

EVALUATION OF BASIS LEVELS AS CONTRACTS APPROACH MATURITY IN  
THE UNITED STATES LIVE CATTLE FUTURES MARKETS

By

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by

Christian J. Salnars Polanco

This thesis is dedicated to my parents Andy and Lilian, to my sister Stephanie, and to the love of my life María Elena, thanks for your support.

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Abstract of Thesis Presented to the Graduate School  
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Over the past decades, the live cattle and beef industries have experienced structural changes which have had an effect on prices of cattle. An increasingly volatile live cattle market has led many producers to use hedging in the futures markets as a risk management tool to protect themselves against adverse price change. Understanding and being able to accurately predict basis levels is a key for successful hedging. There are many factors that influence cash and futures prices, making it harder to forecast basis levels. Among other factors, this study explores the effects that captive supply procurement methods and market liquidity may have had on basis levels over the time period ranging from 1992 through 2001. A constant period from maturity model (CPM) divides the pooled live cattle futures contracts for the time period being evaluated, and separates them into different periods from contract maturity. This allows for the identification of the influence of factors being evaluated over different periods from contract expiration. The use of captive supplies by meatpackers had a negative effect on

basis levels for nearby contracts, while cattle on feed inventories had a positive effect on basis levels for the nearby contracts, and a negative effect for contracts further away from maturity. The results also suggest that market liquidity in the live cattle futures markets has no significant effect on basis levels. The final results provide policy makers with information that can be used to improve the efficiency of the live cattle futures markets.

## CHAPTER 1 INTRODUCTION

### **Purpose of This Study**

Important structural changes experienced by both the cattle industry and the meatpacking industry in recent decades, and the implications these changes have had on live cattle prices have become increasing causes of concern to many cattle producers throughout the United States (Ward, 2001). According to the United States General Accounting Office (GAO) (2002), structural changes such as increased concentration in the meatpacking industry, different cattle procurement methods, and large decreases in cattle inventories, have had adverse effects on live cattle prices.

As in many other sectors of the agricultural industry, live cattle producers use hedging as a risk management tool. Lawrence (2000) argues that despite educational meetings that are constantly held to further inform cattle producers on how these markets work and how they can be used to manage risk, relatively few producers use this tool. In spite of this, risk management is gaining importance and popularity in the live cattle industry, and as producers better understand the futures markets, more producers are able to benefit from it as a marketing tool.

The key for success in risk management using the futures market is to understand and be able to forecast basis levels. As mentioned earlier, structural changes in the industry have had effects on prices (Ward, 2001), making price and basis forecasting different from the past for cattle producers.

This study focuses on evaluating basis in the live cattle futures markets as contracts approach maturity. The main purpose is to determine the most important factors influencing basis levels over the past decade. This will therefore contribute to a better understanding of live cattle basis.

As Ward (2001) suggests, market structure is of great importance in price determination, and it is an influencing factor for basis levels. Two important characteristics of market structure in the meatpacking industry are that it is highly concentrated, and that captive supply procurement methods are being widely used by the largest meatpackers in the industry.

### **Problematic Situation**

Futures markets are diverse and complex markets that can be affected by a variety of factors. The live cattle industry in the United States is one of the many industries that utilize futures markets as a risk management tool. In order to manage risk, hedgers use futures contracts to eliminate or reduce general price risk by accepting the more predictable risk associated with changes in the relationship between cash and futures prices (basis risk). Prices of live cattle futures contracts, as well as prices in the cash market for live cattle are therefore very important in this process of risk management for hedgers.

The inability to accurately predict basis levels can result in higher risk associated with marketing decisions, for both producers and packers. Given the importance of basis levels, the ability to forecast and understand basis levels for risk management is crucial for hedgers. Studies of this nature are particularly important in markets such as live cattle in which a non-storable commodity is being traded, and many external and internal factors to the industry can affect prices.

Examining historical basis levels, along with good information and common sense has been the way to forecast basis levels in the past. But, as Purcell (2002b) says, today “there are some who suggest that normal relationships between cash and futures markets no longer exist,” making it harder to formulate price expectations. Factors such as rumors about Foot-and-Mouth Disease (FMD) and Bovine Spongiform Encephalopathy (BSE), fluctuations in the demand for beef, droughts, and other factors beyond the control of the industry have made the cattle markets even more volatile. This situation has made basis trends and behavior more complex and difficult to forecast, and the ability to understand them even harder.

Even though some of the factors that alter basis levels cannot be measured or controlled, there are factors that can to some extent be measured or controlled. These factors are worth studying in order to improve the understanding of basis levels, trends, and relationships for more effective risk management.

There is a positive correlation between trading volume and price variability in the futures markets. Traders can profit from predicting price variation in the markets, and in today’s markets where a single trader can exert market power, the question can be raised: could there be unfair trading practices happening in the live cattle futures markets providing only certain traders with profit opportunities?

Samuelson’s (1965) hypothesis, indicates that there is increased price volatility as contracts reach maturity in the futures markets. The live cattle futures prices have been consistent with this theory, but there are reasons to suspect that increased volatility levels in cattle prices have had a tendency to become larger over the years.

Some other aspects of the industry that can interfere with cattle prices are some of the methods being used for cattle procurement. Captive supply procurement methods have become more common in the industry, and the effects these have had on basis levels are not easily understood. Some authors like Parcell et al. (1997) argue that because the agreements made for these types of procurement are not public information, packers may have more information on current and future demand and supply than producers.

Although there is no hard evidence, there are those who suggest that the high degree of concentration in the meat packing industry is applying pressure towards lower prices of live cattle. This trend towards higher concentration has been present for the last 20 years. In addition, the use of captive supply procurement methods and the share of captive supply procurement methods being used in the industry by the largest meat packers have been increasing.

Theory indicates that as the future becomes the present and prices become more sensitive to available information, basis levels for the nearby futures should approach zero. This is of importance to hedgers who constantly forecast basis levels. It is therefore important to evaluate basis in the live cattle futures market and determine if basis is behaving according to what theory dictates.

### **Researchable Problem**

Several questions can be raised regarding the situation in the live cattle futures market and basis levels. This study focuses on attempting to answer several questions that contribute to some extent towards a better understanding of live cattle prices and basis levels, and their behavior in this ever-changing industry that is the live cattle industry.

The most important questions addressed in this study are the following:

- To what degree does a widening basis exist as live cattle future contracts approach maturity?
- To what degree has price volatility of live cattle futures contracts approaching maturity increased over the years?
- What role does market liquidity have on basis levels?
- What role do captive supplies by meatpackers have on basis levels?

### **Objectives**

The overall objective of this study is to contribute to a better understanding of basis levels and their behavior in the United States live cattle futures market. The following sub-objectives will be accomplished in order to achieve the overall objective:

- Relate basis levels to market liquidity in the live cattle futures market.
- Explore the effect of captive supply on live cattle basis levels.
- Provide policy makers with information that can be used to improve the efficiency of the live cattle futures market.

### **Hypotheses**

Several hypotheses will be tested during the course of this analysis. These hypotheses include:

1. After adjusting for transaction and transportation costs, basis levels are not approaching zero as live cattle future contracts approach maturity.
2. Widening basis levels are related to market liquidity as futures contracts approach maturity.
3. Captive supply methods of cattle procurement by meat packing firms have had a negative effect on live cattle basis levels, i.e., more use of captive supply results in wider basis level.

## CHAPTER 2 THE LIVE CATTLE INDUSTRY

### **Introduction**

Live cattle are cattle that have been produced for beef production and are ready for slaughter. Live cattle have to meet specific features such as weight requirements, quality, breed, and yield grades of the animals. Cattle with a predominance of dairy breeding or cattle that show a prominent hump on the forepart of the body do not fit under the category of live cattle.

As R-CALF USA (2002) indicates, the live cattle industry has been one of the largest sectors in U.S. agriculture for over 40 years. Being such a substantial part of American agriculture, the live cattle industry is not only of importance to the country's rural sector, but also to its economy as a whole. As one can imagine, the live cattle industry and the beef industry are strongly linked. Consumer demand for beef influences demand for cattle.

Being the largest beef producer in the world (GAO, 2002), the U.S. cattle industry's deteriorating economic condition over the past decade is of great concern to many. According to a report presented on October 2002 at the Business Forum of the Free Trade Area of the Americas Agreement in Quito, Ecuador by R-CALF United Stockgrowers of America (R-CALF USA)<sup>1</sup> (2002), the U.S.'s cattle feeders and cow/calf producers have incurred substantial losses over the past 10 years. As a result of these

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<sup>1</sup> R-CALF USA is a national, non-profit cattle association representing over 6700 independent cow/calf producers, stockers, and feeders in 42 states, along with 42 state and local United States cattle and farm association affiliates.

continuous losses, a decline in cattle inventories has been experienced since 1996, currently having the lowest inventories since 1960 (USDA, 2002b).

