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TRANSPORTATION AND QUALITY ADJUSTED BASIS:

DOES THE LAW OF ONE PRICE HOLD FOR FEEDER CATTLE?

by

Chad Wade Harris

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in cooperation with Utah State University

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Logan, Utah

2008
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I declare that the dissertation embodies the results of my own research or advanced studies and that it has been compose by me. Where appropriate, I have made acknowledgement to the work of others.

Signed,

Chad Wade Harris
Dated

ABSTRACT

TRANSPORTATION AND QUALITY ADJUSTED BASIS:

DOES THE LAW OF ONE PRICE HOLD FOR FEEDER CATTLE?

by

Chad Wade Harris, International Master of Business Administration

Royal Agricultural College, 2008

Major Professor: Dr. Dillon Feuz
Department: Economics

Beef cattle and calves are raised in all areas of the United States. Since beef cattle are scattered throughout the US, there are many different types of cattle with numerous different quality characteristics which are valued differently. Many calves raised until weaning age across the US are then sent to cattle feeding areas primarily located in Texas, Kansas, Colorado, and Nebraska. The prices that are offered for beef calves vary considerably based on quality and location. The theory of the law of one price suggests that prices in areas that trade should not differ by more than the cost of transportation. Implicit in the law of one price is that the product is homogenous in nature which is not the case with beef cattle. To test the law of one price, prices in the feeder cattle markets that trade should be equal after those prices have been adjusted for the cost of transportation and for differences in quality. Consequently, the objective of this thesis is to adjust prices for transportation costs and quality characteristics to determine if the law of one price holds in the US feeder cattle market.

Data for this dissertation were obtained from Superior Livestock Auction in Brush, Colorado. The original data set included over 30,000 cattle lots sold throughout the entire US from 2004-2006 which includes valuable information such as price, breed, sex, number of head, days to delivery, location of sale, and destination of sale for each cattle lot. However, the data were narrowed to examine price and quality for weaned steer and heifer calves in the fall. This narrowed data set still contained 9,570 cattle lots which includes, specifically, steer and heifer calves, weighing between 450-700 pounds, and delivered in October and November.

In order to determine if the law of one price holds for feeder cattle, first, a Hedonic regression analysis was used to determine the value of selected cattle, lot, and market characteristics. Second, the cost of transportation was calculated by figuring freight rates and animal shrinkage. Prices were then adjusted for freight rates and shrinkage values and for quality differences to determine if prices were equivalent across regions of the US and across states within a specific region of the US.

Results from the Hedonic model showed that most cattle characteristics yielded expected results, and that there are differences in quality characteristics in cattle which affect the price. Further results revealed that the transportation adjusted prices varied by more than transportation costs, and that when adjusted for transportation costs, price were not the same across regions of the country. In combining quality characteristics and transportation costs, results also revealed that prices were different by region and by states within a region. Thus,

based on the results from the data, it does not appear that the law of one price is upheld in the US feeder cattle market.

The implications of the results are that there may be opportunities for arbitrage in feeder cattle markets. The results also indicate that cattle producers who are more distant from major cattle feeding areas receive prices for their calves that are higher than would be justified based on transportation costs and that producers who are closer to major cattle feeding areas receive prices for their calves that are less than should be expected based on transportation costs.

(84 pages)

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ABBREVIATIONS

US.............   United States of America
cwt............   Hundredweight (100 US pounds)
USDA ....   Unites States Department of Agriculture
$ .... U.S. Dollar
CME ....   Chicago Mercantile Exchange
SAS ....   Statistical Analysis Software
SLA ....   Superior Livestock Auction
LimDep…..   Limited Dependent
PROC GLM.. Procedure General Linear Model
AMS………   Agriculture Marketing Service
MPR………   Mandatory Price Reporting
QTAB…….   Quality and Transportation Adjusted Basis

Chapter 1

Introduction

Beef cattle and calves are produced in nearly all regions of the United States (US). In 2002, there were over 33 million beef cows in the US (Utah Agricultural Statistics, 2007). Figure 1.1 shows geographically how beef cattle herds are dispersed throughout the US (National Agriculture Statistics Service, 2002). While beef cattle production occurs in all 50 states, there are certain regions which are more populated with cattle than others. In 2007, the top five beef cow states were, in descending order: Texas, Missouri, Oklahoma, Nebraska, and South Dakota. These states account for nearly 40 percent of total beef cows in the US.
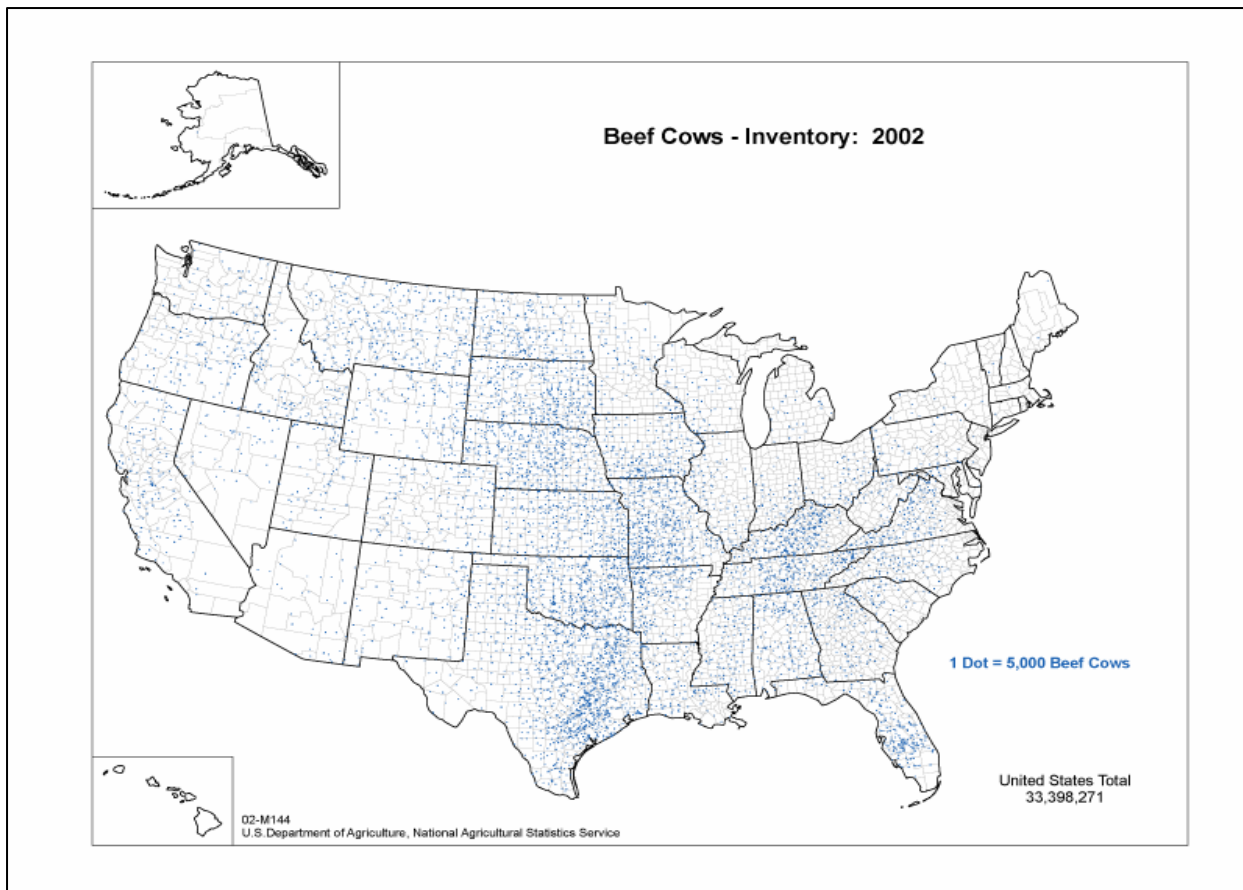
Figure 1.1 Geographical Location of Beef Cows across the US (NASS, 2002).

Other areas of the US may have fewer beef cows than states such as Texas, Missouri, Oklahoma, Nebraska, and South Dakota, but cattle production may still be a major source of agricultural income. Utah, for example, ranks 28th in total number of beef cows, but about one third of the state's total farm income is from the sale of cattle and calves (Utah Agricultural Statistics, 2007). This is by far the largest single agricultural sector for Utah.

Cattle produced in different areas are not all alike. Different regions raise different types of cattle due to environmental, resource, and other factors. For example, a common breed of cattle raised in the southern parts of the US is Brahman which does well in warmer climates but few of these Brahman cattle are raised in northern states. The beef cows that are more economically produced in the arid great basin states are different from the beef cows that are more economically produced in the more humid areas of Missouri, Tennessee, and other Southern states.

Some calves are sold and sent directly to finishing feedlots where they are fed out to harvest weight. Beef cows produce calves which are raised, weaned, and then sent to various feeding programs. Producers, however, have several options to grow their calves outside of finishing feedlots. Calves can be fed in a dry lot on the ranch, be grazed on native or improved pastures, be fed winter wheat, corn stocks, or other crop residue, or be fed in background feedlots. These varied feeding programs are very geographically dispersed based on the varied resources across the country.

The US cattle feeding industry is much more concentrated geographically than beef cow-calf production, Figure 1.2 (National Agriculture Statistics Service, 2002). Cattle feeding is generally concentrated in the Texas and Oklahoma panhandles, Kansas, Nebraska, Eastern Colorado, and Iowa. In 2007, the ranking top five states were in descending order: Texas, Kansas, Nebraska, Colorado, and Iowa.

A study by Brorsen, Bailey, and Thomsen (1997) identified four major cattle feeding areas. The first is the Omaha, Nebraska area which includes eastern Nebraska, eastern South Dakota, Iowa, and southern Minnesota. The
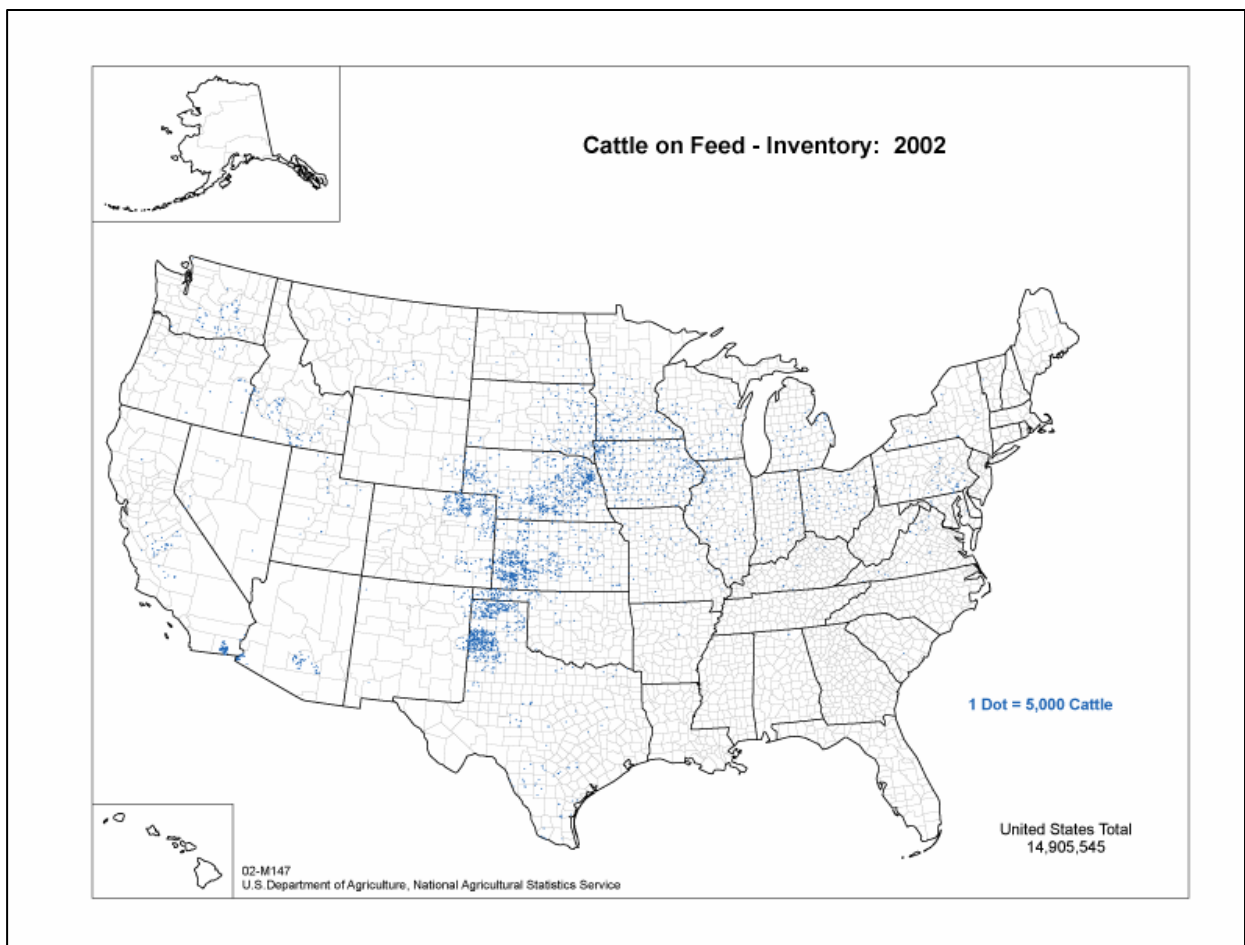
Figure 1.2 Geographical Location of Cattle on Feed in the US (NASS, 2002).

second is the Greeley, Colorado area which contains feedlots in northeast Colorado and western Nebraska. Dodge City is the third area which includes feedlots in and around western Kansas. Lastly, the Amarillo, Texas feeding area which includes the Texas and Oklahoma panhandles. Consequently, feeder cattle scattered throughout the US are sold and typically shipped to any one of these four feeding areas based on the location of the sale. Generally, feeder cattle are shipped to the closest feeding area to minimize transportation costs, but feeder cattle may also be shipped to more distant feeding areas. For example, based on the study by Brorsen, Bailey, and Thomsen (1997), cattle in Montana would typically go to the Omaha, Nebraska cattle feeding areas. Furthermore, after identifying these different markets, the authors discovered that buyers in some market areas offered higher prices for feeder cattle than in others market areas. Are there separate and distinct feeder cattle markets in the US or are these price differences related to transportation costs and/or differences in feeder cattle quality?

Feeder cattle prices are variable throughout different markets in the US. Cattle being sold on the same day in Idaho, Nebraska, and Tennessee may all sell for different prices. For example, in November of 2006 auction sales in Utah, Nebraska, and Tennessee had average prices of $103, $117.35, and $96.07 per hundredweight (cwt) for 500-600 pound steers (Agriculture Marketing Service, 2007). Can these price differences be explained by the transportation costs to the nearest major cattle feeding region? Are there quality differences in the

quality of feeder cattle that are impacting these prices? Is each of these markets responding to different market conditions?

Law of One Price

What should be the relationship between prices in geographically dispersed feeder cattle markets?   The economic law of one price, which assumes that prices in different markets do not differ by more than transportation costs, is generally recognized to apply to agricultural commodity markets (Tomek and Robinson, 1990). This would also apply to the feeder cattle market as well. If differences between feeder cattle prices in two different markets exceeded transportation costs, it is assumed that there would be opportunities for arbitrage. Therefore, price differences between any two cattle markets are expected to be less than, or equal to, transportation costs.

Implicit in the law of one price is the homogenous nature of the commodity. If a commodity is not homogenous, and if there are differences that are valued in the market place, then prices would be expected to reflect these differences. Therefore, if it were the case that the quality of a commodity differed by market area, then price differences between two market areas would not only differ by transportation costs but by quality factors as well.

