the price of slaughter cattle. This was done for the entire data set and for both weight classes of 500 and 700 pounds. The values determined for price of slaughter for the 500 and 700 pound variables were averaged to calculate the variable used in the price premium/discount equation.

The data was collected for all variables and the price variables were deflated using the CPI (1967=100). As in the update, the price premium/discount variable is also deflated. These models were also adjusted for first-order auto correlation and regressed using Stata statistical software.

3.5 Results

3.5a Confirmation

Table 3.1 through Table 3.4 represent the estimated models corresponding to equations (1), and (2). Each equation, individually, has a high adjusted R-squared and a low standard of error estimate (SY). T-statistics are given under each estimate and shown in parentheses.

In order to assess whether the coefficient estimates were statistically significant from what Marsh (1985) reported, a t-statistic was calculated in order to conduct a t-test. This was compared to the estimated coefficient in the confirmation attempt to that reported by Marsh (1985) and used the standard error from the confirmation attempt, assuming that the standard error on what Marsh (1985) reported was zero. This was a simple way to compare the coefficient estimates.

When comparing the first confirmation attempt using real corn price, the estimates yielded were significantly different than those reported by Marsh (1985). There were also large differences in the estimated coefficients on the *COSTG* variables for the models estimating *P400* and *P600*. A modification attempt was completed to account for this large inconsistency and nominal corn price was used instead. This attempt yielded estimates highly similar to what Marsh (1985) produced. When regressed using nominal corn price, the only coefficient estimate that was significantly different from those reported by Marsh (1985) is the estimated coefficient on the intercept. Therefore, allowing speculation that Marsh (1985) used nominal corn prices to estimate the price-dependent models for a 400 pound calf and a 600 pound yearling instead of real corn prices (perhaps accidentally), as he documented.

Excluding dummy variables and intercepts, all variables yielded coefficients with differences of less than 0.08 and within 15% of the reported coefficient (Table 3.2 and Table

3.4). These estimates were also shown to be statistically significant (p-values less than 0.05) consistent with Marsh (1985). These negative relationships between the cost of gain and price of calves or yearlings were revealed to be consistent with expected values (equation (4)), stating that as corn price increases by $1/bushel, the price of 400 and 600 pound cattle will decrease by $0.476/cwt and $0.419/cwt, respectively. It is confirmed that corn price has a larger effect on the price of calves than on the price of yearlings. This suggests that a purchaser will be willing to pay less for lighter weight calves that they will have to add more weight to.

Equation (5) was also shown to be congruent with expectations. The reported coefficients on the price of slaughter for 400 and 600 pound cattle stated that for a $1/cwt increase in the price of slaughter cattle, the price of 400 and 600 pound calf or yearling would increase by $0.666/cwt and $0.754/cwt, respectively. The positive relationship between the price of slaughter cattle and the price of a 400 pound calf or 600 pound yearling, confirms that as slaughter prices rise, prices paid for both weight classes will rise due to the increasing cattle feeding margins. Also, the price of slaughter cattle is shown to have more of an impact on the price of yearlings versus calves. This can be explained by "the profitability risk in placing light versus heavy cattle on feed and finishing them to slaughter market weights" (Marsh, 1985). With a heavier weight animal there is less weight to be added in order for it to be ready for the slaughter market, which is less expensive for a producer on a per animal basis, but not necessarily on a per hundred weight basis.

The consistencies in expected signs, gives significance to the results yielded by Marsh (1985). However, when estimating these two models, there seems to be large discrepancies with estimating the intercept and dummy variables. The intercepts were excessively overstated and were not statistically significant with p-values greater than 0.05.

The estimated coefficients on the dummy variables (January omitted) are also shown in Table 3.1 through Table 3.4. The estimations of coefficients for the dummy variables were inconsistent from what Marsh (1985) reported and were rarely found to be statistically significant with p-values greater than 0.05. These seasonal dummy variables signify the fluctuations in price of calves, price of yearlings, or price differences during different months of the year compared with January. Signs on all estimated coefficients did not deviate from signs reported from Marsh (1985). However, values were distinctly different. When analyzing the dummy variables for the *P400* and *P600* models, the months of February and August are shown to be the only months throughout the year where prices increase, relative to January. This suggests that these months are when most cattle operations are making crucial management decisions and increases in the markets were present during the years 1972 to 1982. All other months are shown to have negative impacts on the prices compared to estimated prices during the month of January.

Another technique used to compare the coefficient estimates was to use confidence intervals. In order to do this, confidence intervals were calculated for Marsh (1985) using the information provided in the article. These confidence intervals were then compared to those on the estimated coefficients in the confirmation attempts. When analyzing this, the coefficient estimate using real corn price under the *P400* model, was the only estimate that differed from what Marsh (1985) reported. All other confidence intervals for the coefficient estimates overlapped, therefore, not showing much difference.

It should be noted that these models were estimated using nominal corn prices instead of real prices that were deflated using the CPI. However, when real corn prices were regressed in the models, the signs on the coefficients were also consistent, while the values differed. The estimated coefficient for the cost of gain variable was also estimated to have more of an impact on price than initially stated by Marsh (1985) or in the modified confirmation.

Table 3.1 Results of Monthly Steer Calf Prices (*P400*), Real Corn Price, 1972-1982

Variables	Reported by Marsh (1985)		Confirmation attempt (Real Corn Price)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.056		0.260		0.316	-564.06%	No
	(-0.074)		(0.383)				
COSTG	-0.473	**	-1.562	***	-1.089	230.28%	Yes
	(-2.271)		(-4.684)				
PSL	0.720	***	0.737	***	0.017	2.31%	No
	(9.910)		(10.762)				
PSL-1	-1.063	***	-0.975	***	0.088	-8.32%	No
	(-8.194)		(-8.170)				
PSL-2	0.444	***	0.423	***	-0.021	-4.69%	No
	(4.882)		(5.204)				
DEP-1	1.604	***	1.416	***	-0.188	-11.70%	Yes
	(19.602)		(18.053)				
DEP-2	-0.644	***	-0.501	***	0.143	-22.16%	Yes
	(-8.807)		(-6.938)				
February	0.669		0.771		0.102	15.22%	No
	(0.882)		(1.131)				
March	-0.915		-0.648		0.267	-29.23%	No
	(-1.611)		(-1.243)				
April	-2.021	**	-1.690	***	0.331	-16.39%	No
	(-3.036)		(-2.882)				
May	-0.464		-0.557		-0.093	19.96%	No
	(-0.785)		(-1.025)				
June	-1.867	***	-1.792	***	0.075	-4.00%	No
	(-3.00)		(-3.188)				
July	-0.680		-0.906		-0.226	33.25%	No
	(-1.134)		(-1.633)				
August	0.551		0.496		-0.055	-10.04%	No
	(0.891)		(0.892)				
September	-1.333	**	-1.206	**	0.127	-9.55%	No
	(-2.206)		(-2.122)				
October	-1.340	**	-1.391	**	-0.051	3.77%	No
	(-2.077)		(-2.486)				
November	-0.863		-0.999	*	-0.136	15.77%	No
	(-1.619)		(-1.795)				
December	-0.871		-0.990	*	-0.119	13.72%	No
	(-1.185)		(-1.787)				
R^2 (adjusted)	0.983		0.994				
SY	1.207		1.128				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.