In January 2003, the USDA National Agricultural Statistics Service (NASS) (2003a) reported that since 1990, beef cow operations in the U.S. have declined by approximately 135,000 operations, with the most notable decline occurring in the time period extending from 1996 through 2001. The cyclical nature of this industry has been responsible for many expansions and contractions of cattle and calf inventories over time, but as reported by VanSickle and Prevatt (2000), cattle producers are currently experiencing one of the toughest cattle cycles in the history of the U.S. Despite this being one of the toughest cattle cycles recorded in many years, this ongoing crisis being suffered by the U.S. cattle industry cannot be explained entirely by the historical cattle cycles, according to R-CALF USA (2002).

Threats to the industry such as diseases like Bovine Spongiform Encephalopathy (BSE) and Foot-and-Mouth Disease (FMD) have given a large blow to the cattle industry in the recent past, making prices somewhat less predictable. As a result of an aggressive surveillance program by the U.S. Department of Agriculture (USDA), BSE has never been found in the U.S. (USDA, 2003b) and there has not been an outbreak of FMD in this country since 1929 (PL107-9 Federal Inter-agency Working Group, 2003). But, in spite of the industry's success in preventing such diseases, the industry has suffered from a case of BSE reported in Canada in May 2003, the large BSE outbreak suffered by Great Britain in recent years, the fact that FMD has occurred in most countries around the world, and many other occurrences of similar magnitude that have happened around the

world. These examples provide an insight into the vulnerability of the industry towards expectations, and how rumors and misleading information can influence cattle prices.

### **Cattle Demand and Supply**

On a report to the Honorable Tom Daschle of the U.S. Senate, the U.S. General Accounting Office (GAO) (2002) reports that the beliefs of a panel of 40 experts are that domestic demand and supply are the fundamental forces driving cattle prices and producers' incomes. Because demand and supply are such important determinants of prices for most agricultural commodities, including live cattle, it is relevant to include an overview of the demand and supply for cattle.

#### **Demand**

Demand for cattle is strongly linked to demand for beef. As consumer demand for beef rises or falls, so does the demand for cattle. U.S. demand for beef, which has had problems over the past 25 years, is of great importance to cattle producers. Purcell (2002a) provides an overview of the demand for beef and how it has evolved over time. Compared to the growing demand for marbled beef and the accustomed tendency toward family meals that dominated the 1960's, the U.S. consumer became more health conscious and less interested in spending time preparing meals in the late 1970's. Despite the changing consumer needs and wants, there was reluctance by the industry to change product offerings. Per capita consumption of beef declined considerably in the late 1970's and 1980's. A transition from large firms being low cost operations to becoming food product merchandisers with quality assured branded product lines was witnessed in the 1990's. In the years 1999, 2000 and 2001, beef demand witnessed its first real improvement in about 20 years (Alabama Cooperative Extension System, 2002). Billions of dollars have been invested by the industry to counter some of the negative

factors determining consumer demand. Some of the measures taken by the industry have been to improve consumer perceptions about beef's contribution to a healthy diet, to decrease health concerns tied to food safety, and to introduce numerous convenience oriented beef products. Despite the improvement in consumer demand for beef and the improvements in the live cattle industry in recent years, the future performance of the industry is still uncertain.

### **Supply**

Supply of cattle is largely determined by whether cattle producers are making profits. Existing trends in the industry such as the decreasing number of operations also affect supply. A report by the Alabama Cooperative Extension System (2002) indicates that the number of cattle operations in the United States has declined approximately 44 percent since 1975. As a consequence, the average size of cattle operations has increased. Supply of cattle also depends on a variety of other factors. According to GAO (2002), the most important factors that affect cattle supply are the cattle cycle, feed and other input costs, cattle quality, expected prices, futures prices, and technological changes in production, among others. The cattle cycle is best described by VanSickle and Prevatt (2000) as the pattern of expansion and contraction in the inventory of cattle and calves over time. These changes in inventory affect cattle prices as well as supply. Due to the long biological cycle of cattle, producers have to make financial commitments and decisions on supply quantities many months before they sell their product, making expected prices very important for cattle producers.

### **Captive Supply Procurement Methods**

A spot market is where transactions such as buying and selling of commodities for immediate delivery and immediate cash payment take place. Although there are

numerous factors that play a role in characterizing spot markets, the simplest approach to understanding the concept is that current delivery and current payments take place.

Historically, as with many other commodities, spot markets have been used for purchases and sales of cattle. Many of the sales made in these spot markets are cattle ready for immediate delivery, and are paid for at a spot market price. An example of spot price would be the price paid for a steer ready for delivery on a particular day in the Oklahoma City spot market. Spot prices at different spot markets throughout the country will vary depending on numerous factors such as geographic location, and transportation costs (among others).

Due in part to structural changes in the cattle and beef industry such as a decrease in the number of feeder operations, increased packer concentration, vertical integration in the industry, improved communication networks, and other similar changes, cattle procurement today involves purchases directly from feedlots, which requires closer links between packers and feedlots. This has given birth to what are known as captive supplies. Procuring cattle by the way of captive supplies has become more prevalent in the industry. Captive supplies are defined by the USDA (2002a) as “livestock that is owned or fed by a packer more than 14 days prior to slaughter, livestock that is procured by a packer through a contract or marketing agreement that has been in place for more than 14 days, or livestock that is otherwise committed to a packer more than 14 days prior to slaughter.” Some of the most visible impacts of captive supplies are that they benefit packers by ensuring a given supply of cattle, and that they reduce market information since fewer prices are reported publicly. Although the spot market remains the predominant procurement method (Ward, 2001), captive supplies are being widely

used today by meatpackers throughout the country, especially by plants with larger plant capacity. According to the USDA's Grain Inspection, Packers and Stockyard Administration (GIPSA) (1996), the three largest packers accounted for 88 percent of the marketing agreements and 95 percent of the forward contract transactions in the industry in 1996. Smaller firms perform most of the packer fed procurement forms of captive supply while the three largest packers are less active in this procurement method.

### **Forward Contracts**

Forward contracts consist of base prices set for cattle that will be delivered in the future as agreed by the seller and the packer. This price is typically set using a formula based on information such as publicly reported prices, or in other cases futures prices. Premiums and discounts are applied for differences in cattle quality. When futures prices are used to set base prices, the forward contracts are commonly referred to as basis contracts. Agreements on factors such as month of delivery, quality standards, specific cattle to be delivered, and price basis are reached between the packers and feedlots when using this procurement method (USDA, 2002a).

### **Marketing Agreements**

The agreement to purchase cattle at a prearranged schedule with the price to be determined at or after the time of slaughter is called a marketing agreement. Prices are often determined by a formula based on prices paid by the packer for other cattle slaughtered at the plant, or on publicly reported prices. As with the forward contracts, premiums and discounts are applied for differences in cattle quality. Marketing agreements usually include minimum and maximum numbers of head to be delivered per unit of time, delivery specifications, auditing practices, and pricing method (USDA, 2002a).

### **Packer Fed Cattle**

Cattle fed by a packer, or a company owned or operated by a packer is called packer fed cattle. Cattle fed through partnerships, joint ventures and other feeding agreements that vertically integrate packers and feedlots are also considered packer fed cattle (USDA, 2002a).

### **Incentives to Use Captive Supply Agreements**

Several arguments could be raised regarding potential incentives as to why meat packers and cattle producers may want to enter into captive supply arrangements. Ward (2001) best summarizes these potential incentives in table (1) below.