Feeder cattle are not a homogeneous commodity. There are several cattle characteristics which influence the prices that are offered for cattle. Some of the more influential cattle characteristics that effect price include: weight, gender, and breed. Cattle that are sold on the same day at the same weight could have significantly different prices solely based on the breed of the animals.

For instance, in 1999, in an Oklahoma auction, the sale price for feeder cattle differed greatly between Black Angus and Hereford cattle. Black Angus steers received an average price of $75.09 per cwt whereas Hereford steers received a discounted price of $66.72 per cwt (Smith, Gill, Evicks, and Prawl, 2000). This is but one example of how cattle qualities impact feeder cattle prices.

Earlier in this chapter, there was a discussion of how climate and resources impact the type of cattle produced in different parts of the US. Therefore, it is quite likely that prices for feeder cattle will vary from one region of the US to the next. These quality differences could either add to or subtract from pre-existing price differences due to transportation costs that would exist in different regions.

Objectives

The overall objective of this research is to determine if the law of one price holds in the US feeder cattle market. Three specific objectives are to: (1)Determine the value that the market places on various cattle attributes, sale lot characteristics and market factors; (2)Determine if feeder cattle prices are equivalent across broad geographic regions in the US once they have been adjusted for transportation and quality differences; and (3)Determine if feeder cattle prices are equivalent across states within a specific geographic region of the US once they have been adjusted for transportation and quality differences.

Methods

To determine the value of various feeder cattle quality characteristics, data will be collected on a large number of feeder cattle sale lots. Ordinary least

squares regression analysis will be used to determine the value of various feeder cattle traits. This type of Hedonic regression approach has been used in several prior studies to value feeder cattle characteristics.

The feeder cattle market data used in this research contains the origin of the feeder cattle being sold and their destination. A US postal zip code data base will be used to determine approximate mileage (line of sight distances) from origin to destination. Actual truck freight rates will be used to determine transportation costs, and as cattle shrink during transportation this lost value will also be included in the total transportation cost.

The actual feeder cattle sale prices in the data set will be adjusted for quality based on the results of the Hedonic regression analysis. These prices will also be adjusted for the total cost of transportation. The mean quality and transportation adjusted prices will then be compared to determine if the law of one price holds across regions of the US. Finally, the quality and transportation adjusted prices within a specific region will be examined to determine if the law of one price is upheld within smaller geographic areas.

Data and Scope of Analysis

Most of the data used in this research was obtained on November 27, 2006 from Superior Livestock Auction (SLA) from their head quarters in Brush, Colorado. Superior Livestock Auction is the nation's largest satellite video auction market. The data set includes information from cattle sold nationally in the years of 2004-2006. Superior Livestock Auction data includes many important variables such as price, breed, sex, weight, origin and destination,

number of head, and days to delivery. The original data set included over 30,000 lots containing calves, yearlings, and breeding stock (Superior Livestock Auction, 2006).

In the US feeder cattle market, quite often, calves are born in the earlier months of the year, raised on the ranch or farm for the summer and finally weaned and sold in the fall. Therefore, the scope of the analysis is focused on steer and heifer calves with weights of 450-700 pounds with a delivery date in the fall months of October and November in 2004-2006. Those sale lots not matching this criterion were deleted from the original SLA data. The finished data set included over 9,500 observations, or lots, and is comprised of over one million head of steer and heifer calves.

The scope of cattle weighing between 450-700 pounds was selected to specifically study weaned calf prices. Most of these calves are weaned and delivered in the fall with October and November being the two dominant months.

Thesis Outline

The remainder of this thesis will include several more chapters. Chapter Two will consist of relevant research that has previously been done in reference to the quality price differentials and the law of one price.   The subsequent chapter, Chapter Three, will describe the data set and the methods used in obtaining results.   Following the methodology chapter, Chapter Four will include results which will be presented and analyzed for the regions within US. Chapter Five will present and analyze results for a specific region. Chapter Six will conclude the analyses of the project and discuss the main points of this thesis

and identify possible solutions and/or further areas of research. The concluding chapter will be a brief self-reflection how this experience has affected the researcher.

Chapter 2

Literature Review

In order to effectively examine feeder cattle prices, previous research must be reviewed and considered. This review will be particularly focused on two specific subjects. First, previous research of how cattle qualities and characteristics affect the price offered will be reported. Secondly, a review of the literature on the theory of one price will be undertaken. Of particular interest will be those studies focused on whether or not the law of one price holds for agricultural commodities.

Valuing Feeder Cattle Characteristics

In the past, extensive research has been done to study the value of particular cattle characteristics. This research has approximated the value of various traits that establish the prices that are received for cattle. As Faminow and Gum (1986) state,"…the magnitude of premiums and discounts for feeder cattle affects the decisions of ranchers and cattle feeders..." Researchers have focused on many specific characteristics, including weight, sex, breed, frame, and health just to name a few. Past research will be reviewed to ascertain the affect that certain cattle traits have had on the price. Previous literature will be presented based on individual cattle, lot, and market characteristics.

Weight greatly impacts how cattle are priced. Past research is consistent in identifying that as weight increases, the price per pound decreases (Bailey and Peterson, 1991; Brazle, *et al.*, 1988; Buccola, 1980; Faminow and Gum, 1986; Schroeder, *et al.*, 1998; Smith, *et al.*, 2000; Turner, Dykes, and McKissick, 1991;

Ward and Lalman, 2003). However, there was one exception to prices decreasing with increasing weight. Schroeder, *et al.* (1998) explained that in some instances, particularly in the case of yearling heifers, that the price per pound increased as weight increased. Perhaps the reason for this positive relationship is the demand for breeding stock from yearling heifers. Excluding situations like yearling heifers, most cases indicate that, all things held constant, price per pound decreases as weight increases. Faminow and Gum (1986) and Schroeder, *et al*. (1998) also indicated that depending on the month of the year, or the season, the magnitude of the price decrease compared to the weight increase varied.

Research in the past has been consistent and a clear distinction has been made between prices offered for different genders of cattle. Previously, researchers have established that steers receive premiums over heifers (Faminow and Gum, 1986; Koknaroglu, *et al*., 2005; North Dakota State University, 2006; Schroeder, *et al*., 1988; Smith, *et al*., 2000; Turner, Dykes, and McKissick, 1991; Ward and Lalman, 2003). An article completed by North Dakota State University (2006) reported $9.78 per cwt difference paid for steers over heifers. This is primarily based on the ability of steers to gain weight faster and grade better than heifers (Williams, *et al*., 1991).

Most research that examined cattle breeds found that there were significant differences in price between breeds. Based on breed characteristics in the US, certain breeds fare better than others in different climates. Price premiums or discounts based on breed varied depending on where in the US

data were collected.   For example, a study by Smith, *et al*. (2000) pooled cattle data from Eastern Oklahoma which indicated that black exotic and exotic cattle received premiums over others such as Angus and English breeds. This is logical since exotic cattle are more comfortable in hot, humid southern climates. On the other hand, a study by Parcell, *et al*. (1999) which used data from western Kansas, explained that Angus and Angus cross cattle brought higher premiums when compared to other breeds.

The impact on how different breeds influenced price has changed over time. Genetic improvement and varied marketing schemes may have had an influence on the change in breed premiums over the past two decades.   In 1988, Hereford cattle received higher prices than Angus, dairy, exotic and other breeds (Schroeder, *et al*., 1988), whereas in 2003, Angus cattle received premiums over other breeds (Ward and Lalman, 2003).

Frame is a notable physical cattle characteristic that is quite often detected in the purchasing of cattle. Past research has primarily concluded that small framed cattle are discounted whereas large frame cattle received premiums (Bailey and Peterson, 1991; Brazle, *et al*., 1988; Parcell, Schroeder, and Hiner, 1995; Schroeder, *et al*., 1988; Smith, *et al*., 2000; Turner, Dykes, and McKissick, 1991; Ward and Lalman, 2003). Producers desire larger frame cattle because larger frame cattle have an ability to gain weight faster. If cattle have small frames, it is difficult for the animal to rapidly and efficiently increase in weight (Owens, Dubeski, and Hanson, 1993).

Yet another similar characteristic is the flesh of the animal. Researchers have typically determined that light flesh or thinner cattle received premiums (Bailey and Peterson, 1991; Brazle, *et al.*, 1988; Schroeder, *et al.*, 1988; Smith, *et al.*, 2000). This indicates that buyers desire cattle that are not already heavy or fleshy and, as a result, have the ability to gain weight. More recent research by Ward and Lalman (2003) explains that the desired characteristics are cattle with medium flesh and medium frame. In their study, Ward and Lalman (2003) identified that if the results for heavy or light flesh cattle or for small or large frame cattle were significant, the results produced coefficients that negatively impacted basis in every case.

Horns were not a desirable trait for buyers based on past research. Horned cattle were consistently discounted in price compared to polled cattle (Bailey and Peterson, 1991; Brazle, *et al.*, 1988; Parcell, Schroeder, and Hiner, 1995; Schroeder, *et al.*, 1988; Smith, *et al.*, 2000; Ward and Lalman, 2003). Buyers tend to avoid horns to ensure herd health, safety, and allow feedlot accessibility. Researchers from Oklahoma identified that horned cattle were discounted as much as $3 per cwt (Smith, *et al.*, 2000).

Animal health has a significant impact on the price received. Unhealthy cattle are considerably discounted in price (Bailey and Peterson, 1991; Brazle, *et al.*, 1988; Parcell, Schroeder, and Hiner, 1995; Schroeder, *et al.*, 1988; Smith, *et al.*, 2000; Ward and Lalman, 2003). Parcel, Schroeder, and Hiner (1995) indicated that unhealthy cow/calf pairs were discounted nearly $70 per pair. Schroeder, *et al.* (1988) stated that unhealthy cattle received discounts of 20

percent less than average healthy animal prices. Cattle that are sick, muddy, lame, or impaired cause extra work and time for the buyer; healthy cattle are expected to have less stress and gain optimal weights. Schroeder, *et al*., (1988) stated, "Of all the characteristics examined, health had the most profound influence on price."

Previous research indicates that auction prices generally follow the feeder cattle future market (Bailey and Peterson, 1991; Turner, Dykes, and McKissick, 1991). The degree to which auction prices follow the feeder future prices differs by location and other market variables. Bailey and Peterson (1991) determined that for every dollar the futures price increased, the auction price increased by $0.93 per cwt.

Prices were affected by the number of cattle in a sale lot (Bailey and Peterson, 1991; Brazle, *et al*., 1988; Faminow and Gum, 1986; Parcell, Schroeder, and Hiner, 1995; Schroeder, *et al*., 1988; Turner, Dykes, and McKissick, 1991; Ward and Lalman, 2003). According to Schroeder, *et al*. (1988) and Brazle, *et al*. (1998), optimal lot sizes were 45-50 and 55-65 head, respectively. This is due to the need to fill truck loads of cattle. If a cattle lot is too small to fill a truck, it is not as efficient as a lot that has the optimal number of cattle to fill a truck, and therefore the price would be discounted. Often cattle lot premiums increased at a decreasing rate (Bailey and Peterson, 1991; Schroeder, *et al*., 1988). In other words, as the lot size increases, the price premium will increase to a certain amount; then as lot sizes continue to increase, price premiums tend to stabilize and even decrease. This indicates that sale lots are

offered premiums that are proportional to truck size, however when cattle lots exceed the amount needed to accommodate freight trucks, premiums begin to decrease.

Another important characteristic to consider is the uniformity of the cattle lot. Research claims that uneven lots of cattle are discounted and even lots of cattle receive premiums (Bailey and Peterson, 1991; Brazle, *et al*., 1988; Smith, *et al*., 2000). Cattle buyers want cattle that are uniform so that an even ration can be implemented in feeding which results in cattle that are simultaneously prepared for slaughter.

The order in which the cattle are sold in an auction is another market characteristic which has an influence on the price that is paid for cattle. Previous research shows that sale order affects prices (Brazle, *et al*., 1988; Faminow and Gum, 1986; Parcell, Schroeder, and Hiner, 1995; Schroeder, *et al*., 1988; Turner, Dykes, and McKissick, 1991). Further scrutiny of research distinguishes at which point in the sale premiums are offered. Often, the sales premium prices peak in the second and third quarter of the sale. This may be because buyer attendance is then at its highest (Brazle, *et al*., 1988; Schroeder, *et al*., 1988). However, other studies suggest that premiums are received at the beginning of the sale because buyers have previously perused sale inventory, and they also want to be certain that they fill their desired demand (Parcell, Schroeder, and Hiner, 1995). One study suggested differences in sale price as the order increased, depending on the method in which the cattle were sold such as video auction or traditional sale barn (Turner, Dykes, and McKissick, 1991). The authors

suggested that video auctions were less discouraged to purchase cattle as the sale order increase compared to small traditional auctions. This suggests that video auctions most likely have a large amount of buyers that maintain sale prices throughout the entire sale, whereas traditional auctions tend to have fewer buyers and prices tend to decline as the sale order increases.

There are many other characteristics that have not been extensively studied in past research and others that are not easily measured. Reputation of the seller, for example, is a quality that would perhaps provide either a premium or discount given the appropriate circumstances. Further research and study will help in more fully obtaining vital information in understanding cattle, lot, and market price differentials.

Previous research has examined many different cattle traits and attempted to understand how each affects value in the overall price of the animal. The intent of this thesis is to build on past research to aid in understanding how quality differentials affect the price of cattle, and to give a unique approach to examining specific sets of cattle. This is done several ways. First, because much of the research is outdated, the data set used in this thesis will provide new and up-to-date information. Second, contrary to past research, the extensive size of SLA data provides an abundant amount of observations which will support results in being more accurate and meaningful. Last, because SLA data is narrowed down to 450-700 pound steers and heifers sold in the fall months it will provide data that is relevant to the majority of cattlemen who buy and sell calves in the fall.

Law of One Price

As one compares market price reports across the US, one finds large differences in reported prices. If cattle and market conditions vary, the literature reviewed in the prior section would suggest that prices would also differ. Feeder cattle are produced in all areas of the country, but primarily fed in a few major feeding areas as documented in the prior chapter. Therefore, prices in different parts of the country may vary because of differences in transportation cost from where the feeder cattle are located to where they are being shipped to be fed. For example, the price of steers in Athens, Tennessee may be different from the price of steers in Omaha, Nebraska, which are nearly 900 miles from each other. The difference in price between these two markets could be explained by the cost of transportation and/or perhaps lot characteristics.

The theory of the law of one price applies to agriculture products just as it applies to any other good or product. Tomek and Robinson (1990) stated "Agriculture markets are generally believed to follow the principle called the law of one price, which holds that prices in different markets do not differ by more than transfer costs." In the past, research has been completed to test this theory for both agriculture and non-agriculture products to determine, if indeed, prices that are offered through space are the same when adjusted for transit costs. Chronological review will be completed on how examination of the law of one price has evolved and, if indeed, differences in prices are left just to the cost of transportation.

In 1989, a study by Pier Giorgio Ardeni questioned if the law of on price applied to commodity prices including wheat, sugar, beef, and wool. The author examined prices of commodities in different countries with the assumption that prices would only differ by transit costs. Interestingly, studying the law of one price across national border adds variables which should not be overlooked, such as exchange rates and international trade agreements such as tariffs and taxes. The overall implication was that empirical data were flawed and that cost of transit being the only difference in international commodity prices was "counterfactual" (Ardeni, 1989). Ardeni (1989) concluded that the concept of the law of one price both fails in the short run and long run. In the short run, the law of one price failed due to "slow pass through, stickiness of prices and various slow adjustments…" (Ardeni, 1989). In the long run, effects of exchange rates caused the law of one price to fail. Ardeni suggested that the lack of adequate research data aided in failures of the law of one price. One reason for failure in the short run, when examining the law of one price, was because of slow adjustments. Technology and availability of information could possibly help in the future to discover if the law of one price holds across borders. With modern accessibility of information, this problem may be solved in the future (Pendell and Schroeder, 2006; Ward, *et al.*, 1997).