T-statistics are reported under coefficient estimates and denoted in parentheses.

SY represents standard of error estimate

When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

Table 3.2 Results of Monthly Steer Calf Prices (*P400*), Nominal Corn Price, 1972-1982

Variables	Reported by Marsh (1985)		Modified confirmation (Nominal Corn Price)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.056		1.615	*	1.671	-2984.60%	Yes
	(-0.074)		(1.959)				
COSTG	-0.473	**	-0.476	***	-0.003	0.72%	No
	(-2.271)		(-2.822)				
PSL	0.720	***	0.666	***	-0.054	-7.51%	No
	(9.910)		(9.279)				
PSL-1	-1.063	***	-0.987	***	0.076	-7.11%	No
	(-8.194)		(-7.768)				
PSL-2	0.444	***	0.374	***	-0.070	-15.85%	No
	(4.882)		(4.304)				
DEP-1	1.604	***	1.527	***	-0.077	-4.81%	No
	(19.602)		(19.837)				
DEP-2	-0.644	***	-0.566	***	0.078	-12.07%	No
	(-8.807)		(-7.569)				
February	0.669		0.705		0.036	5.31%	No
	(0.882)		(0.967)				
March	-0.915		-0.789		0.126	-13.74%	No
	(-1.611)		(-1.437)				
April	-2.021	**	-1.729	***	0.292	-14.47%	No
	(-3.036)		(-2.759)				
May	-0.464		-0.507		-0.043	9.17%	No
	(-0.785)		(-0.879)				
June	-1.867	***	-1.757	***	0.110	-5.87%	No
	(-3.00)		(-2.931)				
July	-0.680		-0.691		-0.011	1.57%	No
	(-1.134)		(-1.175)				
August	0.551		0.593		0.042	7.62%	No
	(0.891)		(1.002)				
September	-1.333	**	-1.236	**	0.097	-7.31%	No
	(-2.206)		(-2.043)				
October	-1.340	**	-1.372	**	-0.032	2.42%	No
	(-2.077)		(-2.306)				
November	-0.863		-0.967		-0.104	12.02%	No
	(-1.619)		(-1.633)				
December	-0.871		-0.962		-0.091	10.50%	No
	(-1.185)		(-1.632)				
R^2 (adjusted)	0.983		0.993				
SY	1.207		1.191				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate
When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

Table 3.3 Results of Yearling Prices (*P600*) Real Corn Price, 1972-1982

Variables	Reported by Marsh (1985)		Confirmation attempt (Real Corn Price)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.842		-0.348		0.494	-58.68%	No
	(-1.443)		(-0.698)				
COSTG	-0.411	**	-1.193	***	-0.782	190.16%	Yes
	(-2.335)		(-4.856)				
PSL	0.793	***	0.803	***	0.010	1.27%	No
	(14.413)		(16.603)				
PSL-1	-1.207	***	-1.137	***	0.070	-5.76%	No
	(-10.771)		(-12.629)				
PSL-2	0.534	***	0.522	***	-0.012	-2.16%	No
	(5.750)		(7.505)				
DEP-1	1.493	***	1.368	***	-0.125	-8.40%	No
	(13.932)		(17.920)				
DEP-2	-0.551	***	-0.474	***	0.077	-14.05%	No
	(-5.251)		(-6.613)				
February	0.672		0.584		-0.088	-13.03%	No
	(1.490)		(1.460)				
March	-0.255		-0.273		-0.018	7.07%	No
	(-0.631)		(-0.782)				
April	-0.882	**	-0.907	**	-0.025	2.84%	No
	(-2.145)		(-2.538)				
May	-0.064		-0.222		-0.158	247.61%	No
	(-0.160)		(-0.626)				
June	-0.484		-0.657	*	-0.173	35.82%	No
	(-1.206)		(-1.839)				
July	-0.166		-0.329		-0.163	98.48%	No
	(-0.412)		(-0.917)				
August	0.759	*	0.581		-0.178	-23.50%	No
	(1.896)		(1.628)				
September	-0.637		-0.650	*	-0.013	1.98%	No
	(-1.529)		(-1.775)				
October	-0.230		-0.408		-0.178	77.33%	No
	(-0.569)		(-1.137)				
November	-0.066		-0.187		-0.121	183.06%	No
	(-0.169)		(-0.523)				
December	-0.315		-0.479		-0.164	51.91%	No
	(-0.716)		(-1.349)				
R^2 (adjusted)	0.984		0.992				
SY	0.880		0.783				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate
When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

Table 3.4 Results of Yearling Prices (*P600*), Nominal Corn Price, 1972-1982

Variables	Reported by Marsh (1985)		Modified confirmation (Nominal Corn Price)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.842		0.654		1.496	-177.63%	Yes
	(-1.443)		(1.037)				
COSTG	-0.411	**	-0.419	***	-0.008	1.93%	No
	(-2.335)		(-3.136)				
PSL	0.793	***	0.754	***	-0.039	-4.89%	No
	(14.413)		(14.877)				
PSL-1	-1.207	***	-1.160	***	0.047	-3.93%	No
	(-10.771)		(-12.132)				
PSL-2	0.534	***	0.486	***	-0.048	-9.03%	No
	(5.750)		(6.521)				
DEP-1	1.493	***	1.438	***	-0.055	-3.67%	No
	(13.932)		(18.411)				
DEP-2	-0.551	***	-0.498	***	0.053	-9.66%	No
	(-5.251)		(-6.536)				
February	0.672		0.599		-0.073	-10.87%	No
	(1.490)		(1.417)				
March	-0.255		-0.258		-0.003	1.18%	No
	(-0.631)		(-0.701)				
April	-0.882	**	-0.826	**	0.056	-6.33%	No
	(-2.145)		(-2.193)				
May	-0.064		-0.101		-0.037	58.16%	No
	(-0.160)		(-0.271)				
June	-0.484		-0.522		-0.038	7.80%	No
	(-1.206)		(-1.388)				
July	-0.166		-0.126		0.040	-24.11%	No
	(-0.412)		(-0.335)				
August	0.759	*	0.707	*	-0.052	-6.86%	No
	(1.896)		(1.881)				
September	-0.637		-0.579		0.058	-9.13%	No
	(-1.529)		(-1.499)				
October	-0.230		-0.335		-0.105	45.76%	No
	(-0.569)		(-0.887)				
November	-0.066		-0.148		-0.082	124.51%	No
	(-0.169)		(-0.394)				
December	-0.315		-0.463		-0.148	47.04%	No
	(-0.716)		(-1.238)				
R^2 (adjusted)	0.984		0.991				
SY	0.880		0.826				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate
When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

Table 3.5 and 3.6 highlight the main basis for this research and show the relationships between cost of gain and slaughter prices on price premiums/discounts in the stocker industry. In this instance, using real corn price (Table 3.5) yielded estimated coefficients that were most similar with what Marsh (1985) reported. The coefficient estimates for *COSTG, PSL,* and the lagged dependent variable were revealed to be statistically significant with p-values less than 0.05, which were not significant in the model when estimated using nominal corn price. Thus, allowing the assumption that Marsh estimated this model with deflated corn prices. As hypothesized by Marsh (1985), the price differences are likely due to cost of gain, seasonality, and forecasting of prices in the slaughter market. The expected signs of the estimated coefficients were consistent with the theoretical assumptions stated in equation (6). This concludes that a $1/bushel increase in corn price will cause a $1.368 /cwt decrease in the difference between prices for calves and yearlings. As price of slaughter cattle increases by $1/cwt, the difference in prices will increase by $0.074/cwt. Price premiums for lower weight classes and discounts for heavier weight classes are crucial factors for cow-calf producers and stockers when calculating predicted returns or deciding to sell or retain ownership.