Table 1. Summary of Potential Incentives to Enter into Captive Supply Agreements

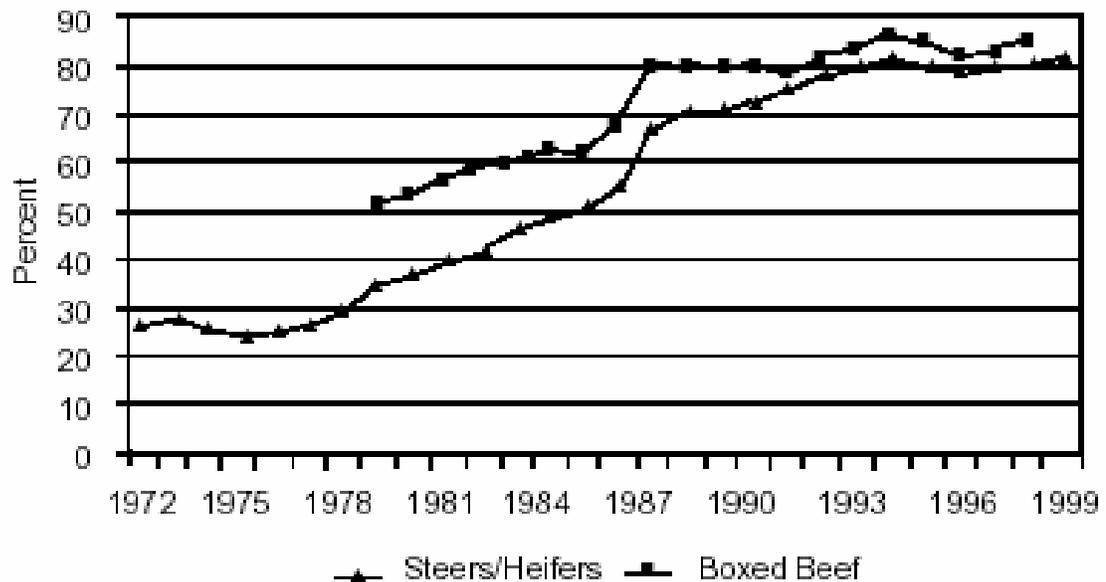
Method of Captive Supply	Cattle Feeder Benefits	Meatpacker Benefits
<u>Forward Contracts</u>	1. Reduce price risk if cattle are hedged or flat priced 2. Obtain favorable financing 3. Ensure a buyer for cattle 4. Reduce marketing cost	1. Secure slaughter needs 2. Source quality supply 3. Reduce procurement costs 4. Reduce price risk
<u>Marketing Agreements</u>	1. Premiums for some cattle quality characteristics 2. Obtain carcass information 3. Ensure a buyer for cattle 4. Reduce marketing costs	1. Increase cattle/beef quality control 2. Secure slaughter needs 3. Reduce procurement costs
<u>Packer Fed Cattle</u>	1. Increase feedlot utilization 2. Improve packer to feedlot relationship	1. Secure slaughter needs 2. Increase cattle/beef quality control

Source: OSU Extension Facts, WF-554.

### **Concentration in the Meat Packing Industry**

An issue that has become a cause of concern to many in the industry over the past two decades is the increased market concentration in the meatpacking industry (Ward, 2001). Market concentration is a measure of total sales or purchases of the largest firms

in a specific market or industry. Ward (2001) demonstrates that in 1998, the four largest meatpacking firms accounted for an estimated 80.4 percent of total steer and heifer slaughter. Figure (1) below demonstrates how market concentration in the industry more than doubled in as little as fifteen years in the time period from 1975 through 1990. This increase in concentration is considered by many cattle producers to be causing a decrease in cattle prices because fewer meatpacking firms are competing for cattle.



Source: OSU Extension Facts, WF-554.

Figure 1. Combined Market Share of the Four Largest Firms

In spite of these recent concerns, as USDA's Technical Article No. 1874 (1999) indicates, market power has been an issue of concern among livestock producers since the early 1900's, when the packing industry was dominated by five firms known as the Big Five. In 1920, the Packer Consent Decree emerged from a Federal Trade Commission investigation conducted as a result of suspected anticompetitive practices by

the Big Five. Shortly thereafter, the share of slaughter performed by the largest firms declined. This decline was a result of the Decree, as well as improved communications, movement of livestock production farther west, and growth of retail chains, among other factors. By 1956 the market share of the four largest firms had declined to 30 percent. In the 1960's, what is known as the boxed beef revolution began, and in the early 1970's cattle slaughter had increased to record levels. In spite of this, cattle slaughtered dropped dramatically in the late 1970's, which gave birth to what is known by some as merger mania in the beef packing industry. Many of the large firms merged with other firms, and bought and built new plants (USDA, 1999). The evolution of the industry has not slowed. Today, three firms dominate the industry in numbers of steers and heifers slaughtered.

## CHAPTER 3 THE FUTURES MARKETS

### **Introduction**

Futures markets can be traced all the way back to the ancient Greek and Roman markets and to the early Japanese rice markets during the Tokugawa era. The modern futures markets however, began in the early 1800's when extremely volatile prices in the agricultural sector were causing chaos in the grain markets of the U.S. In 1848, the Chicago Board of Trade (CBOT) was developed and became the first formal commodities exchange. Many futures markets exist today in the U.S. and around the world where traders participate daily, and these markets have become an important piece of the world's economy.

### **Overview**

Futures markets are organized exchanges of derivative markets where many buyers and sellers meet to trade futures contracts on an ever-expanding list of commodities. As Purcell (1999b) defines it, "a commodity futures contract is nothing more than a legal instrument calling for the holder of that contract to either deliver or accept delivery of a commodity on or by some future date." A futures contract is an example of a derivative, as defined by McDonald (2003), i.e., "simply a financial instrument that has a value determined by the price of something else."

### **Cash vs. Futures Prices**

Understanding cash price behavior plays a critical role in managing price risk. Cash prices are those at which buyers and sellers are willing to trade a particular

commodity at a particular time at a given location. Futures prices on the other hand, are somewhat more complex. They represent trader's expectations about the future value of a commodity at a particular point in time in the future, which has a degree of uncertainty associated with it. Both cash and futures prices generally move together and react to continuous changes in supply and demand factors (Leuthold, 1989).

There are two very important characteristics of the futures markets that must be present in order for effective hedging to take place. First, the direction in which cash prices and futures prices move over time must generally be the same. That is, if the futures prices go up (down), cash prices also tend to go up (down) (Wellman, 1999). And secondly, during the month of maturity of a contract, the price of that futures contract and the price in the cash market should converge or come reasonably close together for commodities meeting the quality standards specified in the futures contract (Leuthold, 1989).

### **Basis**

The futures price (F) on a particular day minus the local cash price (P) in that same day is called the basis (B), i.e.:

$$B = F - P \quad (1)$$

Unless specified differently, the contract nearest to expiration is used to calculate basis. To be consistent with the theoretical model presented in chapter 5, the definition of basis represented by equation (1) above is being used in this study. It is important to note that there is inconsistency in the literature regarding the definition of basis. Most traders and many authors define basis as cash price minus futures price, while others define it as stated in this study. The difference is reflected in the sign of the basis.

Predicting basis levels is critical for risk management. According to Wellman (1999), understanding the basis and being able to forecast the basis is the bottom line of hedging. Numerous factors such as product quality, transportation, location, insurance, time, storage, and delivery method (or some combination of these factors) can all affect basis levels. Since these factors are not the same in the cash market and in the futures market, typically futures prices will be different from the cash prices, making the basis different from zero.

### **Price Volatility**

Many studies have been made regarding price volatility in the futures markets. Samuelson (1965) demonstrated theoretically that “the conditional variance of changes in futures prices should increase as date of maturity approaches,” meaning that volatility in futures prices increases as maturity nears. Many studies performed in the past concur with Samuelson’s theory, and it has been well accepted for many years. Reasons for this behavior are that as time to maturity of a futures contract nears, sensitivity to the information available which influences price levels increases, and large uncertainties are resolved during those final periods of life of the contract (Wellman, 1999).

### **Market Liquidity**

Market liquidity is a weighing of the volume of futures contracts traded by the absolute change in the open interest. Although the live cattle futures markets may not be as liquid as other non-agricultural commodities, given the structure of the cattle industry, market liquidity is an important measure of performance in these markets in terms of any excess costs to entry or exit that could possibly arise out of a thin market.

## **Role of Futures Markets**

There are two main aspects of the futures markets that are considered to be their most important roles. They facilitate risk management and contribute to price discovery.

### **Risk Management**

Futures markets exist primarily for providing an efficient and effective mechanism for the management of price risk. Producers participate in these markets as hedgers for the primary purpose of establishing a price level for a commodity they will either buy or sell at a later point in time in the cash market. Hedgers attempt to protect themselves against volatile prices by opening a futures market position opposite to a position they hold in the cash market. In other words, a hedger can open a position in the futures market by selling a futures contract, and at the end of the feeding period of the cattle he (she) can sell cattle in the cash market, and also offset his (her) position in the futures market by buying a futures contract. Speculators on the other hand buy and sell contracts hoping to profit from anticipated price changes in the markets, helping to provide liquidity, add stability, and assume some degree of risk in the markets.

Cattle producers are vulnerable to risk in the production process, as well as price risk in the market. Today, price risk is the largest risk faced by producers, which creates uncertainties about profits and future performance. These and many other types of uncertainties about the industry lead many producers to use risk management techniques such as hedging in the futures markets and options on futures to reduce risk in their operations. This study focuses primarily on the futures markets, where basis levels are extremely important in developing price expectations.