One year later, another study by Faminow and Benson (1990) examined the integration of spatial markets specifically in the Canadian hog market. Data from the major hog markets of Edmonton, Calgary, Saskatoon, Winnipeg, and Toronto were included in the analysis. Research indicated that hog production is

widely dispersed and a majority of harvesting occurs in the cities listed above. This is similar to the US cattle market. Parallels between the Canadian hog market and the US beef market include factors such as geographical disbursement of production, more consolidated feeding/slaughtering, and, due to vast distances, significant transportation costs. The study examined two different time periods, the first was from 1965 to 1968 and the second from 1968 to 1975. The reason that two different time periods were used was because of different price data. The former suggested that price differentials could be explained by transfer costs, while the later suggested that price differentials were all greater than the cost of transportation. The second study also suggested that price differentials were similar even in the different Canadian locations. The two different study periods examined prices in different times and found different results. To this point in time, this suggests that studies of spatial markets and the law of one price are very subjective and may be influenced by the time the data were collected. The authors stated, "Rarely if ever, have prices found to be highly correlated and differ between two points by transportation costs, thus indicating that the markets under study are not highly integrated and perhaps they are not very efficient" (Faminow and Benson, 1990).

Schroeder and Goodwin (1990) examined eleven different cattle markets over an eleven year period. They found that markets that handled large quantities of cattle reacted to the changes in price over a one to two week period, whereas markets that handled small quantities of cattle reacted to prices much more slowly by up to three or four weeks. Primarily, this demonstrates that there

is a lag in price data in both high volume and low volume markets. Secondly, it demonstrates how high volume markets receive information much faster than low volume markets. Information/price lags such as these leave opportunities for arbitrage and questions the law of one price. Today, with the availability of technology, this may not always be the case. It is possible that new technologies, such as internet and cell phones, may have eliminated much of the information lag and allowed prices to be more integrated across markets (Feuz, 2008).

Goodwin and Schroeder (1991) found in their study that mileage has a negative effect on price. This in turn, altered the connection of markets and prices between those markets. This corresponds with previous research that when large distance exists between two markets, integration is minimal (Faminow and Benson, 1990; Schroeder and Goodwin, 1990).

In relation to previous studies, newer research challenged the failures of the law of one price. In 1991, John Baffes suggested that failures in the law of one prices were the results of problems in the price data and time period rather than a general failure. Perhaps inadequate accounting of transportation costs caused failures in the law of one price. Adjustments for price, time, and transportation could possibly account for perceived failures in the law of one price. Baffes concluded that to fully deny or accept the law of one price further research must be completed (Baffes, 1991). Perhaps with the use of accurate and abundant SLA data, results for this thesis will show that feeder cattle prices do follow the law of one price.

In 1997, McNew and Fackler completed a study which gave interesting insight to spatial markets and integration. They suggested that in order to accurately assess the law of one price, markets have to be well integrated and freight rates have to be stationary. The cattle market has displayed some degree of integration based on the ability to quickly and easily transfer cattle due to actual movement of cattle in the US (Harris, 2008). Research from Brorsen, Bailey, and Thomsen (1997) identified four different cattle markets and suggested that they are "substantially overlapping." This would support the suggestion that the law of one price, to a degree, may be studied excluding the effect of ever changing transportation costs. In the same study by Brorsen, Bailey, and Thomsen (1997), it was suggested that "Transportation costs influence the market area…" This corresponds with McNew and Fackler (1997) in identifying the effect that transportation has on market integration. When transportation costs are high, the affect would be to isolate the market, whereas low transport rates would support market integration. In addition to the effect of transportation costs, Bailey, Brorsen, and Thomsen (1995) suggested that buyers subsidize transportation costs for feeder cattle purchased in distant markets compared to feeder cattle purchased in nearby markets. In other words, cattle buyers are paying for transportation costs for the cattle purchased in distant locations compared to cattle bought in nearby locations. As the law of one price states, prices are equal when adjusted for transportation costs. Therefore, because buyers are absorbing freight costs it would appear the law of

one price is not substantiated and there is some degree of spatial price discrimination.

Barrett (2001) emphasized the importance of measuring integration and efficiency in foreign agricultural markets. The study defined integration as "'the satisfaction of the law of one price". Barrett also suggested that "The [law of one price] states that if trade occurs and all profitable arbitrage opportunities are extinguished, prices are equalized up to the cost of commerce." Barrett questioned this definition and suggested that perhaps it could be broken down by specifically identifying integration and efficiency which would help sort out price-based data and flow-based data. It was also suggested that lack of data inhibited the ability to test market price differentials. Imprecise and insufficient data can certainly skew accurate results in any case especially in studying the law of one price (Barrett, 2001).

Pendell and Schroeder (2006) stated that, "With more complete price and transaction data available to the public than existed under voluntary reporting, arbitrage opportunities should decrease, and correspondingly, one would expect integration between spatial markets to increase." This is in reference to the mandatory price reporting (MPR) implemented by the United State Department of Agriculture's agriculture marketing service (AMS). MPR is price data collected from five regional cattle markets in the US designed to provide valuable information to the cattle industry. Regions that data were collected included: Colorado, Iowa-Southern Minnesota, Kansas, Nebraska, and Texas/Oklahoma. The authors suggest that usage of MPR data increases market integration

between the different cattle markets and prices more closely follow a one to one

ratio. This, in effect, supports the theory of the law of one price within cattle

markets that implement programs such as MPR. Conversely, this study only

includes fed cattle markets in the major cattle feeding areas leaving out other

outlying cattle markets (see Figure 1.2). Therefore, perhaps the law of one price

holds in major cattle feeding areas, whereas in outlying cattle markets, that may

not be the case. In other words, perhaps individual regions may abide by the law

of one price while areas including several regions do not.

Prior research has outlined the evolution of the law of one price and

spatial integration. Compared to what has been done previously, the current

study will build upon past ideals and add to them in several ways. First, the data

from SLA grants current up-to-date information which will provide current results.

Second, prior research had difficulties with accurate and availability of

information. Superior Livestock Auction data will provide information which will

be relevant and accurate for the desired research. Last, most past research

focused on international commodity trade or large US Midwestern cattle markets

and overlooked outlying cattle markets. Thus, this study will examine the feeder

cattle market for the entire US within a specific framework of data.

Chapter 3

Theory, Methodology and Data

This chapter is divided into five main sections. The first section discusses the theory behind the law of one price and the underlying critical assumptions. The next three sections discuss the methods used to accomplish the specific objectives of this thesis. They are: (1)Quantify the value the market places of various cattle quality characteristics ; (2)Test the law of one price when adjusting for the complete cost of transporting feeder cattle; and (3)Test the law of one price in the US feeder cattle market and the Intermountain West by adjusting actual prices for quality differences and transportation costs. The last section is a detailed description of the data and an explanation of the process of narrowing the data to create the final data set.

Theory of Law of One Price

The law of one price is based on the assumptions that markets are efficient and competitive. Essentially, the law of one price states that prices in different markets do not differ by more than transfer costs. The economic concept of arbitrage drives this relationship. If prices in one market exceeded those in another market by more than the transfer costs, than there is an economic incentive for an individual to buy the good in the low priced market and ship it to the high priced market to resell. This arbitrage will drive up the price in the lower priced market and drive down the price in the higher market through the forces of supply and demand. Arbitrage will continue until the price differential in the two markets is just equal to the transfer costs.

Implied in this theory is that the good or commodity being traded is homogenous. This is often explicitly stated by those evaluating this theory. However, the theory also implies that profits, and therefore costs also do not differ by more than transfer costs in different market areas. In a perfectly competitive market, there is no long run economic profit. If prices, and therefore revenue on a homogenous product, do not differ by more than transfer costs, then it must follow that costs are also similar. Otherwise, one market area could be earning a long run economic profit if it had lower costs and was receiving the same market price. In the long run, one would expect the factors in production to be valued such that there was no long run economic profit.

As has been previously stated, feeder cattle are not homogenous. Therefore, it is necessary to determine the value of different feeder cattle traits so as to be able to compare feeder cattle prices in different markets. Furthermore, feeder cattle change with time and with transportation. Some of these changes, tissue shrink, can be valued and included in the transfer costs. However, transporting feeder cattle multiple times for arbitrage purposes may also increase incidence of sickness and even death. This is more difficult to evaluate but may in fact limit the amount of arbitrage that would otherwise occur in the feeder cattle market. As much as possible, this thesis tries to account for these differences in the methodology.

Valuing Cattle, Lot, and Market Characteristics

Feeder cattle are typically purchased with the intent of eventual re-sale of the animals. Depending upon whether the purchaser is a stocker operator or a

feedlot operator; they will likely value certain cattle or lot characteristics differently. For example, feedlot operators may place a higher value on lot sizes that comfortably fill one or more pens in their yard. A stocker operator, who plans to purchase calves to graze wheat pastures, may place a different value on size and condition of the calves compared to a feedlot operator. The goal of both the stocker operator and the feedlot operator is to add value to the calves that they plan to purchase. When they purchase cattle they have an expected output in mind.

The value of marginal product can be specified as:

$$VMP = P_{input} \tag{1}$$

The value of the marginal product is the sum of the value placed on each characteristic that makes up an entire good, or animal in this case. Each buyer will value each characteristic differently. For example, a cattle producer in a hot climate may value a particular breed more than a cattle producer in a cooler climate.

Lancasterian Demand Theory (Lancaster, 1924-199) suggests that the value of a particular good is really the sum of the value of the individual characteristics that make up that good. In the case of feeder cattle, the value of a particular pen of feeder cattle is based on the sum of the values for cattle, lot, and market characteristics. In other words, cattle buyers are buying separate attributes such as: breed, sex, weight, flesh, frame, lot size, days to delivery, and shrink, as opposed to the whole animal.

In most of the prior studies on the value of particular feeder cattle characteristics, the actual market price for each lot of cattle sold is the dependent variable. However, in this research, rather than using price as the dependent variable, basis is used. Basis is defined as:

$$Basis_i = Price_i - Futures_j \qquad \textbf{(2)}$$

where Price$_i$ is the actual price bid for the ith lot for i=1,2,3,…,I and Futures$_j$ is the value of the Chicago Mercantile Exchange (CME) jth Feeder Cattle contract on the auction date and for the month of delivery or the closest month after delivery if no contract is traded in the delivery month. For example, in order to obtain the correct futures data for a sale on the 10th of July with 100 days to delivery, the futures price that was used would be the CME October Feeder Cattle Future price on July 10th. Basis was used rather than the actual price because there were multiple sale dates each year for calves that were to be delivered in October or November. If one accepts the assumption that futures markets are efficient and unbiased predictors of prices in the future, then buyers and sellers in the markets should be using the futures market to establish prices for feeder cattle for future delivery. Therefore, basis will be less impacted by changes in the market price level from one sale date to the next for the same expected delivery date than with the actual prices.

The general form of the equation to obtain the value of individual lot characteristics can be written as:

$$b_i = \alpha_0 + \sum_{j=1}^{J} \beta_j CC_{ij} + \sum_{k=1}^{K} \gamma_k LC_{ik} + \sum_{n=1}^{N} \theta_n MC_{in} + \varepsilon_i \qquad \textbf{(3)}$$

where b_i is the basis for the ith lot for i = 1,2,3,…,I, where I is the number of lots

sold in the dataset. The intercept is represented as α_0 with ε_i as white noise

error term. CC is the jth cattle characteristic of the ith lot of cattle, LC is the kth lot

characteristics of the ith lot of cattle, and MC is the nth market characteristic for

the ith lot of cattle with $\beta_j,$ γ_k and θ_n are parameter estimates. This equation is

similar to that used by Bailey, Brorsen, and Fawson (1993).

The cattle, lot, and market characteristic variables used in the analysis are

displayed in Table 3.1. A brief description of each of these variables follows with

a discussion of the anticipated impact each will have on the dependent variable,

basis.

<u>Cattle Characteristics</u>

As indicated in the literature review, steers are expected to receive higher

prices than heifers. This is due to the fact that steers gain weight faster and yield

better which make them more desirable for buyers. Therefore, the *HEIFER*

(Heifer) coefficient is expected to have a negative sign. With the exception of

cases of breeding stock, all previous research supports that heifers are

discounted compared to steers (Faminow and Gum, 1986; North Dakota State

University, 2006; Schroeder, *et al*., 1988; Ward and Lalman, 2003).

The price per cwt for cattle would be expected to decrease as *WEIGHT*

(Average Weight per Animal) increased. Except in rare cases, or that of

breeding stock, all past research examined was consistent in that weight and

price have an indirect relationship. However, this reduction in basis is likely non

linear, decreasing at a decreasing rate as weight increases. Previous research

Table 3.1 Independent variables for cattle, lot, and market characteristics used in regression equation represented by equation 2.

Variable Description/Base[a]	Variable Name	Type	Expected Sign
Cattle Characteristics:			
Sex: Steer*			
Heifer	*HEIFER*	Binary	-
Average Weight Per Animal	*WEIGHT*	Continuous	-
Average Weight Squared Per Animal	*WEIGHTSQ*	Continuous	+
Breed: Angus*			
Angus-English Cross	*ANGXENG*	Binary	-
Angus-Exotic Cross	*ANGXEXO*	Binary	-
English-Exotic-Ear Cross	*ENGXEXOXEAR*	Binary	-
Angus-Eng-Exotic Cross	*ANGXENGXEXO*	Binary	-
Charolais-Angus Cross	*CHARXANG*	Binary	-
Red Angus	*REDANGUS*	Binary	+
Other Breeds	*OTHER*	Binary	-
Frame: Medium*			
Small	*SMALL*	Binary	-
Large	*LARGE*	Binary	+
Flesh: Medium*			
Light	*LIGHT*	Binary	+
Heavy	*HEAVY*	Binary	-
Steroid Implants:			
Not Implanted*			
Implanted	*IMPLANTS*	Binary	-
Presence of Horns:			
No Horns*			
Horns	*HORNS*	Binary	-

Table 3.1 Independent variables for cattle, lot, and market characteristics used in regression equation represented by equation 2, continued.

Variable Description/Base[a]	Variable Name	Type	Expected Sign
Lot Characteristics:			
Number of Head	*HEAD*	Continuous	+
Number of Head Squared	*HEADSQ*	Continuous	-
Weighing Conditions:			
Weighed off Ranch*			
Weighed at Ranch	*RANCH*	Binary	-
Percent Shrink	*SHRINK*	Continuous	+
Weight Variation:			
Even*			
Uneven	*UNEVEN*	Binary	?
Market Characteristics:			
Sale Order	*ORDER*	Continuous	+
Sale Order Squared	*ORDERSQ*	Continuous	-
Days to Delivery	*DAYS*	Continuous	+
Miles to Delivery	*MILES*	Continuous	-
Futures Price	*FUTURES*	Continuous	?
Annual Dummy Variables			
2004*			
2005	*2005*	Binary	?
2006	*2006*	Binary	?

[a] The base for binary variables is indicated by an asterisk "*".

by Bailey and Peterson (1991), Buccola (1980) and Faminow and Gum (1986) have consistently found this relationship.