Observations were slightly different regarding the estimated coefficients for the dummy variables in the *P400 – P600* model. February and March are the only months that are shown to widen the price difference between calves and yearlings when compared to January, while all other months are shown to narrow the difference in prices. However, it should be noted that the statistical significance of the majority of these estimates are found to be obsolete (p-value greater than 0.05). This suggests that fluctuations in premiums or discounts are not considered to be highly seasonal.

Table 3.5 Results of Price Differences (*P400 – P600)* Real Corn Price, 1972-1982

Variables	Reported by Marsh (1985)		Confirmation attempt (Real Corn Price)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.747		0.766		1.513	-202.53%	No
	(-0.840)		(0.916)				
COSTG	-1.051	***	-1.368	***	-0.317	30.18%	No
	(-3.431)		(-3.678)				
PSL	0.121	***	0.074	***	-0.047	-38.62%	No
	(3.145)		(2.527)				
PSL-1	-		-			-	
	-		-			-	
PSL-2	-		-			-	
	-		-			-	
DEP-1	0.907	***	0.904	***	-0.003	-0.34%	No
	(31.44)		(33.014)				
DEP-2	-		-			-	
	-		-			-	
February	1.230	**	1.011	*	-0.219	-17.77%	No
	(1.704)		(1.477)				
March	0.470		0.322		-0.148	-31.54%	No
	(0.729)		(0.532)				
April	-0.690		-0.636		0.054	-7.78%	No
	(-1.039)		(-1.014)				
May	-0.373		-0.374		-0.001	0.37%	No
	(-0.577)		(-0.601)				
June	-1.786	***	-1.709	**	0.077	-4.29%	No
	(-2.759)		(-2.732)				
July	-1.293	**	-1.414	**	-0.121	9.34%	No
	(-2.008)		(-2.271)				
August	-0.342		-0.298		0.044	-12.91%	No
	(-0.531)		(-0.479)				
September	-0.115		-0.263		-0.148	128.55%	No
	(-0.180)		(-0.423)				
October	-1.539	**	-1.695	**	-0.156	10.16%	No
	(-2.365)		(-2.720)				
November	-1.382	**	-1.638	***	-0.256	18.55%	No
	(-2.185)		(-2.637)				
December	-1.180	*	-1.291	**	-0.111	9.43%	No
	(-1.676)		(-2.083)				
R^2 (adjusted)	0.917		0.947				
SY	1.434		0.696				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate
When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

Table 3.6 Results of Price Differences (*P400 – P600)* Nominal Corn Price, 1972-1982

Variables	Reported by Marsh (1985)		Modified confirmation (Nominal Corn Price)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.747		1.347		2.094	-280.30%	No
	(-0.840)		(1.238)				
COSTG	-1.051	***	-0.374	***	0.677	-64.39%	Yes
	(-3.431)		(-1.847)				
PSL	0.121	***	0.016		-0.105	-86.92%	Yes
	(3.145)		(0.543)				
PSL-1	-		-				
	-		-				
PSL-2	-		-				
	-		-				
DEP-1	0.907	***	0.960	***	0.053	5.88%	Yes
	(31.44)		(40.769)				
DEP-2	-		-				
	-		-				
February	1.230	**	1.014		-0.216	-17.58%	No
	(1.704)		(1.445)				
March	0.470		0.241		-0.229	-48.80%	No
	(0.729)		(0.382)				
April	-0.690		-0.702		-0.012	1.67%	No
	(-1.039)		(-1.082)				
May	-0.373		-0.420		-0.047	12.56%	No
	(-0.577)		(-0.650)				
June	-1.786	***	-1.815	**	-0.029	1.61%	No
	(-2.759)		(-2.806)				
July	-1.293	**	-1.469	**	-0.176	13.63%	No
	(-2.008)		(-2.281)				
August	-0.342		-0.379		-0.037	10.95%	No
	(-0.531)		(-0.590)				
September	-0.115		-0.361		-0.246	214.26%	No
	(-0.180)		(-0.562)				
October	-1.539	**	-1.834	**	-0.295	19.15%	No
	(-2.365)		(-2.845)				
November	-1.382	**	-1.727	***	-0.345	24.96%	No
	(-2.185)		(-2.683)				
December	-1.180	*	-1.331	**	-0.151	12.82%	No
	(-1.676)		(-2.075)				
R^2 (adjusted)	0.917		0.940				
SY	1.434		0.732				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate
When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

3.5b Update

The statistical results from the updated data set for years 1973 to 2013 are shown in Tables 3.7 through 3.9. Just as above, these values represent the estimated coefficients for models presented by equations (1), (2), and (3). Each equation, individually, has a high adjusted R-squared and a low standard of error estimate (SY). T-statistics are given under each estimate and shown in parentheses.

This update produced coefficient estimates for the updated data series that included the years 1973 to 2013. These values are compared with those reported in Marsh (1985) for his time period of January 1972 to December 1982. In all three models, the majority of estimates yielded are significantly different from the coefficient estimates reported by Marsh (1985). When looking at these three models for predicting price and price difference of a 400 pound calf and a 600 pound yearling, even though these results are significantly different from Marsh, all major price variables were seen to be significant (p-values less than 0.05). As yielded in the above models, the negative relationships between the cost of gain and price of calves or yearlings were revealed to be consistent with expected values in equation (4), stating that as corn price increases by $1/bushel, the price of 400 and 600 pound cattle will decrease by $1.098/cwt and $0.635, respectively. It is also again confirmed that the cost of gain has a larger effect on the price of calves than on the price of yearlings.

When analyzing the results in regards to equation (5), these were also shown to be congruent with expected signs on the coefficients. This confirms that there is a positive relationship between the price of slaughter cattle and the price of a 400 pound calf or 600 pound yearling, which means that as slaughter cattle prices increase $1/cwt, prices paid for 400 and 600 pound cattle will increase by $0.675/cwt and $0.640/cwt, respectively. However, in this update, the price of slaughter cattle is shown to have slightly more of an impact on the price of calves versus yearlings. These consistencies in expected signs, gives significance to the results yielded by Marsh (1985) even when using updated data. However, when estimating these two models, there still seems to be large discrepancies between the values of the estimates produced by Marsh (1985) and those estimated during the update, even though the major price variables showed significance at less than the 0.05 level.

The estimations of coefficients for the dummy variables were significantly different from what Marsh (1985) reported and were rarely found to be statistically significant with p-values greater than 0.05. Unlike in the confirmation, some of the signs on the estimated coefficients did deviate from signs reported from Marsh (1985) and values estimated varied greatly.

The results for the *P400-P600* model were consistent with the expectations in equation (6). This concludes that a $1/bushel increase in corn price will cause a $0.658 /cwt decrease in the difference between prices for calves and yearlings. As price of slaughter cattle increases by $1/cwt, the difference in prices will increase by $0.048/cwt.