An example of hedging in the futures market is a cattle feeder who hedges against a price fall in cattle prices, or on the other hand, a meat packer who hedges against a rise in cattle prices. In a nutshell, what futures markets do is allocate risk.

### **Price Discovery**

Price discovery is the second most important role of the futures markets. Futures prices change as buyers' and sellers' judgments about what a commodity will be worth at a particular point in time change. These judgments are subject to supply and demand developments, and the availability of current information when these judgments are made. This process of judgment reassessment and price adapting is called price discovery, which is a continuous process.

### **Futures Markets as a Risk Management Tool**

Price risk faced by producers depends on the level of competition and the demand and supply for the product. The price risk faced by producers includes risk associated with changes in the general level of prices of a particular commodity (general price risk), and risk associated with changes in the relationship between cash and futures prices (basis risk). Hedgers can eliminate the general price risk through hedging, leaving basis risk as the only remaining price risk. Because livestock markets deal with a non-storable commodity, the basis risk in livestock markets is not always less than the general price risk (Leuthold, 1989). This illustrates the importance of good basis studies for helping hedgers managing risk.

The easiest way for hedgers to estimate basis is to examine historic basis levels in terms of their fluctuations, patterns, and relationship between the size of the basis and the price of the cattle. The more a hedger understands about basis patterns, the better he or she will be at managing risk.

After hedging and eliminating the general price risk, vulnerability to basis risk still exists. If the live cattle markets become more volatile near the date of maturity as hypothesized, then it is also true that it becomes increasingly difficult to manage basis risk. This is because the understanding and proper forecasting of basis levels is crucial to the process of managing basis risk.

## **Live Cattle Futures Markets**

### **The Chicago Mercantile Exchange**

Founded initially as the Chicago Butter and Egg Board in 1898, what is now the Chicago Mercantile Exchange (CME) has evolved to be the largest futures exchange in the United States. On November 30, 1964 the first live cattle contract began trading at the CME, becoming the first futures contract based on a non-storable commodity. Live cattle is also considered by some to fall in the category of semi-storable commodity. Today, the only futures markets in North America to offer cattle futures contracts are the CME and the Mid-American Commodity Exchange.

### **Live Cattle Contract Specifications**

Live cattle futures contracts have undergone significant change since they first began trading in 1964. They have evolved to become useful in risk management programs. The most recent significant change to the live cattle futures contract specifications took place with the June 1995 contract, when among other modifications, it switched from 100% choice to 55% choice. Today, live cattle contracts traded at the CME have the specifications shown in table 2 below.

Table 2. Live Cattle Contract Specifications

Ticker Symbol	LC
Trading Unit (underlying)	40,000 pounds of 55% choice, 45% select USDA grade live steers between 1100-1300 pounds
Quotations	Cents per pound
Minimum Price Fluctuation (Tick)	0.025 cents per pound or \$10.00 per contract
Contract Months	Feb, Apr, Jun, Aug, Oct, Dec

Source: Chicago Mercantile Exchange, July 2003.

## CHAPTER 4 REVIEW OF PAST BASIS RELATED STUDIES

### **Introduction**

This chapter presents a review of past basis related studies. It includes reviews of studies related to basis in the futures markets in general, as well as reviews of studies related to basis in the live cattle futures markets specifically. All the previous live cattle basis related studies reviewed for this study highlight the important role basis predictions play in making important decisions related to pricing, hedging, and forward contracting.

### **Effects of Captive Supply on Basis**

The need for optimizing plant efficiency by meatpackers who want to operate plants at full capacity, along with other incentives has created an increase in the use of captive supply procurement methods in the industry. The effects of this increased use of captive supply on prices are still widely debated.

Parcell et al. (1997) suggest that the number of captive supply cattle relative to total cattle marketing did have a negative effect on basis, widening it statistically and significantly in two out of the four states included in their study.

Ward (2000) concluded that packer concentration and captive supplies have had an effect on cattle prices. There is evidence that negative price impacts from increased packer concentration have been present in general, but they are small. There is also evidence that larger plants use captive supplies strategically and that these methods have had a small negative impact on prices in general.

**Time to Maturity Effect**

Samuelson's time to maturity effect predicts a rise in the volatility of futures prices as maturity nears when large amounts of uncertainty are resolved. Madarassy (2002) presents evidence on the maturity effects from eleven financial futures markets. Her results suggest that maturity may have an effect in some financial markets like the currency futures and interest rate futures, as well as it can have a small effect or no effect in other markets such as the equity indices.

Milonas' (1986) presented evidence that supports the time to maturity effect for ten out of eleven commodities. Out of the eleven commodities studied, eight were agricultural commodities and three were interest rate futures. The agricultural commodities presented stronger evidence of the maturity effect than the interest rate futures. This is consistent with Galloway and Kolb's (1996) results from which they found evidence of the time to maturity effect on agricultural commodities.

This study compares futures contracts at different periods from maturity, with particular attention given to the final month of life in the contracts, where the time to maturity effect is expected to be most present.

## CHAPTER 5 BASIS

### **Introduction**

In the futures market the term basis is very important because it describes price relationships between cash and futures prices. These relationships can be quite different when referring to non-storable goods, compared to storable or semi-storable goods due to the different set of conditions that surround the markets for these goods. Leuthold et al (1989) notes the following significant contrast between storable and non-storable goods: net cost of storage guides price relationships and inventory of storable goods, whereas varying production decisions are the main influence on price relationships for non-storable goods. Despite these differences, there are some characteristics that hold for both. These characteristics will be addressed later in this chapter.

The basis in the live cattle market is dictated mainly by supply and demand of live cattle and trader expectations about the future (Wellman, 1999). Supply and demand dictate the cash price, while trader expectations about the future dictate the futures price. Hence, the basis varies according to how much traders believe the cash price will change as maturity of a futures contract approaches.

### **Important Considerations of Basis in Risk Management**

The key to executing successful risk management using the futures market is to understand and develop the ability to forecast basis levels. The idea behind this risk management technique is to first eliminate general price risk, and then manage the remaining basis risk to minimize its potential impact on returns. Location is a significant

consideration that hedgers must have knowledge about when forecasting basis levels. Transportation and transaction costs may differ between two different locations; therefore the basis will also differ. Trade patterns among different locations and associated costs of transportation determine differences in cash prices among different market locations. Due to the relatively stable and predictable patterns of trade and transfer costs from one year to the other, basis levels also tend to be stable and predictable from year to year. This does not imply that significant variations in basis do not occur. Thus, it is important for a hedger to determine the local basis to manage risk.

Quality of the product and time of delivery are two other very important considerations that need to be taken into account when calculating basis. The cash market prices used must be those of products with the same or very similar quality attributes specified in the futures market contract. Prices used should also reflect the point in time at which delivery of the physical product will or should be made, i.e., the date of expiration of the futures contract.

### **Behavior of Basis as Contract Maturity Approaches**

There is an interesting characteristic that holds for basis levels in the markets for non-storable goods as well as for storable and semi-storable goods as contracts approach maturity. The price of the futures contract and the price in the cash market at futures market delivery points for product meeting the quality standards specified in the futures contract should gradually come close together by a fairly predictable amount as the delivery date approaches, regardless of whether the basis is positive or negative.

This converging of cash and futures prices, or narrowing of the basis, is caused by several factors. First, as maturity of a contract approaches there is an increase in the amount of information available and uncertainties about the future that cause futures and

cash prices to differ become fewer. Still, having fewer uncertainties about the future does not necessarily cause futures prices to equal cash prices. Second, if basis is not near zero at contract maturity, speculators may arbitrage between cash and futures prices, making some profits and forcing the prices to merge. For example, in a scenario where futures prices are higher than cash market prices, profits could be made by buying the commodity in the cash market, selling it in the futures market and then making delivery of the commodity. On the other hand, in a scenario where the futures price is lower than the cash market price, profits could be made by buying in the futures market, accepting delivery, and then selling the commodity in the cash market.

However, for most cattle producers it is not feasible to arbitrage due to the non-storable nature of the commodity. Cattle for slaughter have to be ready for slaughter in a futures contract delivery period in order to be delivered. According to Wellman (1999), slaughter cattle have approximately ten to fourteen days when they can be merchandized at the proper weights and grades.