The majority of previous literature has shown that breed impacts cattle prices (Bailey and Peterson, 1991; Brazle, *et al*., 1988; Faminow and Gum, 1986; Schroeder, *et al*., 1998; Smith, *et al*., 2000; Turner, Dykes, and McKissick, 1991; Ward and Lalman, 2003). Since Angus cattle made up 25 percent of all breeds within the data set (see table 3.2), they were used as the base category. Therefore, all other breeds were compared to the Angus breed. Compared to Angus cattle, other breed coefficients such as *ENGXEXOXEAR* (English-Exotic-Ear Cross), *ANGXEXO* (Angus-Exotic Cross), *CHARXANG* (Charolais-Angus Cross) are expected to be discounted. This is primarily due to recent trends in consumer and cattle buyer preference for Angus cattle.

Past research has indicated buyer preference for larger framed and lighter fleshed feeder cattle (Bailey and Peterson, 1991; Brazle, *et al*., 1988; Schroeder, *et al*., 1998; Smith, *et al*., 2000; Turner, Dykes, and McKissick, 1991; Ward and Lalman, 2003). Therefore, *LARGE* (Large Frame) is expected to have a positive impact and *SMALL* (Small Frame) a negative impact on basis compared to medium frame. Likewise, *LIGHT* (Light Flesh) is expected to have a positive impact and *HEAVY* (Heavy Flesh) a negative impact on basis compared to medium flesh.

Not much research has been done in the past concerning the affects of steroids implants on prices. However, through a personal interview it was noted that in several cases buyers were able to offer price premiums for yearling calves

that were not implanted with steroids (Harris, 2008). Therefore, the coefficient for *IMPLANTED* (Steroid Implants) would be expected to have a negative impact on basis.

The coefficient *HORNS* (Horns) are expected to be discounted due to human and animal safety as well as feeder accessibility. This is consistent with prior research (Bailey and Peterson, 1991; Brazle, *et al*., 1988; Schroeder, *et al*., 1998; Ward and Lalman, 2003).

<u>Lot Characteristics</u>

Based on previous research completed by Schroeder, *et al*. (1998) and Brazle, *et al*. (1988), *HEAD* (Number of Head) is expected to positively impact basis. However, it is likely that increasing lot size beyond a certain point will have a decreasing impact on basis and may actually decrease basis if lots are considered too large for many buyers. As a result, the expected sign for *HEAD* (Number of Head) would be positive while the expected sign for number of head squared would be negative.

Feeder cattle that are weighed at the ranch of origin are likely to have experienced less shrink than cattle that have already been loaded on a truck and freighted some distance before a weight is obtained. Therefore, the coefficient for *RANCH* (Weighed at Ranch) would be expected to have a lower price and hence the impact on basis should be negative.

The majority of cattle lots sold had a certain percentage of shrink discounted to gross weight to account for gut fill in animals while in transit. This shrink amount would be expected to have a direct effect on price. This coincides

with research by Turner, Dykes, and McKissick (1991) which found that as shrink increased the price also increased. Consequently, the expected result is that as *SHRINK* (Percentage Shrink) increase sellers and buyers should typically expect a higher price.

Several past researchers have examined the effect that uniformity has on cattle prices. However the conclusions of past research are divided. Bailey and Peterson (1991) concluded that cattle uniformity had no effect on prices, whereas Brazle, *et al*. (1988) and Smith, *et al*. (2000) both confirmed that cattle uniformity brought price premiums. In addition, through a personal interview, information was shared that explained that while uneven cattle may be slightly discounted, uniform cattle lots received no premiums (Harris, 2008). Therefore, the sign for *UNEVEN* (Weight Variation) is expected to be unknown.

Market Characteristics

Feeder cattle prices are expected to increase as the *ORDER* (Sale Order) increases. Past research by Brazle, *et al*. (1988), Schroeder, *et al*. (1998), and Turner, Dykes, and McKissick (1991) indicates that sales order affects the price received but there are differences as to when prices are at an optimal level. Possible reasons for the decrease in price as the sale order increases are because buyers fill their orders earlier in the sale and therefore are not active bidders later in the sale. Therefore the *ORDERSQ (S*ale Order Squared) is expected to decrease thus explaining that buyers have filled orders and as a result price premiums begin to decline. This suggests that the price is expected

to increase at a decreasing rate as the sale progresses (Parcell, Schroeder, and Hiner, 1995).

The expected sign for *DAYS* (Days to Delivery) is expected to be positive. Bailey and Peterson (1991) stated that "…sellers receive premiums for cattle delivered in the future." Buyers are possibly eliminating certain elements of risk by buying cattle at a premium for future delivery rather than dealing with the risk of high priced cattle in the future. Therefore, as the number of days to delivery increases the price is expected to increase.

As indicated in the Table 3.2, cattle lots may be expected to be shipped anywhere from zero to 1,607 miles. Additionally, the average number of miles cattle lots are shipped is 429 miles. Although very little literature was found on the effect that miles have on price, based on significant mileage numbers, *MILES* (Miles) is expected to have negative expected sign. For example, as the amount of miles increases, the price is expected to decrease. Personal interviews contribute to this expectation, that cattle bought from distant locations were discounted more than cattle bought from nearby locations (Harris, 2008). Focus will be aimed at how much miles affects the price, and particularly if a decrease in price for every mile is enough to compensate for the cost of transportation. However, Bailey, Brorsen and Thomsen (1995) stated "Buyers absorb freight costs on cattle they purchase more than 200 miles from their final destination." Taking this into account, even though miles are expected to have a negative impact on price, cattle sold in distant locations are expected to receive prices similar or even greater than cattle sold from nearby locations. This suggests that

buyers purchasing cattle from distant locations are essentially paying for freight costs.

FUTURES (Futures Price) may also impact the price offered for cattle. If higher overall price levels, as reflected by the futures market, lead to even higher cash prices, then the impact on basis may be positive. However, if higher overall price levels create greater uncertainty, and if cash prices does not follow the futures higher prices, then the impact on basis may be negative. At this point, the sign is left indeterminate.

There is no *a priori* information which is statistically significant on *2005* and *2006* (Annual Dummy Variables). Therefore, the expected sign for the year dummy variable is unknown.

Equation 2 (see page 22) was estimated using ordinary least squares regression. The regression procedure of LIMEP, an econometric software package, (Greene, 2003) was used to perform the regression analysis. The model was found to have problems of heteroscedasticity. Consequently, a White estimator was used to correct for heteroscedasticity and provide more accurate results.

Transportation Adjusted Basis

As indicated by definition of the law of one price, in order to determine the relationship between prices, or basis in this case, basis for each cattle lot must be adjusted for tranportation costs. Therefore, several factors must be considered in order to properly account for transportation costs. First, and most obviously, the actual cost of freight for hauling cattle per loaded mile must be

determined. Secondly, the loss of tissue shrink in cattle due to effects of transporting them must be valued. Lastly, the percent shrink or "pencil shrink" that may have been part of the sale terms must be considered and deducted from the actual shrink. Once each of these factors are calculated they will be incorporated together to determine the total cost of transportation for each sale lot. Subsequently, the cost of transportation will be figured into the respective basis to derive the transportation adjusted basis.

As mentioned, the most influenctial factor in the cost of transporting cattle is the price of freight. Using data from a reputable cattle freight company based out of Malta, Idaho, a cost per loaded mile was obtained. Average freight rates for the years 2004, 2005 and 2006 were $2.45, $2.67, and $3.30 per mile, respectively (Harris Brothers Trucking, 2007). Using the corresponding yearly average freight rates, total freight costs were calculated for the amount of miles each lot was transported. Total freight costs were then converted to a cost per cwt, which is based on cattle trucks weight capacity of 50,000 pounds.

Tissue shrink is the loss of weight in cattle both through excretion and tissue loss due to stress, and deprivation of feed and water. According to animal scientists at Michigan State University, cattle that are being shipped in freight hauling trucks lose .61 percent of their body weight for each 100 miles in shipment. This .61 percent shrink is considered half actual tissue loss and the other half as excretory (Brownson, 1986). Because this is a significant cost to feeder cattle buyers, tissue shrink must be added to the cost of transportation so as to compensate for economic losses in route.

Many sale lots include a pencil shrink as part of the sale conditions. Pencil shrink is the amount that is discounted from the gross weight of cattle to account for gut fill (Falkner, 1998). In this data set the average shrink for 450-700 pound steers and heifers was 1.5 percent with a range from 0-3 percent (see Table 3.2). Consequently, the price received for purchased cattle is based on the pay weight, which has been adjusted for pencil shrink, rather than gross weight. Pencil shrink must be discounted from transportation costs rather than added because cattle buyers received compensation for shrink loss at the time of the sale.

The following equation was used to determine the total transportation cost per hundred weight for each sale lot:

Transportation Cost$_i$ =   **(4)**

rate$_j$*miles$_i$/500 + (price$_i$*((weight$_i$/100)*((((miles$_i$/100)*.61)/100)-shrink$_i$)))

where *i* is the ith sale lot for i=1 to I, *j* is the jth rate for j=2004 to2006, *rate* is the trucking rate charged in that year, *price* is the actual auction price, *weight* is the animal weight in cwt, *miles* is the distance from the sale origin to the sale destination, and *shrink* is the pencil shrink offered in the terms of the sale.

This transportation cost per cwt for each sale lot was added to the basis for each lot to obtain a transportation adjusted basis. Essentially, this price would represent the expected price if transportation were free. In other words, if buyers were not paying any actual freight, were not expecting the cattle to actually lose weight, and were not receiving any pencil shrink, then this would be the price that should have been offered if buyers and sellers were all correctly

accounting for transportation in their negotiations. If feeder cattle were homogeneous, then it would follow that the transportation adjusted basis should be equal across all regions of the US. Thus, if transportation adjusted basis are equal than the law of one price is upheld.

Ignoring for the moment that other cattle, lot, and market characteristics impact basis, an initial test of the law of one price was conducted by looking at the mean differences in basis. Procedure General Linear Model (PROC GLM) with the lsmean statement was used in Statistical Anaylsis Software (SAS) to determine if these mean values differed by each of the classifications. The data were classified by steers and heifers and by three weight categories: 450-499 pounds, 500-599 pounds, and 600-700 pounds. Gender and weight were divided into categories due to significant differences in price between that of steers and heifers and weight. Additionally, the US was divided into six regions where the origin of each cattle lot was represented.

Quality Adjusted Transportation Basis

From the prior literature on the value of various feeder cattle characteristics, it is obvious that additional characteristics beyond gender and weight impact feeder cattle value and price. If there are quality differences by region, then it may be the case that the transportation adjusted basis will not be equal across regions because there is a different price being paid for the varying quality of feeder cattle. In order to truly examine the law of one price, price or basis must be adjusted for quality, as well as for transportation costs.

The first objective of this research was to determine the value of various cattle, lot, and market characteristics for each sale lot of feeder cattle. These values were obtained by ordinary least squares regression. To arrive at a quality adjusted basis, the parameter estimates obtained from the Hedonic regression are used to adjust the basis to be higher or lower depending on the cattle, lot, and market characteristics of each sale lot. Essentially, a predicted basis is calculated using the parameters of the regression equation estimated. The same adjustment for transportation costs is also made to the data. The result is a quality and transportation adjusted basis (QTAB) as determined for each sale lot.

The data were again classified by gender and weight, in the same manner as the classifications in the transportation adjusted basis. The same six regions were also used and each lot was assigned to be in the region of cattle origin. PROC GLM with the lsmean statement was again used in SAS to determine if these mean values differed significantly by each of the classifications.

The hypothesis of this work is that after basis has been adjusted for quality differences and for transportation costs, there will be no differences in basis level between regions of the country. This would imply that the law of one price is in existence in the feeder cattle market, at least in the case of a national satellite video auction market.

Data

Primary data for this study were collected from SLA located in Brush, Colorado on November 27, 2006. The data included a large range of cattle from nearly all regions of the US sold between the years of 2004-2006. The data were

very detailed with informative physical characteristics such as sex, breed, weight, frame, and flesh. The data also included market data for each lot including lot size, sale date, delivery date, location, destination, and sale order. The original data set includes 29, 246 lots which contains 3, 252, 512 head of cattle sold. The data contains sale lots for steers, heifers, mixed, bred cows, and bulls. Weights from the original data set ranged from 210 pounds to 2,075 pounds. Superior Livestock Auction offers cattle sales throughout the year in which delivery occurs in all months of the year.

This research was directly focused on the steer and heifer calf market. In the US, the dominant practice is to calve in the spring, raise the calves through the summer and eventually wean and sell in the fall. While calves were sold at sales throughout the year, the majority were sold with delivery to occur in October and November. Calf weights in the range of 450-700 pounds accounted for more than 70 percent of the all steer and heifer sale lots. Therefore, the data set was narrowed to only include sale lots of steer and heifer calves, weighing 450-700 pounds, and being delivered in either October or November of 2004-2006. Descriptive statistics for these data are displayed in Table 3.2.

Originally, the data did not include the amount of miles the lot was transported to destination. Instead, the data included zip codes of sale location and destination. Using a zip code data base, miles were calculated based on direct distances from the zip code of the sale origin to the zip code of the sale destination.

Table 3.2 Descriptive statistics for the 9,570 sale lots included in the analysis.

Variable	Mean	Std. Dev	Minimum	Maximum
Price	122.528	9.8764	61.75	164.25
Basis	12.7992	9.8980	-43.00	56.00
Transportation Adjusted Basis	22.9887	18.3698	-38.43	85.87
Quality & Trans. Adj. Basis	4.2216	16.3030	-42.31	69.59
Heifer	0.3820	0.4859	0	1
Weight	567.7785	63.1389	450	700
Small Frame	0.0016	0.0396	0	1
Large Frame	0.1079	0.3102	0	1
Light Flesh	0.1084	0.3109	0	1
Heavy Flesh	0.0355	0.1850	0	1
Angus	0.2479	0.4318	0	1
Angus-English Cross	0.1215	0.3268	0	1
Angus-Exotic Cross	0.1708	0.3764	0	1
English-Exotic-Ear Cross	0.0810	0.2728	0	1
Angus-English-Exotic Cross	0.0800	0.2714	0	1
Charolais-Angus Cross	0.1023	0.3031	0	1
Red Angus	0.0216	0.1455	0	1
Other Breeds	0.1748	0.3798	0	1
Horns	0.2178	0.4127	0	1
Implanted	0.2936	0.4554	0	1
Number of Head	115.9006	65.8802	24	880
Uneven	0.9362	0.2443	0	1
Weighed at Ranch	0.4307	0.4952	0	1
Percent Shrink	0.0149	0.0103	0	0.03
Sale Order	708.8293	474.5509	1	1933
Days to delivery	88.0856	40.5879	0	285
Miles to delivery	429.3193	272.1989	0	1607
Futures	109.7247	4.3124	94.50	118.33
Year 2005	0.3660	0.4817	0	1
Year 2006	0.3021	0.4592	0	1

The entire data set originally included 22 different breeds. However, many

of the breeds were similar and/or only had a few observations. Therefore, the

original 22 breed classifications were narrowed into eight different breed and cross-breed categories so as to simplify the analysis.

Flesh and frame were each narrowed from nine selections to three. The selections were constricted to small, medium, and large for frame and light, medium, and heavy for flesh. Cattle with medium flesh made up nearly 85 percent of total observations while light and heavy flesh only made up 11 percent and four percent respectively. Similar to flesh, cattle with medium frame made up approximately 89 percent of total observations compared to small and large frame cattle with one percent and 10 percent respectively.

Originally, the data included three different locations where cattle would be weighed. The first site was coded as cattle weighed on scales at the ranch. The next location was a facility off the ranch where cattle could be weighed such as auction scales. The last site was cattle being weighed on the truck. Since there was little difference between weighing at an auction and weighing on a cattle truck, the two categories were combined. Consequently, weighing locations were essentially narrowed to cattle weighed at the ranch and cattle weighed off the ranch.