The observations in respect to the estimated coefficients for the dummy variables in the *P400 – P600* model were different than those reported by Marsh (1985). Five of the eleven months were shown to widen the price differences, while the other six were shown to narrow it. As in the confirmation, it is noted that the majority of these estimates are found to be insignificant (p-value greater than 0.05), which suggests that fluctuations in premiums or discounts are not considered to be highly seasonal for the 1973 to 2013 period either.

As done in the confirmation, the confidence intervals calculated for Marsh (1985) were compared to those yielded in this update to more accurately assess the difference of the coefficient estimates. When doing this, the coefficient estimates for the lagged dependent variables and the April dummy variable under the *P400* model varied from what Marsh (1985) reported. In addition, the coefficient estimate for the one-month lagged price of slaughter cattle differed from Marsh (1985). All other confidence intervals for the coefficient estimates overlapped, therefore, not showing much difference.

It should be noted that these updated models were estimated using only real corn prices instead of also estimating them with nominal corn prices. Though it was concluded that Marsh most likely estimated the *P400* and *P600* using nominal corn price instead of real corn price, there is not much to be gained in the update by using nominal corn price when all price variables are to be deflated using the CPI (1967 = 100). Therefore, when comparing the estimated coefficients from Marsh (1985) and the update, there could be large discrepancies due to this circumstance.

Table 3.7 Results of Monthly Steer Calf Prices (*P400*) 1973-2013

Variables	Reported by Marsh (1985)		Update Estimates (1973-2013)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.056		0.248		0.304	-543.21%	No
	(-0.074)		(1.015)				
COSTG	-0.473	**	-1.098	***	-0.625	132.12%	Yes
	(-2.271)		(-4.668)				
PSL	0.720	***	0.675	***	-0.045	-6.30%	No
	(9.910)		(13.265)				
PSL-1	-1.063	***	-0.750	***	0.313	-29.44%	Yes
	(-8.194)		(-8.931)				
PSL-2	0.444	***	0.200	***	-0.244	-55.01%	Yes
	(4.882)		(3.440)				
DEP-1	1.604	***	1.200	***	-0.404	-25.19%	Yes
	(19.602)		(26.915)				
DEP-2	-0.644	***	-0.269	***	0.375	-58.18%	Yes
	(-8.807)		(-6.230)				
February	0.669		0.689	***	0.020	2.94%	No
	(0.882)		(2.698)				
March	-0.915		-0.034		0.881	-96.31%	Yes
	(-1.611)		(-0.138)				
April	-2.021	**	-0.037		1.984	-98.17%	Yes
	(-3.036)		(-0.151)				
May	-0.464		-0.519	**	-0.055	11.94%	No
	(-0.785)		(-2.115)				
June	-1.867	***	-0.182		1.685	-90.23%	Yes
	(-3.00)		(-0.733)				
July	-0.680		-0.133		0.547	-80.39%	Yes
	(-1.134)		(-0.540)				
August	0.551		0.572	**	0.021	3.86%	No
	(0.891)		(2.336)				
September	-1.333	**	-0.441	*	0.892	-66.95%	Yes
	(-2.206)		(-1.803)				
October	-1.340	**	-0.596	**	0.744	-55.49%	Yes
	(-2.077)		(-2.426)				
November	-0.863		0.424	*	1.287	-149.16%	Yes
	(-1.619)		(1.711)				
December	-0.871		0.200		1.071	-122.94%	Yes
	(-1.185)		(0.820)				
R^2 (adjusted)	0.983		0.979				
SY	1.207		1.093				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate
When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

Table 3.8 Results of Yearling Prices (*P600*) 1973-2013

Variables	Reported by Marsh (1985)		Update Estimates (1973-2013)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.842		0.163		1.005	-119.32%	Yes
	(-1.443)		(1.052)				
COSTG	-0.411	**	-0.635	***	-0.224	54.48%	No
	(-2.335)		(-4.535)				
PSL	0.793	***	0.640	***	-0.153	-19.23%	Yes
	(14.413)		(19.499)				
PSL-1	-1.207	***	-0.861	***	0.346	-28.66%	Yes
	(-10.771)		(-14.786)				
PSL-2	0.534	***	0.312	***	-0.222	-41.49%	Yes
	(5.750)		(7.673)				
DEP-1	1.493	***	1.375	***	-0.118	-7.90%	Yes
	(13.932)		(33.352)				
DEP-2	-0.551	***	-0.442	***	0.109	-19.81%	Yes
	(-5.251)		(-11.028)				
February	0.672		0.503	***	-0.169	-25.10%	No
	(1.490)		(2.914)				
March	-0.255		-0.025		0.230	-90.18%	No
	(-0.631)		(-0.159)				
April	-0.882	**	-0.110		0.772	-87.55%	Yes
	(-2.145)		(-0.687)				
May	-0.064		-0.236		-0.172	268.90%	No
	(-0.160)		(-1.473)				
June	-0.484		0.169		0.653	-134.85%	Yes
	(-1.206)		(1.042)				
July	-0.166		0.152		0.318	-191.79%	Yes
	(-0.412)		(0.953)				
August	0.759	*	0.191		-0.568	-74.79%	Yes
	(1.896)		(1.204)				
September	-0.637		-0.269	*	0.368	-57.71%	Yes
	(-1.529)		(-1.691)				
October	-0.230		-0.341	**	-0.111	48.19%	No
	(-0.569)		(-2.126)				
November	-0.066		0.365	**	0.431	-653.03%	Yes
	(-0.169)		(2.259)				
December	-0.315		0.187		0.502	-159.51%	Yes
	(-0.716)		(1.180)				
R^2 (adjusted)	0.984		0.989				
SY	0.880		0.705				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate
When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

Table 3.9 Results of Price Differences (*P400 – P600*) 1973-2013

Variables	Reported by Marsh (1985)		Update Estimates (1973-2013)		Difference	Percent Difference	Significantly Different (Y/N)
Intercept	-0.747		0.089		0.836	-111.94%	Yes
	(-0.840)		(0.618)				
COSTG	-1.051	***	-0.658	***	0.393	-37.39%	Yes
	(-3.431)		(-4.975)				
PSL	0.121	***	0.048	***	-0.073	-60.73%	Yes
	(3.145)		(4.948)				
PSL-1	-		-			-	
	-		-			-	
PSL-2	-		-			-	
	-		-			-	
DEP-1	0.907	***	0.874	***	-0.033	-3.64%	No
	(31.44)		(44.319)				
DEP-2	-		-			-	
	-		-			-	
February	1.230	**	0.199		-1.031	-83.82%	Yes
	(1.704)		(1.321)				
March	0.470		-0.017		-0.487	-103.58%	Yes
	(0.729)		(-0.115)				
April	-0.690		0.065		0.755	-109.35%	Yes
	(-1.039)		(0.441)				
May	-0.373		-0.213		0.160	-42.96%	No
	(-0.577)		(-1.453)				
June	-1.786	***	-0.326	**	1.460	-81.77%	Yes
	(-2.759)		(-2.224)				
July	-1.293	**	-0.366	**	0.927	-71.70%	Yes
	(-2.008)		(-2.502)				
August	-0.342		0.260	*	0.602	-176.15%	Yes
	(-0.531)		(1.779)				
September	-0.115		-0.107		0.008	-6.95%	No
	(-0.180)		(-0.732)				
October	-1.539	**	-0.234		1.305	-84.81%	Yes
	(-2.365)		(-1.598)				
November	-1.382	**	0.084		1.466	-106.07%	Yes
	(-2.185)		(0.573)				
December	-1.180	*	0.035		1.215	-103.00%	Yes
	(-1.676)		(0.242)				
R^2 (adjusted)	0.917		0.870				
SY	1.434		0.657				

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.