### **Basis Theory**

A cattle producer who is feeding cattle for later sale basically has two alternatives. The first alternative is to make a contracted sale of his production to a particular buyer at a future point in time at a predetermined price. The second alternative is to sell at a later date, when the cattle are ready for slaughter, but at an uncertain price. If the producer chooses the second alternative, he then has the option of either hedging in the futures market, or not hedging in the futures markets. Stein (1966) suggests that in order for the producer to maximize his expected utility, he should allocate his stocks between hedged and un-hedged holdings.

Stein's future equilibrium model illustrates theoretically how equilibrium in the futures market and the stocks (storage) market is reached. This chapter provides an explanation of this model, which is the theoretical base for this study.

### Stein's Future Equilibrium Model

Theoretically, according to Stein's (1966) future equilibrium model, in order for market equilibrium to exist, the demand for stocks should be equal to the amount of stocks in existence (refer to equation (2) below), and the supply of futures contracts should be equal to the demand for futures contracts (refer to equation (3) below).

$$\overbrace{H(P^* - F^* + B - M, K) + U(P^* - P - M, L)}^{\text{Stocks demanded}} = \overbrace{X(P, A, Z) + S_{-1}}^{\text{Stocks in existence}} \quad (2)$$

$$\overbrace{H(P^* - F^* + B - M, K)}^{\text{Supply of contracts}} = \overbrace{G(F' - F)}^{\text{Demand for contracts}}, \quad (3)$$

where:

- H = Amount of stocks that are hedged
- U = Amount of stocks that are un-hedged
- X = Excess storage
- S<sub>-1</sub> = Stock inventories from previous period
- B = Basis
- P\* = Expected cash market price
- P = Current cash market price
- F\* = Expected futures market price
- M = Costs of storage (assumed constant)
- $X(P, A, Z) = S(P, Z) - D(P, A)$
- K = Factors influencing H
- L = Factors influencing U
- A = Factors influencing demand
- Z = Factors influencing supply
- F' = Price that speculators think will prevail in the futures market
- F = Actual Price in the futures market.

In order to relate this theoretical model to the live cattle industry and put it in the context of the study being performed, the argument could be made that  $Z$  is a function of the number of cattle slaughtered, the inventory of cattle on feed, and the extent to which captive supply is being used, among other things that could influence the supply of cattle; and  $K$  is a function of the time left to contract maturity, the liquidity of the market, the futures market price volatility, and the cash market price volatility, among other things that could influence the supply of future contracts; and  $L$  is a function of the extent to which captive supply is being used in the industry, among other things that would make producers hold un-hedged stocks.

$$\frac{\partial H(P^* - F^* + B - M, K)}{\partial (P^* - F^* + B - M, K)} = H' \geq 0$$

$$\frac{\partial U(P^* - P - M, L)}{\partial (P^* - P - M, L)} = U' \geq 0$$

$$\frac{\partial X}{\partial P} = X_P \geq 0$$

$$\frac{\partial X}{\partial A} = X_A \leq 0$$

$$\frac{\partial X}{\partial Z} = X_Z \geq 0$$

Differentiating equation (2) with respect to cash market price ( $P$ ), and solving for

$\frac{\partial B}{\partial P}$  yields equation (4).

$$H' \frac{\partial B}{\partial P} + U' \frac{\partial (-P)}{\partial P} = X_P$$

$$H' \frac{\partial B}{\partial P} - U' = X_P$$

$$\frac{\partial B}{\partial P} = \frac{X_p + U'}{H'} > 0 \quad (4)$$

Equation (4) above represents the change in basis level as a result of changes in cash market prices. From this we can derive the SS curve in figure 2 below, all along which the pair of B and P makes demand and supply of stocks equal.

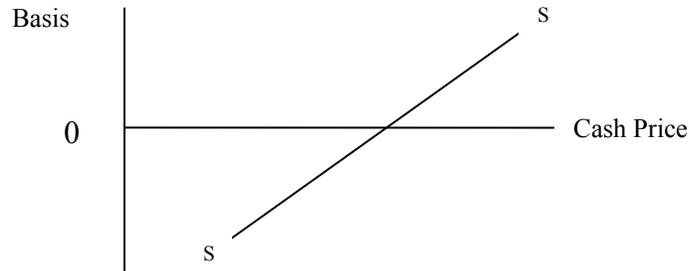


Figure 2. Equilibrium Market for Stocks

Stein (1966) expresses the logic of the SS curve in literary terms as follows: Given price expectations, a higher cash price (P) will increase the quantity of stocks in existence by increasing production and decreasing consumption. The basis (B) must then change to cause an increase in the quantity that people want to hold. By increasing utility of holding hedged stocks, B must also rise to equilibrate the supply and demand for stocks, i.e., equation (4) holds.

Inserting P-P into the right hand side of equation (3), and substituting B for F-P, and differentiating with respect to cash market price (P), and solving for  $\frac{\partial B}{\partial P}$  yields equation (5).

$$H(P^* - F^* + B - M, K) = G(F' - F)$$

$$H(P^* - F^* + B - M, K) = G(F' - F + P - P)$$

$$H(P^* - F^* + B - M, K) = G(F' - B - P)$$

$$H(B - B^* - M, K) = G(F' - B - P)$$

$$H' \frac{\partial B}{\partial P} = G' - G' \frac{\partial B}{\partial P}$$

$$\frac{\partial B}{\partial P} = \frac{(-G')}{H' + G'} < 0 \quad (5)$$

Equation (5) above represents the change in basis level as a result of a change in cash market prices. From this we can derive the FF curve in figure 3 below, all along which the pair of B and P makes demand and supply of futures contracts equal.

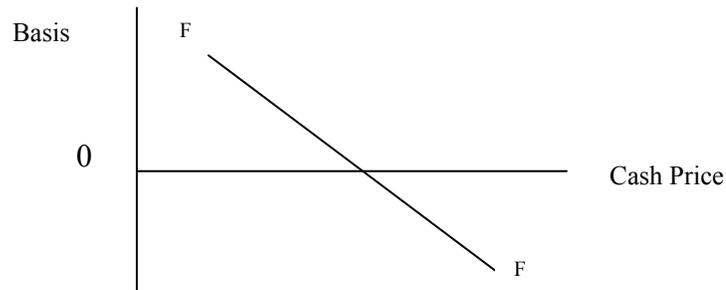


Figure 3. Equilibrium Market for Futures Contracts

In a similar way as the explanation provided for the SS curve earlier, the logic of the FF curve is explained by Stein (1966) in literary terms: assume a rise in cash price (P), but the futures price (F) rises by the same amount. The rise in futures prices will decrease the demand for future contracts by speculators, but the supply of future contracts will remain unchanged. The excess supply of futures contracts will then lower F, which in turn causes a decline in basis (B), i.e., equation (5) holds.

Equilibrium in the market is reached when supply and demand for stocks are equal, and the supply and demand for futures contracts are equal. This equilibrium is present in point  $(P_o, B_o)$  in figure 4 below.

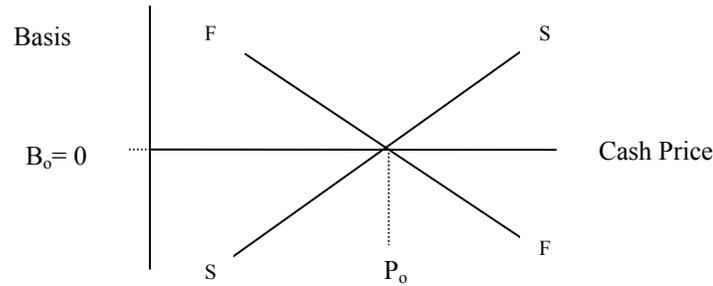


Figure 4. Stein's Futures Equilibrium

Factors such as  $M, K, L, A, Z$  addressed in equations (2) and (3), and expectations about the future will cause the  $SS$  and the  $FF$  curves to shift or rotate. The independent variables included in this study are those that could cause these changes to occur in the live cattle industry. Detailed in chapter 6 are the variables included in this study, along with an explanation as to why they were included.

Stein's futures equilibrium model is applicable to both storable and semi-storable commodities. Although it is a little less flexible when referring to semi-storable commodities rather than storable commodities, the theory still holds.

## CHAPTER 6 METHODOLOGY

### Introduction

Based on Stein's theoretical future equilibrium model presented in chapter 5, the model used in this study captures the effects that the independent variables may have on basis levels. The constant period from maturity (CPM) model allows evaluating basis levels and the effects of the independent variables at different periods from contract maturity. The independent variables included in this study capture the factors that could cause basis levels to change over time. These variables and the data collected for the study are explained in detail in this chapter.