The data set includes sales in nearly all states of the US. In examining the law of one price, the data will be sorted into six specific regions. Regions of the US were categorized based selecting groups of neighboring states that had somewhat similar environmental and market conditions. The states represented in each region are found in Table 3.3. Not all states are listed, as some had few or no SLA sales for the narrowed data set.

Table 3.3 Division of US states into six regions.

Region	States
West Intermountain	Washington, Oregon, California
West	Idaho, Montana, Wyoming, Colorado, Nevada, Utah
Midwest	Kansas, Nebraska, North Dakota, South Dakota, Minnesota, Iowa, Missouri
Southwest	Oklahoma, Texas, Arizona, New Mexico
Southeast	Florida, Georgia, Alabama, Mississippi, Louisiana, Arkansas, North Carolina, Tennessee, Kentucky
Northeast	Indiana, Illinois, Wisconsin

Chapter 4

U.S. Results

Similar to the order in which methods are presented in the previous chapter, results in this chapter will be presented. First, results for estimating the value of various cattle, lot, and market characteristics will be examined and analyzed. Second, results from the transportation adjusted basis will be evaluated to determine if transportation costs account for differences in basis between regions, and ultimately, if the law of one price is upheld. Last, after adjusting price for transportation and quality, the law of one price will once again be tested between regions.

Value of Cattle, Lot, and Market Characteristics

Equation 3 in Chapter 3 was estimated using ordinary least squares regression to determine the impact various cattle, lot, and market characteristics had on the basis for the sale lots. However, the model exhibited heteroscedasticity. Consequently, a White estimator was used to correct for heteroscedasticity and provide more accurate results. The parameter estimates are displayed in Table 4.1.

The variables in the regression model accounted for approximately 70 percent of the variation in basis. The adjusted R^2 was .7004 and the F value was significant at the 99 percent level. Each estimated coefficient explains how much basis per cwt would change for a one unit change in the independent variable. Most parameter estimates were as expected and were significantly different from zero at the one percent level.

Table 4.1 OLS-White parameter estimates for feeder cattle basis ($/cwt.) differentials.

Independent Variables	Coefficient	Standard Error	P-Value
Adjusted R^2	0.7004		
F value	799.97		0.0000
Intercept	214.5898	5.1506	0.0000
Cattle Characteristics:			
Sex:			
HEIFER	-8.7252	0.1171	0.0000
Delivery Weight			
WEIGHT	-0.5073	0.0158	0.0000
WEIGHTSQ	0.0004	0.1365D-04	0.0000
Breed:			
ANGXENG	-1.8812	0.1858	0.0000
ANGXEXO	-2.0205	0.1566	0.0000
ENGXEXOXEAR	-5.0055	0.2602	0.0000
ANGXENGXEXO	-3.0217	0.2026	0.0000
CHARXANG	-1.1957	0.1988	0.0000
REDANGUS[a]	0.4233	0.3954	0.2844
OTHER	-4.8052	0.2084	0.0000
Frame:			
SMALL[b]	-10.0038	4.1412	0.0157
LARGE[a]	0.0035	0.0070	0.6221
Flesh:			
LIGHT	1.5746	0.2460	0.0000
HEAVY[a]	0.0015	0.0026	0.5743
Steroid Implants:			
IMPLANTED	0.0045	0.0008	0.0000
Presence of Horns:			
HORNS	-1.5640	0.1657	0.0000

Table 4.1 OLS-White parameter estimates for feeder cattle basis ($/cwt.) differentials, continued.

Independent Variables	Coefficient	Standard Error	P-Value
Lot Characteristics:			
Number of Head			
HEAD	0.02048	0.0027	0.0000
HEADSQ	-0.1848D-4	0.5617D-5	0.0000
Weighing Conditions:			
RANCH	-0.4791	0.1205	0.0001
Percent Shrink			
SHRINK	0.0020	0.0004	0.0000
Weight Variation:			
UNEVEN	-0.0043	0.0011	0.0001
Market Characteristics:			
Sale Order			
ORDER	0.0047	0.0005	0.0000
ORDERSQ	-0.2609D-05	0.2654D-06	0.0000
Miles to Delivery			
MILES	-0.0033	0.0002	0.0000
Days to Delivery			
DAYS	0.03699	0.0020	0.0000
Futures Price			
FUTURES	-0.2525	0.0199	0.0000
Annual Dummy Variables:			
2005	-0.8659	0.1280	0.0000
2006	-3.4853	0.1667	0.0000

[a] Values are **not** statistically different from zero at the 10 percent level.
[b] Values are significantly different at the 5 percent level of confidence, however, they are not statistically different from zero at the 1 percent level.
All other values are statistically different from zero at the 1 percent confidence level.

Cattle Characteristics

The coefficient for *HEIFERS* (Heifers) explains that heifers were heavily discounted compared to steers which was not surprising considering past research. Discounts for heifers are primarily due to lack of average daily gains compared to those of steers. Consequently, based on the parameter estimate, buyers are willing to pay $8.73 per cwt more for steers than heifers all else being equal.

The coefficients for *WEIGHT* (Weight) and *WEIGHTSQ* (weight squared) were significant and yielded expected results. As reinforced by previous research, lighter weight calves receive a premium price per cwt compared to heavier weight calves. However, the relationship between basis and weight is non-linear.   In other words, as weight decreases, basis does not decrease at the same rate. Basis, in fact, decreases at a decreasing rate as weight increases. Figure 4.1 illustrates this weight to basis relationship for feeder calves. This basis price slide is impacted by expected costs of gain in feeding calves, and therefore, is reflective of the feeding costs during the 2004-2006 time frame.

Using the Angus breed as the default breed, parameters were estimated for seven different breed categories and were found to be significantly different from Angus except for the Red Angus breed. The parameter estimate for *REDANGUS* (Red Angus) was not statistically significant which suggests there is no difference between offered prices for Angus and Red Angus cattle. Perhaps Red and Black Angus cattle are perceived as similar in quality, and therefore, no price differences were distinguished. Out of all the different breed and breed
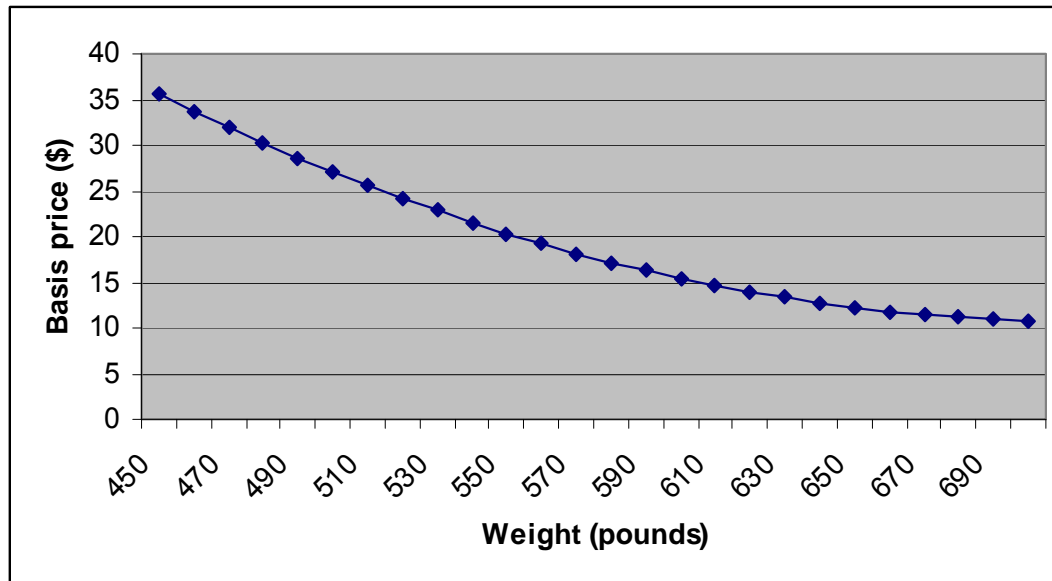
Figure 4.1 Basis price slide for 450-700 pound calves delivered in October and November, 2004-2006.

combinations, *ENGXEXOXEAR (*English-Exotic-Ear) received the largest

discounted price relative to Angus calves. Quite often cattle with Ear influence,

those of the tropical *Bos indicus* species, such as Brahman have larger ears and

therefore are sometimes referred to as Ear cattle in the U.S., are discounted

because of the inability to efficiently gain weight in cooler climates, as well as

marbling deficiencies at harvest. Coefficients for *CHARXANG* (Charolais-Angus)

and *ANGXENG* (Angus-English) cross breeds are priced the closest to Angus

cattle being discounted at $1.20 per cwt and $1.88 per cwt, respectively.

The parameter estimates for frame were generally as expected with

*LARGE (*Large Frame) being positive and *SMALL* (Small Frame) being negative.

However, the coefficient for *LARGE* (Large Frame) was statistically insignificant

compared to cattle with medium frames. This suggests that medium and large

frame cattle are not perceived as different or that one does not receive a higher

price over the other. The coefficient for *SMALL* (Small Frame) cattle was as expected and significant at the five percent level of confidence. This suggests that buyers discount small frame cattle by $10 per cwt compared to medium framed cattle. This supports past research in suggesting that buyers prefer medium to large frame feeder cattle and discount small frame cattle.

Results for the flesh coefficients were as expected. Compared to cattle with medium flesh, coefficients for *LIGHT* (Light Flesh) calves received a price premium. However, the coefficient for *LIGHT* (Light Flesh) cattle was statistically different than zero at the one percent level. This reinforces previous research which suggests that light flesh cattle are expected to receive premiums. However, the *HEAVY* (Heavy Flesh) coefficient explained that heavy flesh cattle statistically had no significant impact on price relative to medium flesh calves.

The coefficient for *IMPLANTED* (Steroid Implants) was positive and significantly different than zero at the one percent level. This was contrary to what was proposed in the methodology chapter. While this parameter estimate is statistically significant, economically it appears to have no importance as it only influences the value of a calf by two to three cents per calf. This would indicate that buyers may not be concerned about previous feeder cattle steroid implants.

As expected, based on the parameter estimate, *HORNS* negatively impact basis. As indicated by the coefficient, buyers discount cattle lots with horns by $1.56 per cwt. Past research supports these findings, that buyers have an aversion to horned cattle based on safety risks and problems in feeding accessibility.

<u>Lot Characteristics</u>

The parameter estimate for *HEAD* (Number of Head) was positive and non-linear as expected. Basis increases at a decreasing rate up to 541 head and then price begins to decline with larger lot sizes. A lot size of 541 head results in a basis premium of $5.41 per cwt over a lot size of one head. In other words, if a cattle lot of 541 would expect a premium of $5.41 compared to a cattle lot with only one animal all things held constant. This relationship is illustrated graphically in Figure 4.2. This reinforces previous literature that also found lot size to be positively, but non-linearly, related to feeder cattle price.

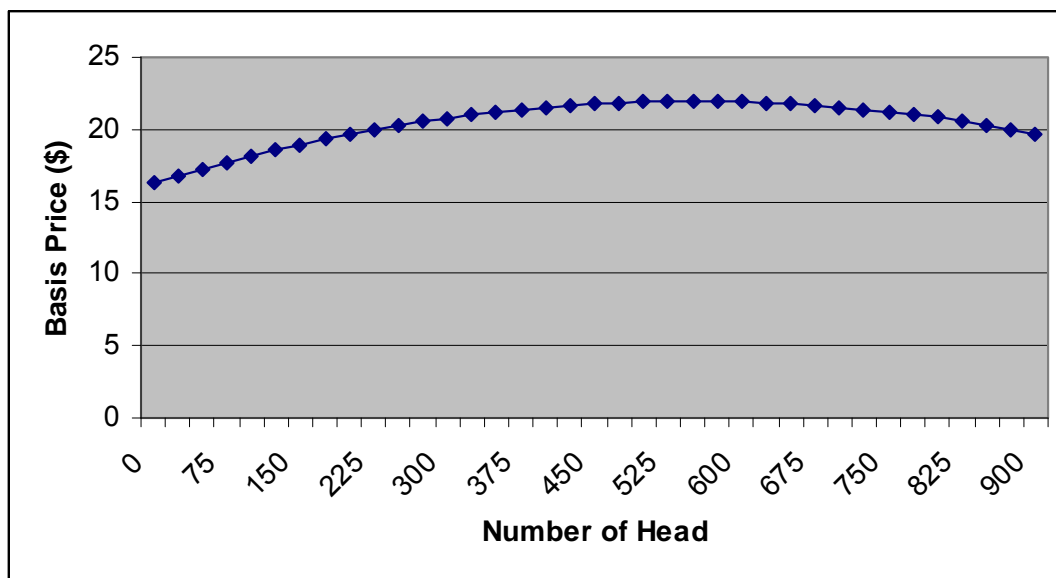**Figure 4.2 Impact of lot size on basis for 450-700 pound calves delivered in October and November, 2004-2006.**

*RANCH (*Weighing Conditions) also produced expected results. Cattle weighed at the ranch location were discounted by $.48 per cwt. Predictions for shrink were also correct, but of a smaller magnitude than would have been expected. A one percent increase in the shrink offered as a term of sale only

resulted in a basis increase of $.20 per cwt. Based on the price level for calves for this data set, an increase of more than one dollar per cwt would have been expected. This suggests that sellers would be better off if they did not offer a shrink on their calves.

Market Characteristics

The parameter estimate for *ORDER (S*ale Order) was as expected which verifies previous research. As the sale order increases, the prices will increase. The coefficient demonstrates that every time the sale order increases, the price is expected to increase by $.005 per cwt all else being constant. However, a negative *ORDERSQ* (Sale Order Squared) coefficient suggests that basis premiums are expected to eventually decrease. In other words, as buyers fill their desired demand, subsequent sale lots have lesser demand, and therefore, receive lower prices.

Results for *DAYS* (Days to Delivery) coefficient are as expected. Buyers are willing to pay premiums for cattle delivered in the future. The coefficient explains that buyers are prepared to pay $.037 per cwt for every extra day that cattle can be held before future delivery.

Another coefficient which is particularly significant to this study is *MILES* (Miles to Delivery). As predicted, the parameter estimate has a negative effect on basis and is statistically different than zero at the one percent level. The *MILES* coefficient explains that for every one mile increase, the basis is expected to be discounted by $.003/cwt. This value appears insignificant compared to freight costs which are much higher. For example, in 2006 when the average

freight rates were $3.30 per loaded mile, the total cost was $.0066 per cwt. All else being constant, this suggests that buyers are paying for at least half of the freight to haul cattle when considering deductions to price based on miles. The difference between transportation cost and the number of miles discounted is $.0036 per cwt. Perhaps, there are quality issues which are not included in the study that could explain why buyers are willing to pay for added freight, such as reputation of the sellers or a preference for cattle from certain regions. However, as mentioned in the literature review, some buyers are willing to absorb freight costs on cattle which were bought in outlying regions. Perhaps this $.0036 per cwt yet verifies that buyers undeniably absorb freight costs for cattle bought in distant locations.

FUTURES (Futures Price) was significant and had a negative impact on basis. The negative coefficient for basis demonstrates that as the futures increases by $1 the cash market will only follow by $.75 thus leaving a decrease in basis by $.25. Perhaps the explanation is that as the futures market rallies, the cash market does not share the same enthusiasm. Likewise, the cash market is less pessimistic on declining markets. In other words, for at least this data set, cash prices appear to be more stable than futures prices.