T-statistics are reported under coefficient estimates and denoted in parentheses.

SY represents standard of error estimate

When determining whether a coefficient estimate was significantly different, the coefficient estimate from the confirmation attempt was subtracted from the coefficient reported by Marsh (1985) and then divided by the standard error of the estimated coefficient to yield a t-statistic. The t-statistics were then compared to the critical value of 1.96 to determine if they were significantly different at the 5% level.

In addition to updating this article, it was important to understand any structural change that might have occurred during or after Marsh (1985). In order to test for structural change since Marsh's original analysis, regression results from three time periods were used to conduct a Chow test. Using the updated data set and the regression data from the January 1973 to December 2013 time period, models were regressed using the time frame of January 1973 to December 1982 to represent the original period used by Marsh (1985) and then all models were regressed for the time frame of January 1983 to December 2013. All coefficient estimate results for these three time periods are shown in Tables 3.10, 3.11, and 3.12.

Tables 3.10 through 3.12 highlight the regression results for the January 1983 to December 2013. This represents the time frame since Marsh's article. These values are the estimated coefficients for the models in equations (1), (2), and (3). All equations yielded smaller adjusted R-squared and a lower standard of error estimate (SY) than those seen in the models ran for the 1973 to 1982 and 1973 to 2013 time periods. T-statistics are given under each estimate and shown in parentheses.

These results yielded negative relationships between the cost of gain and price of calves or yearlings and were consistent with the expected values in equation (4), stating that as corn price increases by $1/bushel, the price of 400 and 600 pound cattle will decrease by $0.674/cwt and $0.323, respectively. As in the other instances, it is confirmed that corn price has a larger effect on the price of calves than on the price of yearlings.

The expected signs on the coefficients in regards to equation (5) were also shown to be consistent with the expectations. This shows that there is a positive relationship between the price of slaughter cattle and the price of a 400 pound calf or 600 pound yearling, which means that as slaughter prices increase $1/cwt, prices paid for 400 and 600 pound cattle will increase by

$0.507/cwt and $0.514/cwt, respectively. As in the confirmation, the price of slaughter cattle is shown to have slightly more of an impact on the price of yearlings versus calves. These consistencies in expected signs, gives significance to the results yielded by Marsh (1985) even when using a different time period. When estimating the *P400* and *P600* models the values of the estimates changed slightly from those in the 1973 to 1982 models. However, the significance of the major price variables was consistent except when estimating coefficients on *PSL-2* and *DEP-2,* which were not significant in the *P400* model.

The estimations of coefficients for the dummy variables differed from the estimates for the 1973 to 1982 time period. When analyzing the 1983 to 2013 models, there was no longer significance on the coefficient estimated for the August and November variables. However, the coefficient estimates for months of September and October yielded significance for both models and the estimate for the month of May was significant in the *P400* model. Some of the signs on the estimates also deviated from the models ran for the previous period.

The *P400 – P600* model has the lowest adjusted R-squared with the data only explaining 79.6% of the model. However, all major price variables had coefficient estimates of significance and that corresponded with the appropriate signs in equation (6). The monthly dummy variables yielded coefficients that were significant for the months of May, June and July. By running the model for this time period, it was possible to complete a Chow test to test for structural change.

Table 3.10 Differing Time Frames of Monthly Steer Calves Prices (*P400*)

Variables	**Estimates 1973-1982**		**Estimates 1983-2013**		**Estimates 1973-2013**	
Intercept	-1.361		0.440		0.248	
	(-1.463)		(1.207)		(1.015)	
COSTG	-1.233	***	-0.674	**	-1.098	***
	(-2.997)		(-2.076)		(-4.668)	
PSL	0.779	***	0.507	***	0.675	***
	(9.459)		(5.467)		(13.265)	
PSL-1	-0.989	***	-0.459	***	-0.750	***
	(-7.087)		(-3.117)		(-8.931)	
PSL-2	0.400	***	0.067		0.200	***
	(4.033)		(0.694)		(3.440)	
DEP-1	1.428	***	0.907	***	1.200	***
	(16.940)		(16.996)		(26.915)	
DEP-2	-0.507	***	0.019		-0.269	***
	(-6.417)		(0.359)		(-6.230)	
February	1.885	**	0.370	*	0.689	***
	(2.422)		(1.689)		(2.698)	
March	0.286		-0.106		-0.034	
	(0.431)		(-0.460)		(-0.138)	
April	0.003		-0.192		-0.037	
	(0.005)		(-0.825)		(-0.151)	
May	-0.667		-0.626	***	-0.519	**
	(-0.971)		(-2.694)		(-2.115)	
June	-0.518		-0.314		-0.182	
	(-0.742)		(-1.321)		(-0.733)	
July	0.109		-0.309		-0.133	
	(0.155)		(-1.322)		(-0.540)	
August	2.019	***	0.036		0.572	**
	(2.921)		(0.155)		(2.336)	
September	-0.385		-0.560	**	-0.441	*
	(-0.555)		(-2.431)		(-1.803)	
October	-0.823		-0.656	***	-0.596	**
	(-1.190)		(-2.806)		(-2.426)	
November	1.000		0.208		0.424	*
	(1.433)		(0.884)		(1.711)	
December	0.790		0.064		0.200	
	(1.159)		(0.276)		(0.820)	
R^2 (adjusted)	0.987		0.944		0.979	
SY	1.428		0.897		1.093	

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate

Table 3.11 Differing Time Frames of Yearling Prices (*P600*)

Variables	Estimates 1973-1982		Estimates 1983-2013		Estimates 1973-2013	
Intercept	-0.705		0.247		0.163	
	(-1.159)		(1.217)		(1.052)	
COSTG	-0.811	***	-0.323	*	-0.635	***
	(-2.937)		(-1.897)		(-4.535)	
PSL	0.738	***	0.514	***	0.640	***
	(13.266)		(8.876)		(19.499)	
PSL-1	-1.025	***	-0.627	***	-0.861	***
	(-9.991)		(-6.479)		(-14.786)	
PSL-2	0.429	***	0.183	***	0.312	***
	(5.694)		(2.928)		(7.673)	
DEP-1	1.490	***	1.219	***	1.375	***
	(18.533)		(23.754)		(33.352)	
DEP-2	-0.569	***	-0.278	***	-0.442	***
	(-7.520)		(-5.451)		(-11.028)	
February	1.201	**	0.308	**	0.503	***
	(2.254)		(2.031)		(2.914)	
March	-0.121		0.017		-0.025	
	(-0.269)		(0.115)		(-0.159)	
April	-0.543		-0.050		-0.110	
	(-1.153)		(-0.340)		(-0.687)	
May	-0.478		-0.233		-0.236	
	(-1.015)		(-1.591)		(-1.473)	
June	0.011		0.115		0.169	
	(0.023)		(0.771)		(1.042)	
July	0.318		0.047		0.152	
	(0.668)		(0.321)		(0.953)	
August	0.939	**	-0.082		0.191	
	(0.668)		(-0.563)		(1.204)	
September	-0.313		-0.330	**	-0.269	*
	(-0.664)		(-2.255)		(-1.691)	
October	-0.428		-0.370	**	-0.341	**
	(-0.910)		(-2.497)		(-2.126)	
November	0.812	*	0.181		0.365	**
	(1.725)		(1.213)		(2.259)	
December	-0.428		0.135		0.187	
	(-0.910)		(0.925)		(1.180)	
R^2 (adjusted)	0.990		0.974		0.989	
SY	0.966		0.564		0.705	

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate.