### Constant Period from Maturity (CPM) Model

As mentioned earlier, basis ( $B_t$ ) is a function of a variety of independent variables that affect both cash market prices and futures market prices, that is:

$$B_t = f(ML_t, FV_t, CSP_t, CSL_t, COFI_t, CSCH_t, CM_{jt}, DDE_{ijt})$$

where:

- $B_t$  =  $F_t - P_t$
- $i$  = Constant period from maturity ( $i=1, 2, 3$ )
- $t$  = Time period
- $F_t$  = Futures price
- $P_t$  = Cash market price
- $ML_t$  = Market liquidity  $\left( \frac{TV}{|\Delta OI| + 1} \right)$
- $FV_t$  = Futures price volatility
- $PV_t$  = Cash price volatility
- $CSL_t$  = Weekly total cattle slaughter
- $COFI_t$  = Monthly cattle on feed inventories
- $CSP_t$  = Monthly captive supplies

$CSCH_t$  = Change in LC contract specifications  
 (0= before June 1995, 1= after June 1995)  
 $CM_{jt}$  = Dummy variable for contract maturity  
 { $j$ = [Dec. is the base (i.e., 6)], 1, 2, 3, 4, 5}  
 $DDE_{ijt}$  = Time period to expiration  
 { $i$ = 1, 2, 3}  
 { $j$ = [final 5 days of period is the base (i.e., 6)], 1, 2, 3, 4, 5}  
 $TV_t$  = Total volume of live cattle contracts traded  
 $OI_t$  = Open interest

A more detailed explanation of all these variables is provided in the following section.

Basis was calculated across contracts reflecting a constant period from maturity (CPM). CPM models were calculated for contracts 30 days or less from maturity (CPM<sub>1</sub>), contracts from 60 to 31 days away from maturity (CPM<sub>2</sub>), and contracts 90 to 61 days away from maturity (CPM<sub>3</sub>). The three basis models estimated using ordinary least squares (OLS) regression are presented in equation (6).

$$\begin{aligned}
 B_{it} = & \beta_0 + \beta_1 ML_t + \beta_2 FV_t + \beta_3 CSP_t + \beta_4 CSL_t \\
 & + \beta_5 COFI_t + \beta_6 CSCH_t + \sum_{j=1}^5 \delta_j CM_{jt} + \sum_{j=1}^5 \alpha_j DDE_{ijt} + u_t
 \end{aligned} \tag{6}$$

This set of OLS regressions was intended to evaluate basis levels, and identify the extent to which different factors could be influencing basis levels, in particular the use of captive supply by the industry and the market liquidity of the markets as contract maturity approaches.

The TSP Version 4.4 Software was used to perform some of the econometric procedures for this study. It was used to estimate the three OLS regressions, the standardized beta coefficients, and the descriptive statistics.

## Selection of Variables

### Dependent Variable

In this model, the dependent variable evaluated was basis. The simplest approach was used in this study towards computing the basis. Basis ( $B_t$ ) was referred to as the closing futures price ( $F_t$ ) minus the cash market price ( $P_t$ ) as shown in equation (1) of chapter 3.

### Independent Variables

Based on the theory presented in chapter 5 and on past basis related studies presented in chapter 4, a series of independent variables that could influence basis levels were included in the model.

Part of the main objective of this study is to measure the effects that increasing use of captive supply may have on basis levels and price discovery. Therefore one of the independent variables most relevant to this study is that of captive supply ( $CSP_t$ ) use by the beef packing industry.

To account for effects that supply of cattle may have on basis levels, the independent variables of total cattle slaughter ( $CSL_t$ ) and cattle on feed inventories ( $COFI_t$ ) were included in the model.

The independent variables representing captive supply and cattle on feed inventories are reported by USDA (2003c) are on a monthly basis, and the same value is assumed for every day of the month. The independent variable representing cattle slaughter is reported by USDA (2003c) on weekly basis and the same weekly number was assumed for every day of the week.

Market liquidity ( $ML_t$ ) was included to measure the performance of the markets in terms of excess costs of entry or exit that may arise due to a thin market. Market

liquidity is a weighting of the total volume of contracts traded ( $TV_t$ ) by the absolute change in the open interest ( $OI_t$ ).<sup>1</sup>

Futures price volatility ( $FV_t$ ) was included to measure the effect volatility may have on basis as contracts approach maturity. Price volatility is defined in this study later in this chapter.

Modifications were made to the live cattle futures contract, and began with the June 1995 contract. The main modification was the switch from 100% choice to 55% choice, among other changes. A control variable was included to account for the modifications in the live cattle futures contract ( $CSCH_t$ ) where the variable was set to zero before the modifications and to one after the modifications.

Seasonality was accounted for with a set of dummy variables representing the months in which live cattle contracts expire (contract maturity). That is,  $CM_{jt}$  represents the separate contract maturity months, where  $j$  goes from 1 to 6 (1 = February, 2 = April, 3 = June, 4 = August, 5 = October and 6 = December). The month of December was chosen as a base.

Another set of dummy variables was created to account for the effect that proximity to maturity may have on the basis levels. The dummy variables  $DDE_{ijt}$  represent 5 day intervals within the 30 day periods being evaluated, where  $i$  goes from 1 to 3 and represents the CPM period, and  $j$  goes from 1 to 6 (1 for 0 to 4 days, 2 for 5 to 10 days, 3 for 11 to 15 days, 4 for 16 to 20 days, 5 for 21 to 25 days, and 6 for 26 to 30 days to the end of the CPM period, respectively).  $DDE_{i6j}$  was chosen as a base.

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<sup>1</sup>  $ML=TV/(|\Delta OI|+1)$  The +1 is included in order to eliminate the problem that arose when change in open interest was 0 from one day to the other.

## **Data Requirements**

The complexity and dynamic nature of the futures markets, the many factors that can affect futures prices, and the limited availability of data make studies such as this seem somewhat complex. A variety of data collections were made in order to create a model that considers aspects such as supply, demand and some structural change in the industry to explain basis levels in the live cattle futures markets.

The data relevant for this analysis is of historical nature, and includes data from the years 1992 through 2002. The data were obtained from the Chicago Mercantile Exchange (CME) and the U.S. Department of Agriculture (USDA). The data involving futures markets came from Barchart.com<sup>2</sup>, whose source is the CME. The data regarding factors affecting demand and supply came from USDA (2003c).

### **Futures Market Data Requirements**

Daily close live cattle futures prices for the CME and daily cash market prices from Oklahoma City were used in order to calculate the basis levels for each day of trading during the last six months of trading for each contract. Although cash market prices vary from one location to another, Oklahoma City was chosen as a representation market for cattle cash prices in general due to its geographical location and size.

Total volume of live cattle contracts traded and open interest for each day of trading were collected in order to calculate market liquidity in the market.

### **Cash Market Data Requirements**

To consider the effect that supply of cattle has on live cattle prices and basis levels, the monthly cattle on feed inventories for the 1000 plus capacity feedlots in seven states

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<sup>2</sup> Market Research, Inc. (Barchart.com) has an Internet website that supplies commodity traders with historical charts and data, among other services.

(AZ, CA, CO, IA, KS, NE, TX), and weekly total cattle slaughter federally inspected in the United States over the period of time being evaluated were included in the model. Monthly and weekly values respectively were included rather than daily values due to lack of availability of daily values.

Monthly captive supply (packer fed, forward contract, marketing agreement steer and heifer slaughter as a percentage of total steer and heifer slaughter for the 4 largest packers) was included in the model to measure the effect these procurement methods by the highly concentrated beef industry have had on basis levels. Again, monthly values were used rather than daily due to the lack of availability of daily values.

## CHAPTER 7 RESULTS AND DISCUSSION

### **Introduction**

This Chapter presents and discusses the results obtained from the CPM model along with a series of tables that aid in the interpretation of the results. The parameter estimates are presented in this chapter, together with a series of discussions regarding the effects of captive supply, market liquidity, and other relevant variables on basis levels.

### **Constant Period from Maturity Model**

As indicated earlier, a regression involving the same independent variables was estimated for basis at three different periods from maturity. The TSP Version 4.4 Software was used to estimate the CPM models described earlier in chapter 6, using an ordinary least squares (OLS) regression procedure.

### **The Estimated Model**

R-squared estimates for the OLS regressions were 0.337, 0.363, and 0.377 for the CPM<sub>1</sub>, CPM<sub>2</sub>, and CPM<sub>3</sub> models, respectively. Mentioned throughout this study, is the fact that basis levels are influenced by a great variety of factors, indicating that studies of this nature usually fail to capture all the factors influencing basis.