Transportation Adjusted Basis

To determine if the law of one price was upheld across regions, basis were adjusted for explicit transportation costs. First, the estimated actual cost of freight for hauling cattle per loaded mile was determined for each sale lot. Second, the loss of tissue shrink in cattle, due to effects of transporting, were

valued on a per hundred weight basis. Last, the percent shrink or "pencil shrink"

that was part of the sale terms was considered and deducted from the actual

shrink. The result of this process was a transportation adjusted basis for each

sale lot.

The data were sorted by steer and heifer, by weight categories, and by

regions within the US. The PROC GLM in SAS was used to test for difference of

means among each of these classifications. Table 4.2 contains the predicted

mean transportation adjusted basis based on gender, weight, and region, and

denotes if these means are significantly different across regions. Findings in the

difference of means were tested using t-values at a 95 percent confidence level.

The findings are categorized by gender, weight, and region. It is important

to recognize that the predicted mean basis for the categories of gender (steers

and heifers) and weight (450-499 pounds, 500-599 pounds, and 600-700

pounds) were all significantly different. This result was expected and is not

reported in any detail here. The focus of this research was to determine if basis

within weight and gender classifications were consistent across regions.

While observation of individual transportation adjusted basis for each

region is insightful, more importantly Table 4.2 demonstrates whether or not the

regions are statistically different based on a 95 percent confidence level.

Footnotes attached to each basis denote statistical differences or similarities.

Within each weight and gender category estimated basis means are to be

examined between regions. Within each column or category, basis means with

Table 4.2 Mean transportation adjusted basis by gender, weight and region.

Region	Steers			Heifers		
	450-499	500-599	600-700	450-499	500-599	600-700
West Coast	37.57_b	22.83_b	14.34_b	24.26_b	15.86_{bc}	7.76_{ab}
Intermountain West	45.12_c	32.76_c	27.85_d	30.37_c	24.19_d	21.56_d
Midwest	36.00_b	27.69_b	19.71_c	22.15_b	18.21_c	12.80_c
Southwest	26.35_a	13.98_a	4.24_a	13.37_a	4.72_a	-0.78_a
Southeast	40.21_{bc}	27.98_b	22.39_c	19.40_{ab}	11.76_b	9.61_{bc}

Means with matching subscripts in each weight and gender column signify that basis is statistically the same at a 95 percent level of confidence. The a subscript denotes the smallest mean and each successive letter is a statistically higher mean.

matching subscripts signify that basis is statistically the same. On the other

hand, subscripts that are different signify that the basis is statistically different.

In every case, in all weight and gender categories, the mean

transportation adjusted basis between all regions were not equal.

For example, for 600-700 pound steers, there are four statistically different sets

of basis. The Southwestern region bears an "$_a$" footnote which denotes that

mean basis is lower than all other regions for that weight and gender

classification. Therefore, because only the Southwest region carries an "$_a$"

subscript, estimated basis is statistically different than other regions of the US

within the category of 600-700 pound steers. Next, the West coast region

displays a "$_b$" footnote, which is not shared with any other region, signifying that

the respective basis is statistically different from all other regions. The Midwest

and Southeast regions both bear a "$_c$" footnote which explains that basis are not

statistically different between the two regions and that basis are the same. Last,

the Intermountain West region yielded the highest transportation adjusted basis

which was far larger than values from other regions. The Intermountain West region bears a "$_d$" which indicates that the transportation adjusted basis in other regions were all statistically different.

In further investigation of the findings on Table 4.2, several interesting result were revealed. General observation of the results show, that even though the basis has been adjusted for the cost of transportation, basis remain very different. The region that consistently yielded the lowest transportation adjusted basis was the Southwest region. Figure 1.1, representing the geographical location of beef cattle in the US, reveals that a large portion of the US beef cattle herd is found in this four state region. One reason for consistently low transportation adjusted basis could be simple supply and demand factors. With a large portion of the US cattle herd located in this Southwest region, particularly in Texas and Oklahoma, perhaps significant cattle supplies force prices down. However, this is not the case with the Midwestern region which also carries a large portion of the US beef cattle herd. Clearly, the two regions (Midwestern and Southwestern) are different in basis; however, they seem to carry relatively similar amounts of beef cow inventories based on the distribution of beef cattle shown in Figure 1.1. A possible explanation of variability in basis between these two regions is that of quality. As indicated in the previous section, ear and exotic cattle breeds, which are typically for the Southwest region are quite heavily discounted compared to Angus cattle. Breed and perhaps several other quality attributes, may account for the difference in basis between regions. Adjusting for these qualities may conceivably account for basis differences.

In contrast to low transportation adjusted basis in the Southwest, the Intermountain West consistently had a larger transportation adjusted basis in each of the three weight categories for both steers and heifers. This poses questions as to why basis are higher considering large distances to feedlot areas and low beef cow numbers relative to other regions. Once again, quality is perhaps the factor affecting higher basis in the Intermountain West region compared to other regions.

Originally, the Northeast region was included in the data set. However, due to the limited number of sale lots in this region, mean differences for each gender, weight, and region classifications could not be estimated. Therefore, the Northeast region was excluded and is not discussed as a separate region.

Tomek and Robinson (1990) stated that "prices in different markets do not differ by more than transfer cost." Therefore, according this definition, prices would have to be the same within particular markets in the cattle industry. However, based on the results presented on Table 4.2, the previous definition is challenged. Basis in Table 4.2 are very different, and in most cases four statistically different price levels are represented in each weight and gender category. Therefore, based on the findings presented on Table 4.2 it appears based on the data the law of one price is not substantiated. However, as John Baffes (1991) suggested, in order to fully deny the law of one price, further research must be completed. The law of one price implies that products are homogenous in nature, and as established by the White estimator displayed on Table 4.1, this is not the case with feeder cattle. Accounting for quality may

perhaps explain the variation in basis, and as a result, substantiate the law of one price.

Quality and Transportation Adjusted Basis

As mentioned previously, the law of one price is defined as prices being the same for a certain commodity through space adjusted for transfer costs. However, feeder cattle have numerous characteristics which affect the price. The results of the Hedonic regression model estimated as part of this research and previously discussed documents the differences in basis from cattle, lot, and market characteristics. Using the results of the Hedonic regression, each sale lot price was adjusted for the various characteristics. For example, if a lot of cattle had horns, then they were likely discounted in price. Therefore, to adjust to a standard quality, the parameter estimate for the horns discount was added back into this lot price. On the other hand quality characteristics that brought price premiums, such as Angus cattle, were subtracted back into this lot price. This was done for all cattle, lot, and market characteristics, except for those dealing with transportation. The transportation adjusted basis already explicitly accounts for transportation differences.

Once each sale lot price was adjusted for cattle, lot, and market characteristics, the same procedure was used to adjust for transportation differences and applied to each sale lot. The result is a quality and transportation adjusted basis (QTAB) for each sale lot. The PROC GLM in SAS was again used to determine if the mean QTAB varied by each of the gender, weight, and region classifications.

Results for QTAB price are found in Table 4.3. This table format is similar to Table 4.2 in that comparisons are made based on regional categories in both steers and heifers and weight categories of 450-499 pounds, 500-599 pounds and 600-700 pounds. Differences in weight and gender already proved to be statistically different, thus specific attention will be given to differences between regions. Statistical significance was measured using t-values at a 95 percent confidence level.

Even after adjusting basis explicitly for quality and transportation differences, basis still varied from region to region. It was anticipated that once prices were adjusted for quality, the basis would have been equal across regions. However, while the adjustments made for quality did slightly narrow the differences between the regions, basis means remained statistically disparate.

Table 4.3 Mean quality and transportation adjusted basis by gender weight and region.

Region	Steers			Heifers		
	450-499	500-599	600-700	450-499	500-599	600-700
West Coast	7.27_{bc}	3.13_b	1.88_b	-7.31_b	-5.42_b	-4.4_{ab}
Intermountain West	13.32_d	11.49_d	13.95_d	-1.89_c	1.89_c	7.14_d
Midwest	6.5_b	7.29_c	6.59_c	-8.45_b	-3.26_b	$-.17_{bc}$
Southwest	$-.55_a$	-2.84_a	-3.22_a	-13.35_a	-12.19_a	-7.46_a
Southeast	12.80_{cd}	7.43_c	15.05_d	-7.21_b	-4.66_b	3.37_{cd}

Means with matching subscripts in each weight and gender column signify that basis is statistically the same at a 95 percent level of confidence. The a subscript denotes the smallest mean and each successive letter is a statistically higher mean.

Even with quality characteristics factored into the price, mean basis in the Southwest remain the lowest in every category. This implies that cattle in the Southwest region are expected to consistently receive the lowest basis in the nation. Conversely, the Intermountain West region, in every case, yielded the highest mean basis. For the Intermountain West region, in the heavier weights, basis means were double and even triple that of other basis means from other regions. Perhaps, it is the superior quality of cattle raised in the Rocky Mountains or the developed reputation of producers in the Intermountain West. Perhaps, this corresponds with Bailey, Brorsen, and Thomsen (1995) in suggesting that cattle in more distant locations receive premiums over more nearby locations which conversely receive discounts.

Regions of the Midwest, West, and Southeast yielded results that varied by category. As the Southeast generally produced high QTAB, the Midwest and West regions generally produced lower QTAB. The West region generally retains cattle within California or, if cattle are shipped, they are shipped to feed yards eastward in Idaho. Basis in Southeast and Midwest regions may be higher and lower, respectively, based on the same conclusions as price differences in the Southwest and Intermountain West. Regions that are near feeding areas, such as the Midwest region, receive lower prices compared to distant locations such as states in the southeast.

Regardless of how high or low basis are in each region, the key objective is to determine whether they are statistically different or similar. In every category, there are at least three statistically different sets of prices. Based on

these results, the theory of the law of one price is challenged. The nature of SLA

data allows for buyers to be well informed in nearly all areas of the US feeder

cattle market. As a result, based on adjustments made for quality and

transportation, it appears that the law of one price does not hold in US feeder

cattle markets. This corresponds with past commodity research which also

concluded similar findings (Ardeni, 1989; Barrett, 2001; and Faminow and

Benson, 1990). However, John Baffes (1990) explained that additional research

must be performed in order to fully deny the law of one price. Perhaps, there are

variables that are immeasurable or are not considered in this data set. Attributes

like reputation, which can not be empirically measured, may have a profound

affect on basis. Furthermore, there may be other implicit costs to arbitrage that

are not considered here and that would therefore result in price differentials being

greater than the transfer costs measured here. Nonetheless, based on

transportation and cattle characteristics embodied in this research, it appears the

law of one price does not hold for feeder calf prices.

Chapter 5

Intermountain West Region Results

In the prior chapter, it appeared based on SLA data that the law of one

price did not hold for feeder calves across broad geographic areas. As a result,

further investigation was given toward examining the law of one price in tighter

geographic areas. Consequently, the Intermountain West region was selected

for further analysis to determine if the law of one price holds for states within this

region. This region was of particular interest because of its remarkably high

basis compared to that of other regions, and because this research is being

conducted from within that region.

Results for the Intermountain West states were calculated in the same

manner as the results for regional basis. The PROC GLM difference of means

test was again utilized to calculate the QTAB for each of the six states in the

Intermountain West. The states included in the Intermountain West region are

Colorado, Idaho, Montana, Nevada, Utah, and Wyoming (see Table 3.3).   The

mean QTAB price for each state in the Intermountain West region and for the

three weight categories (450-499 pounds, 500-599 pounds, and 600-700

pounds) for both steers and heifers are displayed in Table 5.1.

Compared to basis within different regions of the US, as illustrated on

Table 4.3, basis between states in the Intermountain West region are slightly

more similar. For example, in Table 4.3 regional basis for 600-700 pound steers

resulted in four statistically differently price sets, whereas the six states within the

Intermountain West region for the respective category resulted in only three

Table 5.1 Mean quality and transportation adjusted basis for Intermountain West states by gender, weight and state.

	Steers			Heifers		
Weight	450-499	500-599	600-700	450-499	500-599	600-700
State						
Colorado	12.05_b	4.28_a	1.66_a	-6.00_a	-7.68_a	-6.3_a
Idaho	12.68_b	8.72_b	9.25_b	-4.98_a	-5.48_{ab}	-1.97_a
Montana	19.80_c	18.29_c	24.68_c	6.93_b	8.98_d	17.38_d
Nevada	5.67_a	6.06_b	7.98_b	-3.88_a	-1.6_b	14.4_{cd}
Utah	14.52_{bc}	13.23_c	10.45_b	-4.42_a	3.78_c	5.65_{bc}
Wyoming	16.38_{bc}	8.75_b	6.84_b	-2.63_a	1.41_{bc}	-1.63_{ab}

Means with matching subscripts in each weight and gender column signify that basis is statistically the same at a 95 percent level of confidence. The a subscript denotes the smallest mean and each successive letter is a statistically higher mean.

different series of prices. Overall, QTAB consistently tend to be more statistically equivalent within the Intermountain West region compared to regional QTAB results. The closest that the Intermountain West states came to statistically having the same prices was for 450-499 pound heifers. Two different series of prices were represented with all the states having the same price except for Montana. Nevertheless, mean basis remain statistically different within the Intermountain West states. Therefore, additional analysis was conducted to better understand why QTAB were different within the Intermountain West.

From Table 5.1, it is clear that Montana consistently has the statistically highest prices in all three weight groups for both steers and heifers. This is especially interesting considering that Montana has the highest average mileage that cattle are transported from sale location to delivery destination of any state in the Intermountain West (see Table 5.2). This corresponds to the study

Table 5.2 Average mileage that calves were shipped from each state to various destinations.

Year	Colorado	Idaho	Montana	Nevada	Utah	Wyoming
2004	290	525	626	492	487	448
2005	296	532	612	588	534	463
2006	322	464	596	493	555	452
Total Average	303	512	612	527	527	454

completed by Bailey, Brorsen, and Thomsen (1995) in identifying that "Feeder cattle buyers absorb freight costs for cattle purchased in distant locations and discount purchases of nearby cattle by amounts that exceed estimated transportation costs." The reader must bear in mind that results on Table 5.1 have already been adjusted for quality and transportation. Therefore, the results in Table 5.1 support the aforementioned research that distant locations, such as Montana, enjoy price premiums despite vast distances. Supplemental to this concept are Figures 5.1 - 5.6 which demonstrate the movement of cattle from each state in the Intermountain West.

Figure 5.3 demonstrates feeder cattle sold from Montana and the percentage each purchasing state receives. As illustrated, Figure 5.3 displays that the majority of Montana feeder cattle are shipped eastward toward feedlot areas primarily in Colorado, Nebraska, and South Dakota. However, even though buyers are absorbing transportation costs for Montana cattle, Montana still receives much higher basis, often double, than those of other states being examined. This suggests that Montana enjoys premiums for feeder cattle which are dramatically higher compared to those of the other five states in the

Intermountain West. This is possibly due to an influence of reputation or other qualities not considered in this study.

In contrast to Montana's high basis are those represented by Colorado. Colorado basis are in the lowest price series in five out of six categories. Colorado has the lowest average miles of transportation per lot (303 miles). This yet again supports Bailey, Brorsen, and Thomsen (1995) who also stated "…sellers who are close to major feeding areas should be concerned that their prices are discounted more than the cost of transportation to the delivery point." Colorado is undoubtedly near cattle feeding areas as confirmed by Figure 1.2 showing geographically major cattle feeding areas. Figure 5.1 also supports this in illustrating that nearly 70 percent of Colorado feeder cattle sold either remain in Colorado or are freighted to neighboring Kansas and Nebraska. Therefore, based on past research and the results presented on Table 5.1, Colorado is suffering price discounts in contrast to states such as Montana. Even when considering that basis has been adjusted for quality and transportation, Colorado prices are still severely discounted compared to those of its neighbors in the region.