Table 3.12 Differing Time Frames of Price Differences (*P400 – P600*)

Variables	Estimates 1973-1982		Estimates 1983-2013		Estimates 1973-2013	
Intercept	-0.883		0.246		0.089	
	(-1.572)		(1.248)		(0.618)	
COSTG	-0.653	***	-0.436	**	-0.658	***
	(-2.969)		(-2.510)		(-4.975)	
PSL	0.077	***	0.038	***	0.048	***
	(3.161)		(3.042)		(4.948)	
PSL-1	-		-		-	
	-		-		-	
PSL-2	-		-		-	
	-		-		-	
DEP-1	0.877	***	0.852	***	0.874	***
	(24.920)		(31.980)		(44.319)	
DEP-2	-		-		-	
	-		-		-	
February	0.530		0.094		0.199	
	(1.472)		(0.582)		(1.321)	
March	0.491		-0.177		-0.017	
	(1.379)		(-1.185)		(-0.115)	
April	0.606	*	-0.124		0.065	
	(1.689)		(-0.823)		(0.441)	
May	0.025		-0.312	**	-0.213	
	(0.070)		(-2.072)		(-1.453)	
June	-0.574		-0.273	*	-0.326	**
	(-1.605)		(-1.806)		(-2.224)	
July	-0.635	*	-0.311	**	-0.366	**
	(-1.775)		(-2.057)		(-2.502)	
August	0.605	*	0.119		0.260	*
	(1.688)		(0.790)		(1.779)	
September	0.106		-0.183		-0.107	
	(0.297)		(-1.212)		(-0.732)	
October	-0.456		-0.157		-0.234	
	(-1.280)		(-1.037)		(-1.598)	
November	-0.160		0.177		0.084	
	(-0.450)		(1.174)		(0.573)	
December	0.352		-0.049		0.035	
	(0.000)		(-0.327)		(0.242)	
R^2 (adjusted)	0.930		0.796		0.870	
SY	0.774		0.587		0.657	

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate.

Table 3.13 outlines the results found by conducting a Chow test. This was done by calculating F-statistics using the following formula for the Chow test (Gould, 2014):

$$(8)\ \frac{\frac{ess_C-(ess_1+ess_2)}{k}}{\frac{ess_1+ess_2}{N_1+N_2-2k}}$$

where ess_c is the error sum of squares from the combined regression; ess_1 and ess_2 are the error of sum of squares for the separate regressions; k is the number of estimated coefficients; N_1 and N_2 are the number of observations in the two separate regressions.

The resulting test statistics for the *P400* and *P600* models are distributed F(18,454) and the test statistic for the *P400 – P600* model is distributed F(15, 461). These test statistics were evaluated at a five percent significance level. After completing the Chow test, it was concluded that all three models are different for the January 1973 to December 1982 period and the January 1983 to December 2013 period. Thus, meaning that it is not beneficial to group the two time periods together and it would most likely be more accurate to use the regressed models for the January 1983 to December 2013 time period. Structural change in this model is most likely due to the ever-increasing technologies that are being adopted by the beef industry.

Table 3.13 Chow Test Results

	P400	**P600**	**P400-P600**
F-statistic	3.877	3.462	49.842
F-critical	1.92	1.92	2.07
Structural Change	Yes	Yes	Yes

3.5c Expansion

The results from the estimations corresponding to the expanded models are seen in Table 3.14. The models corresponding with equations (1) and (2), individually have a high-adjusted R-squared and low standard of error estimate (SY). T-statistics are given under each estimate and are shown in parentheses.

This model was estimated using 500 and 700 pound weight classes, a forward-looking, basis-adjusted live cattle futures price, and a more recent time period from January 1993 to December 2013. Compared to the values estimated in both the confirmation and the update, the estimates in the expansion differ extremely in magnitude. The cost of gain variable yields much more of an impact on the price of calves or yearlings in this expansion than in the confirmation and update.

Excluding dummy variables, all variables yielded coefficients that were shown to be statistically significant (p-values less than 0.05). The negative relationship between the cost of gain and price of calves or yearlings was revealed to be consistent with expected values in equation (4). Thus, stating that as corn price increases by $1/bushel, the price of 500 and 700 pound cattle will decrease by $4.578/cwt and $4.267/cwt, respectively. It is confirmed that the cost of gain has a larger effect on the price of calves than on the price of yearlings.

The positive relationship between the price of slaughter cattle and the price of a 500 pound calf or 700 pound yearling (equation (5)), confirms that as slaughter prices rise, prices paid for both weight classes will rise. The results in these models were shown to be consistent with this expectation. The reported coefficients on the price of slaughter for 500 and 700 pound cattle stated that for a $1/cwt increase in the price of slaughter cattle, the price of 500 and 700 pound calf or yearling would increase by $0.899/cwt and $0.987/cwt, respectively. The price of slaughter cattle is shown to have more of an impact on the price of yearlings versus calves, although minimal.

The consistencies in expected signs, gives significance to these results generated in this expansion. The intercepts are also larger in magnitude when compared with those results in the confirmation and update. In this expansion the estimated intercepts are statistically significant with p-values less than 0.05.

The estimations of coefficients for the dummy variables (January omitted) slightly differed from the results in previous sections, but the majority were found to be statistically significant with p-values less than 0.05. As mentioned before, the seasonal dummy variables signify the fluctuations in price of calves and price of yearlings during different months of the year compared with January. When analyzing the dummy variables for the *P500* and *P700* models, the months of February, May, June, July, August, October and December are shown to be statistically significant. In the *P700* model, the months of February, May, and October yield estimates that are statistically significant. Of these, February in both models and December in the *P500* model are months where prices increase, relative to January. To reiterate previous conclusions, this suggests that these months are when most cattle operations are making crucial management decisions and increases in the markets were present during the years 1993 to 2013. The other months are shown to have negative impacts on the prices compared to estimated prices during the month of January.

The results for the price premium and discount equation are also shown in Table 3.14. These results highlight the relationships between cost of gain and slaughter prices on price premiums/discounts in the stocker industry. These results yielded estimated coefficients for *COSTG*, *PSL*, and the lagged dependent variable that were revealed to be statistically significant with p-values less than 0.05. The expected signs of the estimated coefficients were consistent with the theoretical assumptions stated in equation (6). This concludes that a $1/bushel increase in corn price will cause a $1.051/cwt decrease in the difference between prices for calves and yearlings. As price of slaughter cattle increases by $1/cwt, the difference in prices will increase by $0.151/cwt.