Table 3 presents the parameters estimated in the model. Side-by-side are the parameter estimates for CPM<sub>1</sub>, CPM<sub>2</sub> and CPM<sub>3</sub>, along with their respective t-values. At simple glance, table 3 indicates that some of the variables included in the model are more significant during the final 30 trading days than in the other time periods included, i.e., more significant during CPM<sub>1</sub> than during CPM<sub>2</sub> or CPM<sub>3</sub>

Table 3. Estimated Parameters for Factors Influencing Basis in the Live Cattle Futures Market

Variable	CPM <sub>1</sub>		CPM <sub>2</sub>		CPM <sub>3</sub>	
	Parameter Estimate	t-value	Parameter Estimate	t-value	Parameter Estimate	t-value
Intercept	172.410	2.659*	36.859	0.289	-761.501	-4.887*
Market liquidity (ML <sub>t</sub> )	3.11E-05	0.015	-3.78E-03	-0.906	6.69E-03	1.007
Futures Volatility (FV <sub>t</sub> )	1021.740	2.297**	1912.080	2.373**	406.356	0.266
Captive Supply (CSP <sub>t</sub> )	2.425	4.832*	0.792	0.786	-2.244	-1.605
Cattle Slaughter (CSL <sub>t</sub> )	-0.017	-0.218	0.216	1.569	0.720	4.064*
Cattle on Feed (COFI <sub>t</sub> )	-0.035	-5.737*	-0.029	-2.295**	0.055	3.277*
Contract Changes (CSCH <sub>t</sub> )	111.823	12.167*	158.205	8.589*	141.883	5.979*
<u>Seasonality:</u>						
CM February	58.678	5.627*	-3.439	-0.172	-233.813	-7.184*
CM April	32.290	3.033*	117.642	5.946*	-31.243	-1.093
CM June	-147.591	-11.393*	-354.215	-16.316*	-443.016	-16.044*
CM August	20.551	1.406	-99.724	-3.704*	-503.988	-20.136*
CM October	102.314	9.422*	128.632	5.029*	33.071	1.254
<u>Time period:</u>						
DDE1	65.268	6.519*	-26.985	-1.362	13.865	0.529
DDE2	36.775	3.867*	-10.671	-0.597	-13.040	-0.550
DDE3	48.046	4.846*	-5.719	-0.301	-9.491	-0.378
DDE4	36.392	3.660*	-30.963	-1.662***	3.845	0.156
DDE5	-0.243	-0.024	-31.244	-1.671***	26.504	1.070
R-squared	0.337219		0.362908		0.3477493	
Number of Observations	1859		1795		1796	

t-values indicate whether the variables are significantly different from the mean value.

\* Significant at the 0.01 level;

\*\* significant at the 0.05 level;

\*\*\* significant at the 0.1 level.

During the final 30 trading days for the live cattle future contracts, most of the independent variables included had a significant impact on basis. The variables FV, CSP,

COFI, CSCH, most of the seasonality variables, and most of the variables for periods from expiration were statistically significant. This is consistent with what was expected, as the final month of a contracts life is when the markets become more sensitive, there is more trading activity, and the cash market becomes more relevant to the futures quote.

### Parameter Estimates

Given that most independent variables represent different measuring units, tables 4 and 5 are included to aid in the interpretation of the parameter estimates. Table 4 exhibits a set of descriptive statistics for the CPM<sub>1</sub> model, while table 5 represents the standardized beta coefficients calculated for the model. These standardized beta coefficients allow a ranking of the importance of each independent variable in the explanation of variations on the dependent variable.

Along with the detailed explanations of each variable presented in chapter 6, table 4 is intended to contribute to the reader's understanding of each variable and its interpretation. Table 4 presents a set of statistics describing each one of the variables included in the model, with the exception of the control and dummy variables. Among the statistics included are the mean, the standard deviation, the minimum and the maximum for each of the variables being evaluated. Out of the three CPM models, descriptive statistics were included for only the CPM<sub>1</sub> model due to its relevance.

Table 4. Descriptive Statistics for Variables in CPM<sub>1</sub> Model

Variable	Mean	Standard Deviation	Minimum	Maximum
Basis	58.36364	147.6154	-538	555
Market liquidity	147.2921	1333.808	0.26571	27420
Futures Volatility	0.011578	0.00694	0.002358	0.04198
Captive Supply	26.02302	8.99229	14.1	47.5
Cattle Slaughter	660.578	47.99094	460.2	767.9
Cattle on Feed	8353.413	1027.401	6237	10231

Table 5 presents the standardized beta coefficients of the regression results presented earlier in table 3. The standardized beta coefficients are represented by equation (7) below, and were derived as follows:

$$Y_t^* = \frac{Y_t - \bar{Y}}{\sigma_Y}$$

$$X_t^* = \frac{X_t - \bar{X}}{\sigma_X}$$

$$Y_t^* = \beta_1 \left( \frac{X_t - \bar{X}}{\sigma_X} \right)$$

$$\beta_1 = \frac{\sum (Y^* - \bar{Y}^*)(X^* - \bar{X}^*)}{\sum (\bar{X} - \bar{X}^*)^2}$$

$$\hat{\beta}_1 \frac{\sigma_X}{\sigma_Y} = \hat{\beta}_1^* \quad (7)$$

where  $Y_t^*$  and  $X_t^*$  are the standardized variables,  $\sigma_x$  is the standard deviation of the independent variable,  $\sigma_y$  is the standard deviation of the dependent variable, and  $\hat{\beta}_1^*$  is the standardized beta coefficient.

These beta coefficients allow for direct comparison between the parameters of the model. If the beta coefficient of a standardized independent variable is larger than that of another standardized independent variable in the model, then that independent variable contributes more relatively to the explanation of the variation in the dependant variable (Gujarati, 2003).

From the definition of the standardized beta coefficients, it is evident that aside from some of the seasonality variables and the control variable included for the contract

specification changes that took place in 1995, the number of cattle on feed explained more of the variation in basis levels than any other independent variable during the three periods evaluated. The percentage of cattle slaughtered that was captive supply also contributed more to the explanation of the variation in basis levels during the final 30 trading days, relative to the other variables included. During the time period when contracts were 60 to 90 days to maturity, the amount of cattle slaughtered played an important role in explaining the variations in basis.

Some of the seasonal dummies ( $CM_{jt}$ ) contributed largely to the explanation of basis changes. The closeness to contract maturity ( $DDE_{jti}$ ) also had a clear contribution to the explanation of variations in basis levels.

Table 5. Standardized Beta Coefficients for CPM Models

Variable	CPM <sub>1</sub>	CPM <sub>2</sub>	CPM <sub>3</sub>
Intercept	0*	0	0*
Market liquidity ( $ML_t$ )	0.000281	-0.03414	0.06048
Futures Volatility ( $FV_t$ )	0.048036**	0.089895**	0.019104
Captive Supply ( $CSP_t$ )	0.14787*	0.048301	-0.1368
Cattle Slaughter ( $CSL_t$ )	-0.00562	0.071674	0.23885*
Cattle on Feed ( $COFI_t$ )	-0.24559*	-0.20016**	0.38536*
Contract Changes ( $CSCH_t$ )	0.3571*	0.50522*	0.4531*
CM February	0.14821*	-0.00869	-0.59058*
CM April	0.081562*	0.29715*	-0.07892
CM June	-0.37232*	-0.89355*	-1.11756*
CM August	0.051909	-0.25189*	-1.27301*
CM October	0.25843*	0.32491*	0.083533
DDE1	0.1627*	-0.06727	0.034564
DDE2	0.098472*	-0.02857	-0.03492
DDE3	0.11977*	-0.01426	-0.02366
DDE4	0.090719*	-0.07719***	0.009585
DDE5	-0.00061	-0.07778***	0.065981

t-values indicate whether the variables are significantly different from the mean value.

\* significant at the 0.01 level;

\*\* significant at the 0.05 level;

\*\*\* significant at the 0.1 level.

Market liquidity had no statistically significant effect on live cattle futures basis levels during any of the CPM periods evaluated. This is not a surprising finding, since the live cattle futures market is considered large and efficient.

For every 0.001 unit increase in futures price volatility, basis widened 1.02 cents/cwt within the CPM<sub>1</sub> period and 1.91 cents/cwt during the CPM<sub>2</sub> period (table 3). During the CPM<sub>3</sub> period, the futures price volatility did not have a significant impact on basis levels. It is important to remind the reader at this point that price volatility was defined as the 14 day standard deviation of the price returns, where the price returns are the natural logarithm of the ratio of the current price to the lagged price. These findings are in concordance with what was expected. Futures price volatility is an additional source of risk in the markets. As suspected, the widening basis as a result of increased price volatility during the final 60 days of trading indicate that this additional risk is being absorbed by the cash market, i.e., by the producers.