Geographically, Idaho and Nevada would seem to claim the largest amount of average miles if feeder cattle were sent to feeding areas in Colorado, Nebraska, and Kansas. However, Idaho and Nevada have different markets relative to other states in the Intermountain West.

Compared to other states in the Intermountain West region, which typically ship feeder cattle east to large feeding areas, Nevada sends nearly 40 percent of

its feeder cattle west to California as shown on Figure 5.4. The next highest percentage of feeder cattle shipped out of Nevada is destined for Texas at 11.86 percent. Nevada's top feeder cattle destinations (California and Texas) are atypical when compared to other states in the Intermountain West which by and large send cattle east. Therefore, it is not surprising that basis is significantly different in Nevada.

Likewise, Idaho also has a unique market (Figure 5.2). Even though a large majority of feeder cattle are shipped eastbound destined for feeding areas mainly in Colorado and Nebraska, Idaho retains over 25 percent within the state. Based on its ability to economically raise feeder cattle, Idaho is capable of retaining the largest portion of feeder cattle sold in Idaho itself. Perhaps with rising fuel costs, purchasers of Idaho cattle find it more economical to feed cattle within the state rather than ship them to eastern feeding areas. This reduces the average miles that cattle are shipped, and consistent with prior results, it appears that prices reflect the fact that cattle sold closer to their destination are discounted relative to cattle requiring more transportation.

Wyoming and Utah both send the majority of their feeder cattle to Nebraska, Colorado, and Kansas (See Figures 5.5 and 5.6). Table 5.1 statistically demonstrates the similarities in price between Utah and Wyoming. However, Wyoming has slightly lower basis means than those of Utah. As explained by Bailey, Brorsen, and Thomsen (1995), feeder cattle that are close to feeding areas are discounted. Therefore, due to the nearness of the Wyoming cattle market to cattle feedlots, prices tend to be discounted. This holds true for

Wyoming as well, with only 454 average miles per lot compared to Utah's 527 average miles per lot.

The objective of examining QTAB within the Intermountain West states was to distinguish if there were any differences in mean basis between the states included in the Intermountain West. As the law of one price states, prices are to be equal with only differences in transportation (Tomek and Robinson, 1990). Since it appeared, based on results obtained through SLA data, the law the one price was not substantiated across broad geographic regions, as presented in Chapter five, the intention was to discover if the law of one price is upheld within smaller specific regions. Due to the nature of SLA data, buyers and sellers are informed of market conditions in the entire Intermountain West and are able to appropriately price their livestock. However, based on the findings presented in Table 5.1, the law of one price does not seem to apply to feeder cattle markets, even within specific regions despite accurate and in-depth SLA data.

Figure 5.1 Destination of **Colorado** Sales in percentage (all values equal 100 percent) – 450-700 pound steers and heifers for October and November delivery from 2004-2006.

.05%
.05%
.78%
.1%
1.47%
.18%
.49%
.09%
14.76%
3.23%
.88% 1.5%
.1%
32.84%
21.7%
.6%
8.31%
1.08%
.2%
7.92%

?- 3.67%

Figure 5.2 Destination of **Idaho** Sales in percentage (all values equal 100 percent) – 450-700 pound steers and heifers for October and November delivery from 2004-2006.

.78%
1.15%
1.81%
25.37%
.82%
.78%
2.47%
1.32%
17.30%
.82%
2.14%
17.78%
.16% 2%
7.74%
7.29%
.99%
3.13%
4.78%

Figure 5.3 Destination of **Montana** Sales in percentage (all values equal 100 percent) – 450-700 pound steers and heifers for October and November delivery from 2004-2006.

Figure 5.4 Destination of **Nevada** Sales in percentage (all values equal 100 percent) – 450-700 pound steers and heifers for October and November delivery from 2004-2006.

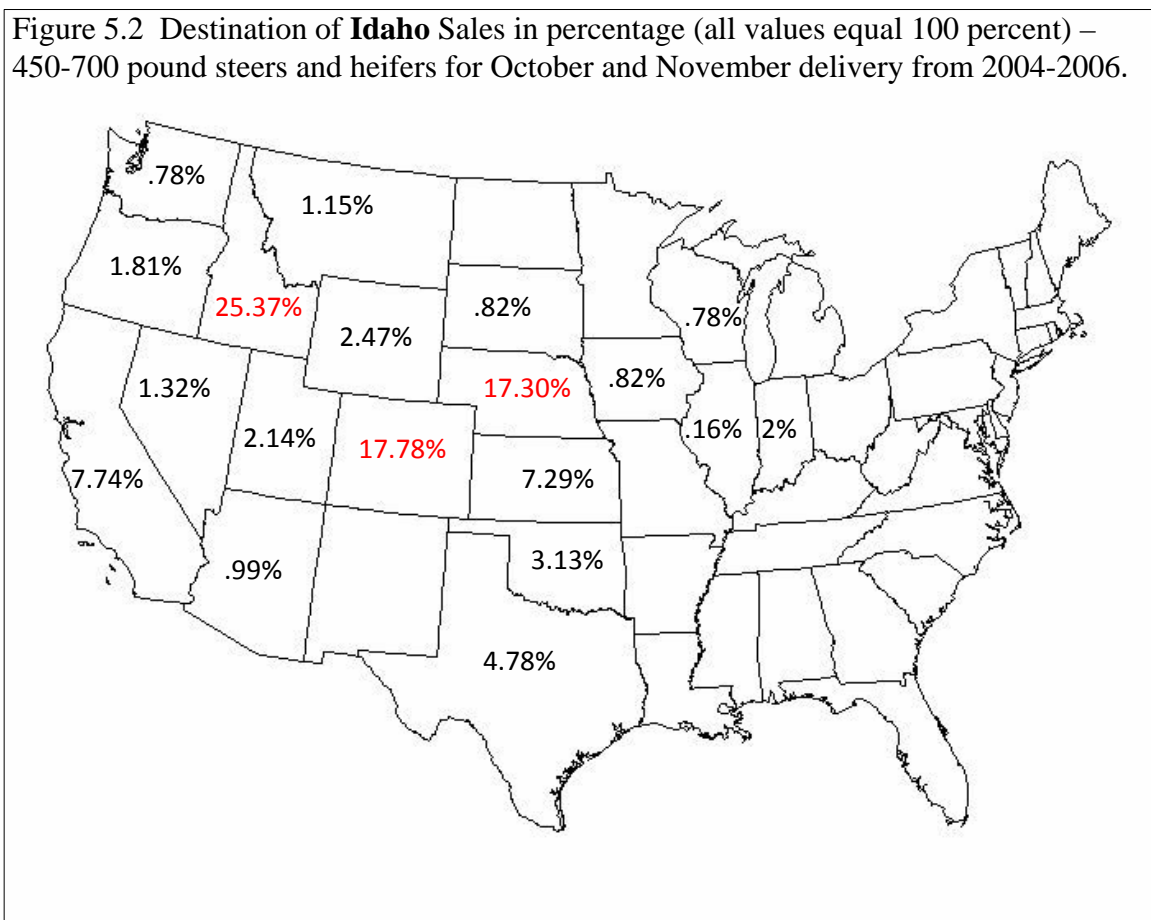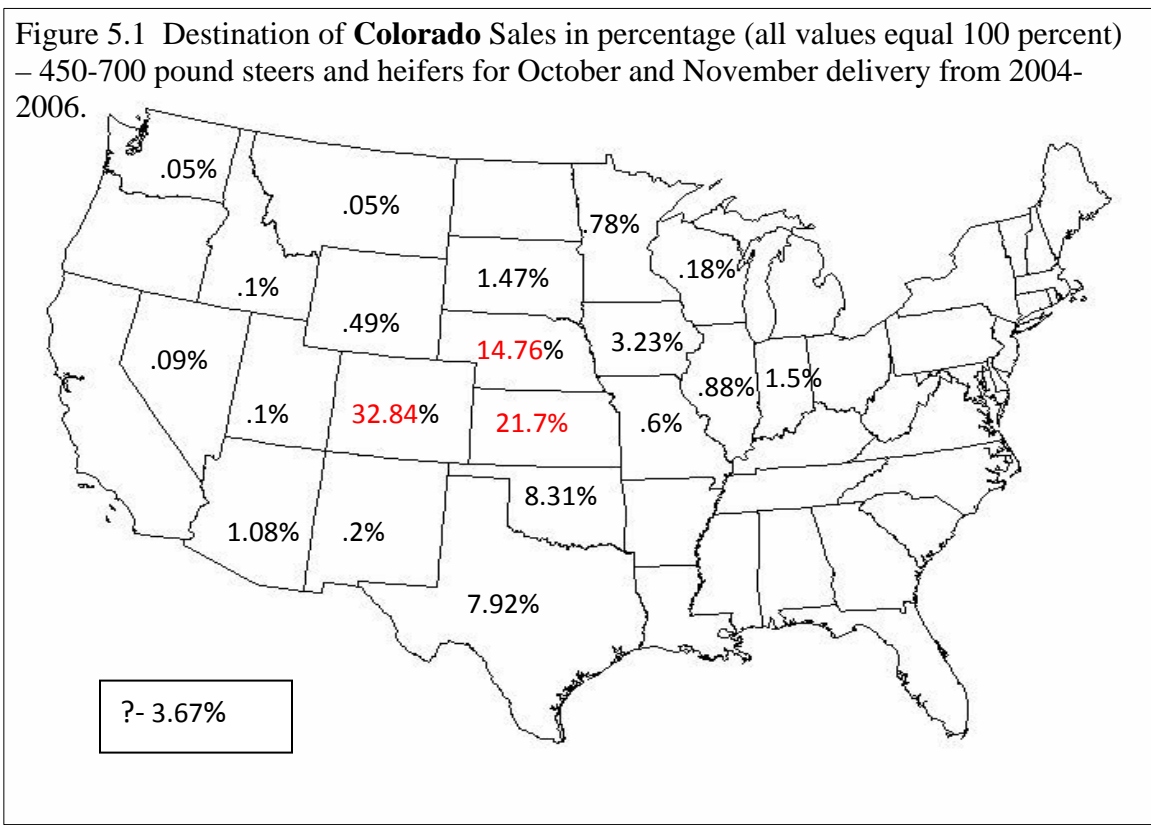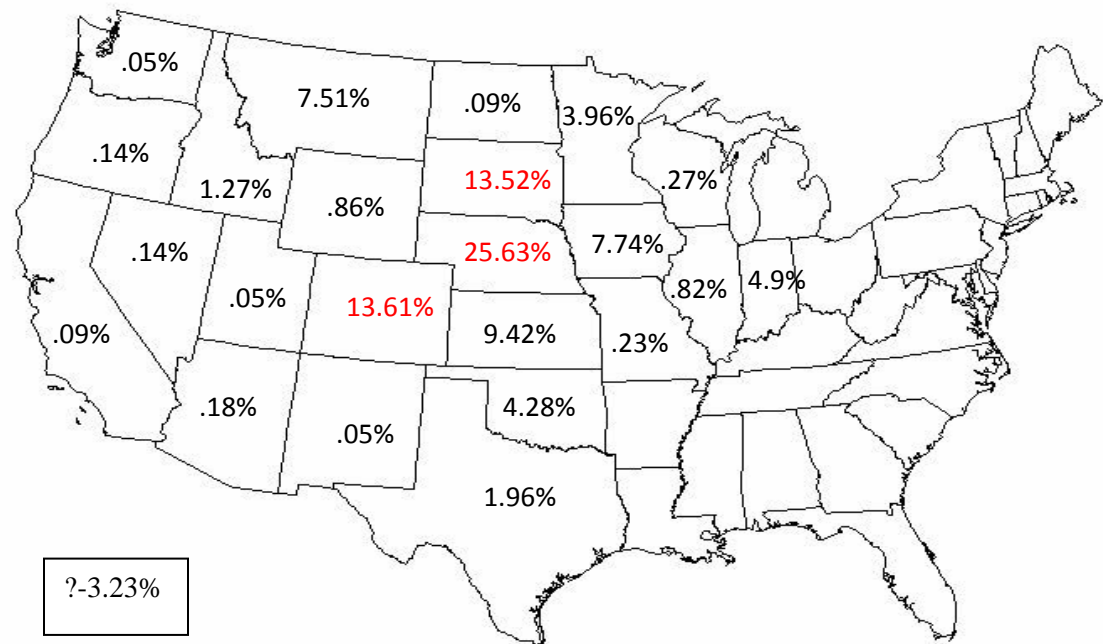Figure 5.5 Destination of **Utah** Sales in percentage (all values equal 100 percent) – 450-700 pound steers and heifers for October and November delivery from 2004-2006.

Figure 5.6 Destination of **Wyoming** Sales in percentage (all values equal 100 percent)– 450-700 pound steers and heifers for October and November delivery from 2004-2006.

Chapter 6

Conclusion

The purpose of this thesis was to examine feeder cattle prices in the US. Within the framework of this project several questions were raised in regard to the price of feeder cattle. The intent was to address these questions by examining and implementing topics such as quality price differentials, cost of transportation, and the law of one price. The process in which conclusions are made is presented in this chapter.

There are about 33 million beef cattle scattered throughout the US and every fall producers ship the calf crop from these cows to feeding areas. While beef cattle production is geographically dispersed, the feeding of beef cattle is generally concentrated in a few major cattle feeding areas. Fall feeder cattle prices differ substantially in geographically dispersed feeder cattle markets.

Tomek and Robinson (1990) stated "Agricultural markets are generally believed to follow a principle called the law of one price, which holds that prices in different markets do not differ by more than transfer costs." The main hypothesis of this thesis was that the law of one price applies to the US feeder cattle market when adjusted for transportation and quality differences. In other words, the law of one price assumes that if feeder cattle are traded between regions then prices would be equal after adjusting for transportation costs. Also, the law of one price assumes that a specific group of goods are homogenous in nature. Based on geographic and climate influences throughout the US, cattle

are very different. Consequently, prices would need to be adjusted for cattle quality differences as well as transportation costs.

In testing the hypothesis that the US feed cattle market abides by the law of one price, three specific objectives were considered: (1) Determine the value that the market places on various cattle attributes, sale lot characteristics, and market factors; (2) Determine if feeder cattle prices are equivalent across broad geographic regions in the US once they have been adjusted for transportation and quality differences; and (3) Determine if feeder cattle prices are equivalent across states within a specific geographic region of the US once they have been adjusted for transportation and quality differences.

Data

Data were obtained from Superior Livestock Auction, which is the largest video auction sale in the US. The data contained information about the quality of the cattle being sold and the location of the cattle, as well as all the relevant sales data (price, weight, delivery date and destination). The original data set was narrowed to specifically focused on 450-700 pound steers and heifers that were delivered in October and November of 2004-2006. There were over 9,500 sale lots in the resulting data set, which provided a rich set of data for this analysis.

Methods

In order to obtain the value the market places on various cattle quality, sale lot, and market characteristics for feeder cattle, SLA data was used to construct a Hedonic regression model. Basis, cash price minus futures price, for

each sale lot was the dependent variable and variables such as weight, breed, frame, number of head sold, days to delivery and futures price level were the independent variables. The sign and magnitude of each of the independent variables was of interest so that ultimately prices could be adjusted for these characteristics to compare feeder cattle prices for standardized quality characteristics in determining the validity of the law of one price.