Observations regarding the estimated coefficients for the dummy variables in the *P500 – P700* model showed statistical significance on eight out of eleven estimates. Of these months, February was the only month that was shown to widen the price difference between calves and yearlings when compared to January. The other seven months (April, May, June, July, August, September and October) are shown to narrow the difference in prices. This contradicts the findings in the confirmation and update and suggests that fluctuations in premiums or discounts are considered to be seasonal.

In addition to the models in Table 3.14, it was thought to be useful to run a model that incorporated the cash market price of slaughter variable that was used in the update and the forward-looking, basis-adjusted live cattle futures price, however, they were highly correlated (0.86) so this was not completed.

Table 3.14 Results for Expansion of Price and Price Premium/Discount Models, 1993-2013

Variables	P500		P700		P500-P700	
Intercept	-2.853	***	-2.045	***	-0.398	
	(-3.920)		(-3.199)		(-1.281)	
COSTG	-4.578	***	-4.267	***	-1.051	***
	(-6.500)		(-8.175)		(-3.867)	
PSL	0.899	***	0.987	***	0.151	***
	(8.833)		(14.461)		(4.788)	
DEP-1	0.439	***	0.332	***	0.663	***
	(7.224)		(6.512)		(13.508)	
DEP-2	0.176	***	0.096	**	-	
	(3.178)		(2.072)		-	
February	0.506	***	0.238	**	0.233	*
	(3.008)		(2.342)		(1.663)	
March	0.303		-0.165		0.078	
	(1.468)		(-1.210)		(0.530)	
April	-0.016		-0.004		-0.335	**
	(-0.071)		(-0.025)		(-2.199)	
May	-0.993	***	-0.652	***	-0.701	***
	(-4.177)		(-3.753)		(-4.760)	
June	-0.692	***	-0.037		-0.818	***
	(-2.848)		(-0.215)		(-5.675)	
July	-0.825	***	-0.071		-0.926	***
	(-3.386)		(-0.390)		(-6.430)	
August	-0.631	**	-0.157		-0.609	***
	(-2.563)		(-0.850)		(-4.131)	
September	-0.336		-0.307		-0.881	***
	(-1.372)		(-1.628)		(-6.061)	
October	-0.513	**	-0.683	***	-0.677	***
	(-2.092)		(-3.507)		(-4.510)	
November	0.130		-0.147		-0.122	
	(0.534)		(-0.772)		(-0.822)	
December	0.433	*	0.208		-0.225	
	(1.775)		(1.096)		(-1.573)	
R2 (adjusted)	0.941		0.961		0.782	
SY	0.666		0.426		0.462	

Note: Statistical significance is represented by asterisks at the three different levels. *, **, *** represent statistically significant at the 10%, 5%, or 1% level, respectively. These asterisks are denoted to the right of the value they are corresponding to.
T-statistics are reported under coefficient estimates and denoted in parentheses.
SY represents standard of error estimate.

3.6 Conclusions

Consistent with Marsh (1985), information on price premiums/discounts is highly beneficial to a producer's decision-making process. Whether a cow-calf producer or a stocker operator, knowing how cost of gain (proxied by corn price) and price of slaughter cattle affects the price of calves or yearlings and the price differential between the two, must be taken into account. A prime example is when cow-calf producers are looking at a market where either slaughter prices are decreasing or feed costs are increasing and they are faced with either selling their calves or retention. Looking at these estimated models it may not always make sense for a producer to sell because the price of calves is decreasing due to the market conditions. While the price of yearlings would also decrease, it may be at a rate proportionately lower than that of calves. A typical scenario that could be encountered in the stocker industry is when slaughter prices are increasing while feed costs are decreasing. Based on the results from this model, producers would steer away from buying lighter cattle since the price of lighter cattle is increasing at a larger proportion than the price of yearlings (Marsh, 1985).

Although, the attempts to confirm the models were not identical to the results produced by Marsh (1985), there were many consistencies. For instance, even though some of the estimated coefficients on the variables differed from reported values, the signs were continuously congruent. Inconsistencies were also present when attempting to confirm the outcomes generated by Marsh (1985). Most of these were seen in the intercepts and coefficients on the dummy variables. There are a couple of reasons that this is possible. First of all, as Tomek (1993) mentions, collecting the original data used when first completing the research is a difficult task. This proved true when all variables were being collected. Marsh's article does not thoroughly specify where cattle price variables were compiled, so efforts to collect similar data were made.

Also, since the corn price received in Omaha was not available in the sources used for confirmation, using the Nebraska corn price was the closest estimate to account for the cost of gain. This could pose some potential hazards as it is not specified whether this value is an average of all locations in Nebraska or a specific location. Another obstacle encountered was when accumulating the CPI (1967 = 100). This index is revised monthly and since Marsh (1985) did not state his actual data source for this, it has likely changed since it was used and is likely incongruent with Marsh's procedure. The largest hindrance in estimating these models was the large differences in magnitude on certain variables. After running multiple models in an effort to account for extreme differences in coefficients, it was concluded that when Marsh (1985) estimated his *P400* and *P600* models, the nominal corn price was used instead of real values. However, in the *P400-P600* model, it was consistent that the real corn price was used. All of these factors explain the differences between the estimated models of Marsh (1985) and those estimated during this confirmation.

Having an understanding of the basic concepts in this article due to the confirmation attempt, allowed for the opportunity to complete an update with newly collected data. It was worthwhile to re-estimate these models with a more recent data set to compare estimates with those generated by Marsh (1985). This enabled a Chow test to be relevant and to confirm that there is structural change over time. Structural change in this model is most likely due to the ever-increasing technologies that are being adopted by the beef industry. In the more recent time period, the coefficient estimates on the *PSL* and *COSTG* variables declined on an absolute value basis. This implies that these variables had less impact on the prices than in the later time period of 1983 to 2013. However, when grouping the two time periods together to regress the 1973 to 2013 models, these values increased on an absolute value basis than in the later time period, meaning that in the entire time period of the data set, these variables had more of impact on prices than in the 1983 to 2013 period.

In addition to confirming and updating the article, an expansion was completed with changes made to the models, originally created by Marsh (1985). As mentioned before, instead of corn price being a proxy for cost of gain, the expanded model was to incorporate a variable that is an actual estimate of feedlot cost of gain from Kansas State University Focus on Feedlot survey. However, due to high correlation (0.95) between the two variables, corn price was used as the proxy for cost of gain. The expansion also included a forward-looking, basis-adjusted live cattle futures market prices instead of using the backward-looking price of slaughter cattle and lags on that slaughter price that were included in Marsh (1985). In addition to those changes, heavier weight classes were used because in today's market it is more applicable to wean cattle at 500 pounds and then send them to the feedyard at 700 pounds. The results from this expansion produced highly beneficial conclusions for producers in the cattle industry. When comparing with the results from the confirmation and update, the coefficient estimates for the *COSTG* and *PSL* increased in magnitude, meaning that they have more of an impact in today's market then they did in the previous models. Also, the amount of statistically significant variables increased when estimating the models for the 1993 to 2013 time period. From these results it can be conclude that if a producer in today's market is wanting to predict prices of weaned calves and yearlings this new model should be used.