The relationship found between the use of captive supply and basis in this study is consistent with the results presented by Taylor (2003), where he suggests there is a negative relationship between captive supply and cash price. For every one percent increase in the steers and heifers slaughtered that are procured through captive supply, basis widened by 2.43 cents/cwt during the final 30 days of trading. During the 60 trading days prior to that, captive supply had no significant impact on basis. The effect of captive supply on basis levels during the final 30 days of trading will be addressed in more detail later in this chapter.

For every 1000 additional head of cattle placed on feed by feedlots with a 1000 plus head capacity in the seven states, basis narrowed 0.04 cents/cwt within the CPM<sub>1</sub>

period, 0.03 cents/cwt within the CPM<sub>2</sub> period and widened 0.06 cents/cwt within the CPM<sub>3</sub> period. The results for the CPM<sub>1</sub> and CPM<sub>2</sub> are not consistent with Parcell et al. (1997) findings, who found a weakening of basis as additional cattle were placed on feed. Due to the fact that cattle placed on feed represents cattle to be marketed several months in the future, the effect of additional cattle inventories reflects to a greater extent on future prices than on the cash price. The anticipated increase in future supply created by the additional cattle placed on feed, reflects in a lower futures price that in turn causes a narrowing basis.

While the use of captive supply and the amount of cattle placed on feed were statistically significant in the CPM<sub>1</sub> period, changes in the number of cattle slaughtered were not statistically significant in the CPM<sub>1</sub> or the CPM<sub>2</sub> periods. They were statistically significant in the CPM<sub>3</sub> period, where for every additional 1000 head of cattle slaughtered, basis widened by 0.73 cents/cwt. Leuthold (1979) found no significant impact from changes in the amount of cattle slaughtered on basis levels of contracts nearest to expiration.

The specification changes applied to the live cattle futures contract in 1995 had a clear effect on basis levels at all three stages of the life of live cattle futures contracts evaluated in this study. A positive relationship was found between the control variable representing the contract specification changes and the change in basis level.

The CM<sub>1</sub> through CM<sub>6</sub> variables clearly indicate there is some degree of seasonality. The arrival of the summer season marks the beginning of what is commonly known as the cookout season or the grilling season. Since demand peaks around this season, based on marketing decisions made previously many producers schedule

production to be ready for slaughter around this season. According to Lawrence and Miller (2003), normally supply outpaces the increased demand, which in turn typically lower prices during late summer. The typical behavior of live cattle prices is normally as follows: high during the first months of the year reaching their seasonal peak around May, when a downward trend begins and continues throughout the rest of the year. This typical price pattern is consistent with the seasonality reflected by the model in this study, in which the month of June represented a narrowing basis due possibly to the lower cash market prices.

The set of dummy variables  $DDE_1$  through  $DDE_6$  suggest that the variables included in the model indicate that basis is widening as contract maturity approaches. They also suggest that further away from contract maturity, time to expiration becomes much less significant.

### **Impact of Captive Supply Procurement Methods on Basis Levels**

As expected, there is a positive relationship between the use of captive supply in the industry and basis levels. This widening of basis due to increased use of captive supply is present only during the final 30 days of life of live cattle futures contracts. When meatpackers use captive supply methods to procure their cattle, they are less dependent on the cash market. Meatpackers using captive supplies are less aggressive in the cash market when cash prices are high, which in turn may cause a decline in the cash market prices; i.e., widening basis levels. This is why the effect of captive supply on prices is said by many not to be clear. The results presented in this study indicated a small widening of basis as the percentage of captive supply cattle increased.

### **Impact of Market Liquidity on Basis Levels**

The liquidity of the live cattle futures market was found not to be significant in any of the three models estimated. That is, regardless of whether contracts were 30, 60 or 90 days away from expiration, market liquidity had no significant effect on live cattle basis levels.

What this probably indicates is that the live cattle futures market has sufficient liquidity to be a useful tool for risk management. The extent to which the live cattle futures markets are utilized both for hedging as well as for speculating, appears to be contributing enough liquidity to the market.

## CHAPTER 8 SUMMARY AND CONCLUSIONS

### **Summary**

The live cattle industry is facing many challenges as a result of structural changes to the industry in recent years. These changes could have had an influence on cattle prices both in the cash market and in the futures market. The increasingly volatile environment in the live cattle market has led many producers to use hedging in the futures markets as a risk management tool to protect themselves against unfavorable price changes. Understanding and being able to accurately predict basis levels is key for successful hedging. The many factors influencing cash and futures prices make accurate forecasting of basis levels a complex task.

This study focused on the time period ranging from 1992 through 2001. Basis levels for contracts approaching maturity date were evaluated over this period of time, and factors influencing basis levels were identified and evaluated for contracts three, two and one months from maturity. Most of the parameters estimated indicate that the independent variables included are behaving according to what was expected.

### **Basis Behavior**

The parameter estimates presented in the previous chapter indicate that the live cattle futures market has a level of liquidity that permits it to perform efficiently. The results also indicate that the use of captive supply by the meatpacking industry had a negative but small effect on live cattle basis levels during the final 30 trading days. The number of cattle slaughtered had no statistically significant effect on basis levels during

the final 60 days of trading, but had a negative effect on the basis of contracts 60 to 90 days from maturity. Cattle on feed inventories had a positive effect on basis for contracts on their final 30 days of trading. Basis reflects the seasonality patterns expected, since prices for cattle are quite seasonal due to the increased demand for beef during the summer. The impact of time to maturity on basis is negative, i.e., according to the model the basis is increasing as maturity nears.

### **Hypotheses Summary**

Several hypotheses were tested in the study. These hypotheses were:

1. “After adjusting for transactions and transportation costs, basis levels are not approaching zero as live cattle future contracts approach maturity.” Based on the results obtained in the model, this hypothesis was not rejected.
2. “Widening basis levels are related to market liquidity as futures contracts approach maturity.” The results presented in this study indicate market liquidity is not an influential factor on changes in basis levels, therefore this hypothesis was rejected.
3. “Captive supply methods of cattle procurement by meat packing firms have had a negative effect on live cattle basis levels, i.e., more use of captive supply, larger basis.” The results of the model fail to reject this hypothesis, since the use of captive supply has a negative effect on basis levels.

### **Limitations of This Study**

The number of potential factors that could influence live cattle cash market prices and live cattle futures market prices is very large. Furthermore, the inability to provide objective measurement of some of these factors or gain access to data representing these factors is limited. Therefore, some factors that could affect basis levels were excluded from this study.

Cash market prices of live cattle vary for different geographical locations. These differences could be due to many factors, but in particular due to transportation and

transaction costs. In this study, the cash market prices for Oklahoma City were used as a representation of cash market prices for live cattle in the United States in general.

Daily cash market prices and futures market prices were included in this study. On the other hand, data representing captive supply and cattle on feed inventories are reported on a monthly basis; and the data for cattle slaughter are reported on a weekly basis. Due to the nature of this data there is no access to daily numbers which would have been ideal for this study in order to be consistent with the daily cash and futures market prices. This represented a limitation to this study, since the monthly and weekly values obtained for the use of captive supply, cattle on feed inventories, and cattle slaughter respectively were assumed for every day within the month for captive supply and cattle on feed, or week in the case of cattle slaughter.

Measures of captive supply in the industry for the years 2002 and 2003 were not available by the time this study was conducted, limiting this study to evaluate basis levels up to the year 2001.

### **Direction for Future Research**

Market concentration is known to be very high in the meat packing industry. The effect this high degree of concentration may have on prices is still widely debated. Most of the research performed in this regards suggests in general that market concentration has a small negative effect on price levels. A very large percentage of the marketing agreements and forward contract transactions in the industry belong to the three largest packers (GIPSA, 1996), and this study demonstrates that the use of captive supply has some impact on basis levels. A study linking the use of captive supply by the cattle industry and market concentration in the meatpacking industry would yield interesting results that could further contribute to the findings of this study.

Madarassy (2002) examined the volatility dynamics of financial futures returns. Given the results presented in this study, a study evaluating the conditional variance of live cattle futures price changes for contracts approaching maturity would contribute to the understanding of the live cattle futures market.

Not only can cattle producers in the U.S. benefit from studies such as this one regarding the live cattle futures markets, but they could also benefit from information regarding the feeder cattle futures market. A study of this nature could be performed including feeder cattle prices and slaughter plant capacity in order to evaluate basis levels, and the factors affecting basis throughout the vertical production chain.

An interesting study that would highlight the importance of studies such as this one, as well as motivate further research on this topic, would be a study that identifies the percentage of cattle producers utilizing the futures markets as a risk management tool and the awareness by producers that this tool is available.

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