Since the origination and destination of each sale lot was known, all sale lot prices were adjusted for the cost of transportation which consisted of freight rates and shrinkage values. Basis for these transportation adjusted prices was then compared across regions and across states within one specific region. Prices were also adjusted for quality differences based on the results of the Hedonic regression model. The basis for these transportation and quality adjusted feeder prices were then compared across regions and across states within one region. A difference of means tests using PROC GLM in SAS was used to test if basis varied by region, weight, and gender classifications for feeder cattle.

Results

Data for cattle, lot, and market characteristics were implemented in a Hedonic regression model to determine their impact on price or in this case basis. Overall, the model explained over 70 percent of the variation in basis. Most parameter estimates such as breed, sex, weight, and lot size were significant and had the expected signs. They were also consistent with past research. The parameter estimate for mileage yielded noteworthy results based

on past research which supports that buyers are willing to absorb costs for cattle in distant locations. The mileage coefficient has a negative effect on price. However, the decrease is not enough to fully account for the cost of transportation which suggests that buyers are subsidizing transportation costs.

Although the results from the Hedonic model, in and of itself, are worthy of recognition, the intent of valuing cattle, lot, and market characteristics was to adjust feeder cattle prices to determine if prices are similar when adjusted for quality.

Before adjusting prices for quality, the law of one price was first tested when adjusted for transportation costs. The first step in obtaining transportation costs was to determine the cost of freight per mile. Next, the impact of pencil and tissue shrinkage was calculated. Adjusting basis for both freight costs and shrinkage values, produced a transportation adjusted basis and allowed for testing of the law of one price. Prices were compared for feeder steers and heifers in three weight categories (450-499 pounds, 500-599 pounds, and 600-700 pounds) in six geographic regions within the US. A PROC GLM difference of means test was used to test the data. The results from the difference of means test demonstrated that even though prices had been adjusted for transit costs, prices were statistically different based on the data used. In every category, price means across regions varied significantly and, at best, represented statistically three different sets of prices. The Southwest region consistently yielded the lowest basis, whereas, the Intermountain West consistently had the highest basis for feeder cattle.

As mentioned before, the law of one price assumes that a particular category of products are identical. Genetically feeder cattle are not identical and there are management decisions that also impact the sale value. This was illustrated by the significant parameter estimates from the Hedonic regression model. Therefore, using the results from the regression model, sale prices were adjusted to a standard quality. Basis was then adjusted for both transportation and the quality. Quality and transportation adjusted basis was tested based on region, gender, and weight similar to the format presented for testing mean basis when adjusted for transportation costs.

The hypothesis was that, after prices had been adjusted for transportation and for quality differences, there would be no differences in basis levels across regions of the US. However, the empirical results did not match the hypothesis. The results from the QTAB test were very similar to the results from the transportation adjusted basis test in that prices remained statistically different. Every weight and gender category yielded at least three statistically different sets of basis across the six regions.

Therefore based on these results, even though prices were adjusted for quality differentials and transportation costs, it can not be concluded from this data set that one price exists. Scrutiny of the results show regions that were further away from major cattle feeding areas tended to have higher transportation adjusted basis; whereas, regions close to major cattle feeding areas tended to have lower transportation adjusted basis. For example, in all weight and gender categories, the Southwest region, which also has a major cattle feeding area

within its boundary, consistently yielded the lowest transportation adjusted basis, whereas the Intermountain West region, which is distant and isolated from major feeding areas, consistently had the highest transportation adjusted basis. Such large differences in QTAB between different regions of the US led to further examination.

While it appeared that different regions of the US had different feeder cattle price levels, it could be argued that only limited trade exists between these regions and that perhaps there are additional quality differentials that were not accounted for in this thesis. Feeder cattle trade does exist within regions and cattle quality is likely also more consistent. Therefore, further study of the law of one price was directed toward a particular region to examine prices within that region. The Intermountain West region was specifically examined. Interestingly, not only did the Intermountain West region consistently have the highest basis compared to other regions in the US, but that region also had the largest numbers of feeder cattle sold on Superior Livestock Auction.

Basis for feeder cattle from the six states within the Intermountain West were compared and mean differences were tested. The results from the Intermountain West QTAB price means were calculated using the same method of obtaining the results from the regional QTAB basis. The Intermountain West yielded results that did not support the law of one price. In all gender and weight categories, there were at least two statistically different sets of basis levels.

Out of the six states studied, Montana consistently yielded the highest basis. This suggests that Montana feeder cattle receive premiums that feeder

cattle in neighboring states do not receive. Paradoxically, Montana has the highest average mileage feeder cattle are shipped from point of sale to destination. This supports the study by Bailey, Brorsen, and Thomsen (1995) that "Feeder cattle buyers absorb freight costs for cattle purchased in distant locations and discount purchases of nearby cattle by amounts that exceed estimated transportation costs." Again this is supported when examining basis results from Colorado. In nearly every case, feeder cattle sold in Colorado, which has the lowest amount of average mileage from point of sale to destination, received the lowest price and had the lowest QTAB price.

Nevada also typically had a low basis. However, the market in Nevada is quite different as many of the feeder cattle in Nevada were shipped westward rather than eastward which is the trend of neighboring states. Idaho also had low basis compared to other states in the Intermountain West. Over 25 percent of feeder cattle sold in Idaho remain within the state. This is due to the Idaho's ability to economically feed cattle.

Implications

There are several implications that arise from this research. Results from both determining the value of cattle characteristics and evaluating the law of one price have implications for the US cattle industry and perhaps point to need for additional research by agricultural economists.

Data from the Hedonic model presents opportunities for cattlemen to better understand and take advantage of recent trends in the value of various quality characteristics. By presenting the results from the Hedonic model to the

public, cattle producers may be informed about price premiums and discounts they may receive from any of the quality characteristics examined in this thesis. Possibly, by using the information generated from the Hedonic model cattlemen may be directed in the business decisions that they make. For example, a producer may discover that a certain breed receives a premium over another breed. That cattleman may chose to alter the breed of his herd to capture this premium. However, this is subjective. There are numerous variables to consider that may alter any expected premiums. Nonetheless, consideration of the results from the Hedonic model may provide a framework for cattle producers and researchers alike to identify new trends in markets and have ability to change if needed.

Based on the results presented in this thesis, it is concluded that prices offered for feeder cattle and the resulting basis differ by more than transportation costs and quality characteristics. Is this a violation of the law of one price? As has been previously mentioned, there may be other costs to arbitrage in the feeder cattle market that effectively increase the transfer costs that are not considered here. Furthermore, the Hedonic regression model explained 70% of the variation in basis, but there is still another 30% of basis variation that is not explained by the model. Perhaps, capturing this additional variability would in fact narrow the differences in the basis from different market areas.

Yet another implication is the effect location has on price. As suggested by past research (Bailey, Brorsen, and Thomsen, 1995) and the results in this thesis, cattle producers in distant locations from major cattle feeding areas are

receiving a price for their calves that is higher than is justified by the quality of cattle and the actual transportation costs. Conversely, feeder cattle producers in locations that are closer to major cattle feeding areas are receiving a price that is lower than is justified based on the quality of the cattle and the actual transportation costs. This may not present any arbitrage opportunities but rather it is simply a case where cow-calf producers in one area are effectively subsidizing cow-calf producers in another area. For example, actual prices for calves of the same weight and quality are lower in Utah than in Colorado, but when those prices are adjusted for transportation, the Utah prices are higher.

For economists, what are the ramifications to the efficiency of markets if the law of one price is not valid in a market? How wide spread is the phenomenon of more distant producers being subsidized by more local producers to a central market? Investigating these questions could provide direction for future research in this area.

Limitations

Despite the superiority of SLA as being the largest video auction in the US, there are several alternative methods in which the majority of cattle are sold. For example, cattle can be sold through local auctions or direct sales. Therefore, much data is not included as SLA data only provides video auction data and is only representative of a small percentage of cattle sold in the US.

Additionally, there are many other qualities and attributes in valuing cattle that are not measurable or plainly not considered such as the impact of other commodities or perhaps the reputation of the seller or a particular region.

Another potential limitation to this study was that transportations cost were assumed constant across all regions of the US. Fuel costs do vary and it is likely that trucking rates do also vary over geographically dispersed market areas.

Chapter 7

Self Reflection

The process of writing this thesis has been very different from what I anticipated. Originally, the intention was to forecast prices for feeder cattle for the benefit of cattle producers, and to be able to more efficiently market cattle. However, as the project unfolded, other opportunities and options led to investigating feeder cattle price differences. Next, decisions had to be made as to which direction the project would take, the structure that would be needed in order to convey those ideas that would be most beneficial, and what key points were to be addressed. Superior Livestock Auction offered a plethora of information that could be used in countless ways. Surprisingly, instead of helping, this information made it more difficult to determine what information and objectives needed to be fulfilled. I discovered that there is a great deal of work that goes unused, which was all part of the process of developing the overall direction of the thesis. Nevertheless, through the directions of helpful instructors, objectives were established, the data were honed, and efforts could be focused.

There were several topics which were interesting to me. First, in valuing cattle characteristics, I was able to see how the market values the quality characteristics of cattle and how the market has changed over time when compared to past research. This section in and of itself is very beneficial to both cattle buyers and sellers. Next, I was shocked to discover that the law of one price is not upheld in the feeder cattle market. Having been personally involved with the cattle market, I have always been curious why cattle prices are always

different depending on the location. Now, through this thesis I have a better understanding of why there are variations in prices.

Through this thesis I was able to examine topics that I would have otherwise never even considered. Due to my background in the cattle industry, this is knowledge that I greatly appreciate.

It is my sincere hope that information from this project will assist cattlemen to better understand the market, and as a result, be more successful.

References

Ardeni, G.P. (1989) Does the law of one price really hold for commodity prices? *American Journal of Agricultural Economics*. 71 (3), 661-669.

Agriculture Marketing Service - United States Department of Agriculture (2008) *Grain and livestock auctions* [online]. Available from: http://www.ams.usda.gov [Date accessed: 12. 1. 08]

Baffes, J. (1991) Some further evidence on the law of one price: The law of one prices still holds. *American Journal of Agricultural Economics*. 73 (4), 1264-1273.

Bailey, D., Brorsen, W.B., and Fawson, C. (1993) Buyer concentration at feeder cattle auctions*. Review of Agricultural Economics*. 15 (1), 103-119.

Bailey, D., Brorsen, W.B., and Thomsen, M.R. (1995) Identifying buyer market areas and the impact of buyer concentration in feeder cattle markets using mapping and spatial Statistics. *American Agricultural Economics Association.* 77,309-318.

Bailey, D., Brorsen, W.B., and Thomsen, M.R. (1997) Mapping market areas using nonparametric smoothing.

Bailey, D. and Peterson, M.C. (1991) A comparison of pricing structures at video and traditional cattle auctions. *Western journal of agricultural economics*. 16 (2), 392-403.

Bailey, D., Peterson, M.C. and Brorsen, B.W. (1991) A comparison of video cattle auction and regional market prices. A*merican journal of agricultural economics*. 73 (2), 465-475.

Barrett, C.B. (2001) Measuring integration and efficiency in international agricultural markets. *Review of agricultural economics*. 23 (1), 19-23.

Brazle, F.K., Grunewald, O., Mintert, J.R., and Schroeder, T.C. (1988) Factors affecting auction prices of feeder cattle. *Cooperative Extension Service*, Kansas State University, Manhattan. C-697.

Brownson, R. (1986) Shrinkage in beef cattle. *Michigan State University Cooperative Extension*. Service Bulletin E-1632.

Buccola, S. T. (1980) An approach to the analysis of feeder cattle price differentials. *American Agricultural Economics Association*. 62 (1), 574-580.

Eastern Oklahoma. *Oklahoma Agriculture Experiment Station*. Fact Sheet. E-955 Oklahoma State, Stillwater, OK.

Falkner, T. (1998) Shrink management in cattle. *K-State Research and Extension, Veterinary Medicine*. 1 (1), 1.

Faminow, M.D. and Benson, B.L. (1990) Integration of spatial markets. *American Journal of Agricultural Economics*. 72 (1), 49-62.

Faminow, M.D. and Gum, R.L. (1986) Feeder cattle price differentials in Arizona auction markets. *Western Journal of Agricultural Economics*. 11 (2), 156-163.

Feuz, D. (2008) Conversation about technology in the cattle industry.

Goodwin, B.K. and Schroeder, T.C. (1991) Cointegration tests and spatial price linkages in regional cattle markets. *American journal of agricultural economics*. 73 (2), 452-464.

Green, W.H. (2003) *NLOGIT 3.0, Econometric Software.*

Harris Brothers Trucking. (2007 Dec 17) Conversation with Zan Zickgraf about average freight rates for hauling cattle.

Harris, W. (2008 Dec 29) Conversation about cattle quality characteristics with professional cattleman.

Lancaster, K. (1924-1999) Professor of economics, Columbia University. Lancasterian demand theory.

McNew, K. and Fackler, P.L. (1997) Testing market equilibrium: Is cointegration informative? *Journal of Agricultural and Resource Economics*. 22 (2), 191-205.

North Dakota State University, (2006) *Sex, lot, size, color still lead auction value* [online]. Available from: http://americancowman.com/health/sex-size-color-auction-value [Date accessed: 12. 1. 08]

Owens, F. N., Dubeski, P. and Hanson, C.F. (1993) Factors that alter the growth and development of ruminants. *Journal of animal science*. 71 (11), 3138-3150.

Parcell, J. L., Schroeder, T.C. and Hiner, F. D. (1995) Determinants of cow-calf pair prices. *Western Journal of Agricultural Economics*. 20 (2), 328-340.

Pendell, D. L. and Schroeder, T.C. (2006) Impact of mandatory price reporting on fed cattle market integration. *Journal of agriculture and resource economics*. 31 (3), 568-579.

Smith, S. C., Gill, D. R., Bess III, C., Carter, B., Gardner, B., Prawl, Z., Stoval, T., and Wagner, J. (2000) *Effect of selected characteristics on the sale price of feeder cattle in eastern Oklahoma: 1997 & 1999* Summary [online]. Available from: http://www.ansi.okstate.edu/research/2000rr/index.htm. [Date accessed: 28. 11. 07]

Schroeder, T.C. and Goodwin, B.K. (1990) Regional red cattle price dynamics. *Western journal of agricultural economics*. 15 (1), 111-122.

Schroeder, T.C., Mintert, J., Brazle, F., and Grunewald, O. (1988) Factors affecting feeder cattle price differentials. *Western journal of agricultural economics*. 13 (1), 71-81.

Superior Livestock Auction (2006 Nov 27) Obtained data through electronic and catalog sources.

Tomek, W. and Robinson, K. (1990) *Agricultural product prices*. 3rd ed. Cornell University Press.

Turner, S.C., Dykes N.S., and Mckissick, J. (1993) Feeder cattle price differentials in Georgia teleauctions. *Southern journal of agricultural economics*. 23 (2), 75-84.

Utah Agricultural Statistics. (2007) Utah department of agriculture and food annual report [online]. Available From: http://www.nass.usda.gov/Statistics_by_State/Utah/Publications/Annual_Statistical_Bulletin/AB07.asp. [Date accessed: 16. 11. 07]

Ward, C. and Lalman D. L. (2003) *Price premiums from a certified feeder calf preconditioning program.* Paper presented in NCR-134 2003 Conference, St. Louis, Missouri.

Ward, C., Mintert, J.R., Schroeder, T.C., and Peel, D.S. (1997). Fed cattle price discovery issues and projections. *Oklahoma Cooperative Extension Service*. AGEC-550

Williams, C., L., Langeneir, M.R., Mintert, J.R., and Schroeder, T.C. (1991) Profitability differences between steers and heifers. *Beef Cattle Handbook* [online]. Available from: http://www.iowabeefcenter.org/pdfs/bch/08054.pdf. [Date accessed: 13. 1. 08]