Chapter 4 - Conclusions

Due to the fact that the stocker industry is not heavily researched and most existing literature is outdated, this research proved beneficial. This research focused on two main areas of price analysis in the stocker industry. The first was forecasting value of gain, which takes into account the amount of revenue to be gained by adding extra weight to a lower weight animal before selling at a higher weight. The second focuses on determinants of price premiums and discounts of buying weaned calves and adding extra weight before selling.

4.1 Forecasting Value of Gain

In the research completed on forecasting value of gain, the hypothesis that the naïve approach would be less accurate as the FMI basis-adjusted approaches was disproved for all five models in all nine scenarios. As mentioned, there are no clear explanations for these results, but there is speculation that since the calculation in the error on the forecast of value of gain is solely based on the selling price, these scenarios incorporate no performance risk or an error in the forecast on buying price. There could also be some explanation of this result due to the short time horizons used when forecasting the value of gain. It is thought that the longer the time horizon, the worse the forecast will be when using the naïve approach compared to the FMI basis-adjusted approach. Even though this research did not obtain expected results, there are still major conclusions seen when analyzing the hypothesis tests for seasonality and yearly dummies. These concluded that seasonality and annual dummies hold for all scenarios and show that the month and year have strong significance when forecasting value of gain.

Due to the need for continued research on the forecasting value of gain there is much future work to be completed. The research conducted on forecasting value of gain was not done as a forward-looking situation, but instead as a producer that made purchasing decisions the day before. The future research will implement a forecasting horizon on buying price in order to better represent the producer's decision-making. This will lengthen the horizon on both the buying and the selling price in the assessment. With this, the forecast will incorporate error on both the buying and selling price, which may yield different results when comparing the naïve approach against the FMI basis-adjusted approaches.

4.2 A Confirmation, Update and Expansion of "Monthly Price Premiums and Discounts between Steer Calves and Yearlings" Marsh (1985)

The confirmation, update, and expansion based on Marsh (1985), proved to yield information on price premiums/discounts that is highly beneficial to a producer's decision-making process. Whether a cow-calf producer or a stocker operator, knowing how cost of gain and price of slaughter cattle affects the price of calves or yearlings and the price differential between the two, must be taken into account. The results in the attempts to confirm the models were not identical to the results produced by Marsh (1985); however, the results yielded many similarities. For instance, the estimated coefficients on the variables differed but the signs were consistent. However, there were large inconsistencies where the intercepts were overstated and coefficients on the dummy variables were not congruent. Due to large differences of estimates on certain variables, multiple models were run to account for the extreme differences. It was concluded that when Marsh (1985) estimated his *P400* and *P600* models, the nominal corn price was used instead of real values and when estimating the *P400-P600* model, it was consistent that the real corn price was used.

The background knowledge from this confirmation led to the opportunity to complete an update using the models from Marsh (1985). This update was worthwhile to re-estimate these models with a more recent data set to compare newly acquired estimates with those generated by

Marsh (1985). The coefficient estimates on the *PSL* and *COSTG* variables declined on an absolute value basis, using the more recent time period, which concludes that these variables had less impact on the prices than in the 1983 to 2013 period. However, when completing an update for the entire time period of the 1973 to 2013 models, the values increased on an absolute value basis, showing that in the 1973 to 2013 time period, the variables had more of an impact on prices than in the 1983 to 2013 period. This also allowed for the confirmation of structural change over time in the models, which was found by conducting a Chow test.

After completing the confirmation and update following Marsh (1985), it made sense to expand on the models originally put in place. The reasons for this expansion are due to changes seen in the current market and more data being available. With futures market data being available, live cattle future prices were incorporated instead of using lags on price of slaughter cattle. When using the live cattle future prices, a 3-year average basis was calculated using the cash market slaughter prices and live cattle futures prices. This basis was then added back to the live cattle futures data and incorporated into the model to represent the price of slaughter cattle, In addition, in today’s market it is more realistic for a producer to wean a 500 pound calf instead of a 400 pound calf and due to this, heavier weight classes were used in the expansion. These new models yielded significant results that showed higher impact of corn price and price of slaughter cattle in today’s market. These results are highly beneficial to producers making decisions.

4.3 Producer’s Decision Making

When cow/calf producers (assuming they are open to backgrounding) and stocker operators are making important management decisions, a producer must understand the beef industry structure, risks involved, and their own risk preferences. In order for stocker operators to make important management decisions, knowing how to accurately forecast value of gain and understanding the drivers on prices/price differentials is highly beneficial. This is due to the fact that stocker operators make their profit solely on the margin of buying lighter weight calves and selling them at heavier weights. Most of the time stocker operators have an idea of internal characteristics of their operations. For instance, they monitor how quickly the cattle are gaining and what cost of gain is estimated to be. However, adding in the forward-looking aspects of this research, stocker operators can have more of an understanding of the current market structure when making their management decisions. This is extremely important since stocker operators are price takers in the beef supply chain. Using this research in their management decisions will allow producers to more accurately forecast value of gain before buying stockers. In addition, they can analyze the current market drivers to assess purchasing decisions prior to making them or even afterwards during backgrounding.

References

Agricultural Prices Annual Summary. Crop Reporting Board, Statistical Reporting Service. U.S. Department of Agriculture. Washington D.C. annual reports 1965 – 82.

Anderson, J.D, and J.N. Trapp. "Corn Price Effects on Cost of Gain for Feedlot Cattle: Implications for Breakeven Budgeting." Journal of Agricultural and Resource Economics. 25(2):669-679.

Brorsen, B. W. "Observations on the Journal Publication Process." North Central Journal of Agricultural Economics. 9(July 1987):315-21.

Dhuyvetter, Kevin and Kevin Herbel. "Differences Between High-, Medium, and Low-Profit Producers: An Analysis of 2008-2012 Kansas Farm Management Association Cow-Calf Enterprise. Kansas State University Ag Manager. (August 2013).

Gould, William. "How Can I Compute the Chow test statistic?". StataCorp. http://www.stata.com/support/faqs/statistics/computing-chow-statistic/. 23 Sept 2014.

Livestock and Meat Statistics; Supplement for 1982.Compiled by Evelyn Blazer, National Economics Division, Economic Research Service. U.S. Department of Agriculture. Washington, D.C. October 1983.

Livestock Marketing Information Center, Denver, CO. http://www.lmic.info/

Marsh, J. M. "Monthly Price Premiums and Discounts between Steer Calves and Yearlings." American Journal of Agricultural Economics. 67(May 1985):307-14.

McElligott, J., G.T. Tonsor. "Fed Cattle Basis: An Updated Overview of Concepts and Applications." Kansas State University Department of Ag Economics, Manhattan, KS. March 2012.

Tomek, W. G. "Confirmation and Replication in Empirical Econometrics: A Step Towards Improved Scholarship." American Journal of Agricultural Economics. 75(October 1993):6-14.

Tonsor, G.T., K.C. Dhuyvetter, and J.R. Mintert. "Improving Cattle Basis Forecasting." Journal of Agricultural and Resource Economics, 29(2), 2004, 228-241

White, B.J., J.D. Anderson, R.L. Larson, K.C. Olson, and D.U. Thomson. "Review: The Cow-Calf Operation Retained Ownership Decision." The Professional Animal Scientist. 23(2007):18-28.