2006

The cattle crush strategy: trading opportunities for cattle producers

Nicolas Acevedo Velez
Iowa State University

The cattle crush strategy: trading opportunities for cattle producers

by

Nicolas Acevedo Velez

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Economics

Program of Study Committee:
John D. Lawrence (Major Professor)
David A. Hennessy
William Q. Meeker

Iowa State University

Ames, Iowa

2006

Graduate College
Iowa State University

This is to certify that the master's thesis of

Nicolas Acevedo Velez

has met the thesis requirements of Iowa State University

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ABSTRACT

This research shows that it is possible for cattle feeders to obtain additional profits if a consistent technical strategy for trading is applied to the cattle crush spread. However, when trading costs are introduced, the likelihood of obtaining profit from trading the crush reduces considerably. It also shows that the level of gains from the cattle crush is related to the month the cattle are marketed. When the crush is used as a hedging strategy it decreases the profit from the feeding operation and reduces the volatility of those returns, helping producers to transfer part of the price risk associated with their production.

To provide evidence of these findings, this study utilizes daily prices for 1995 to 2006 of the futures contracts of corn, feeder and live cattle to construct the daily cattle crush spread for two different combination of futures contracts. These contract combinations suppose that cattle are fed in feedlots for 170 days before being marketed in April and in October. Two different scenarios are also evaluated using the cattle crush spread: one in which the crush is employed as a pre-placement hedging tool and another in which the crush is used as a post-placement hedging method.

CHAPTER 1. GENERAL INTRODUCTION

Introduction

Feeding cattle in Iowa is an enterprise that implies dealing with risk. This risk comes from different sources: a) once the feeding process starts, there is a minimum holding period within which the cattle can not be sold (investment is fixed), b) there is uncertainty about the selling price of the fed animal, and c) there is variability of the price of the production inputs (i.e. feed). Besides the risk that comes from price volatility, there is the uncertainty of obtaining positive returns on the feedlot operation. According to the Estimated Livestock Return for Iowa calculate by Iowa State University (Figure 1.1), the return on finishing yearling steers (i.e. feeding animals from 750 lb to 1,250 lb to Choice slaughter grade) was unprofitable 40% of the time during the period 1991 to 2006. Monthly average return in terms of fed cattle sold ranged from a loss of $11.15/cwt to a profit of $35.23/cwt and the average return was $1.95/cwt.

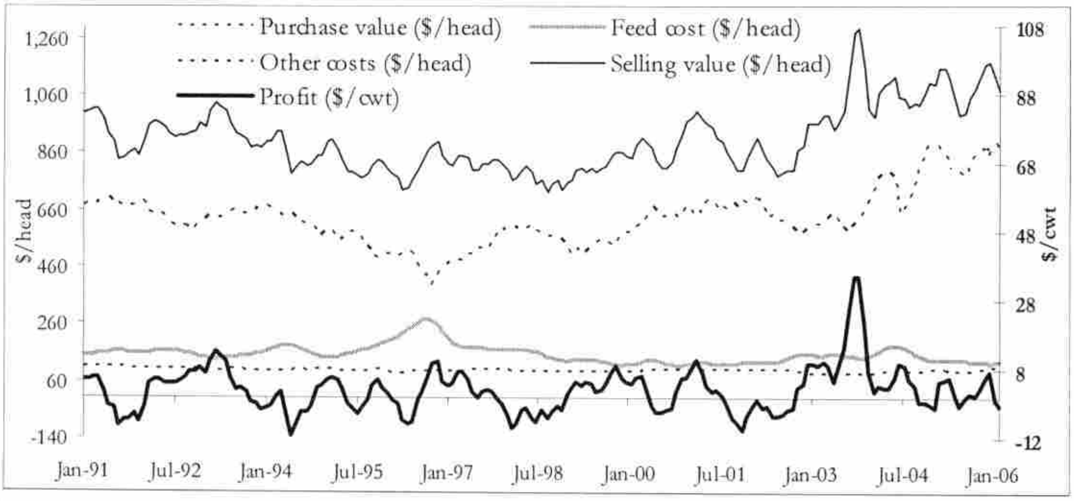

Figure 1.1. Estimated returns for finishing medium No. 1 yearling steers to Choice slaughter grade, Iowa-Minnesota (1991-2006)

Iowa cattle production is an important economic enterprise. According to the Iowa's Beef Center (2006), cattle sales represent about 20% of Iowa's annual agricultural income and the total economic impact of the cattle sector from inputs to processing is estimated at $5.32 billion annually. By January 2006, Iowa had the seventh largest cattle inventory in the US with 3.8 million of head (around 3.9% of the total), while it had the fifth state largest amount of cattle on feed with 920,000 head which is equivalent to 6.5% of the nation's cattle total (USDA-NASS).

Return (and its variability) from the feeding process depends on multiples aspects. However, the cattle price margin (the difference between fed cattle and feeder cattle price) has a greater effect on the variability of return from feeding, as it is shown in Figure 1.2.[1] Indeed, Swanson and West (1963) using coefficients of separate determination found that the cattle price margin explained 38% of profit variation, while Langemeier et al. (1992) and Schroeder et al. (1993), using the same method found that fed cattle and feeder cattle prices explained approximately 50% and 25% of return variation respectively. In addition, Albright et al. (1993) found that together, fed and feeder steer prices explain 71% to 80% of profit risk.[2]

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[1] Correlation between these two variables was large (ϱ=0.94) for the period from January of 1991 to March of 1996.
[2] Figures A.1 to A.3 in the appendix show the volatility of the Iowa cash markets for corn, feeder cattle and fed cattle.

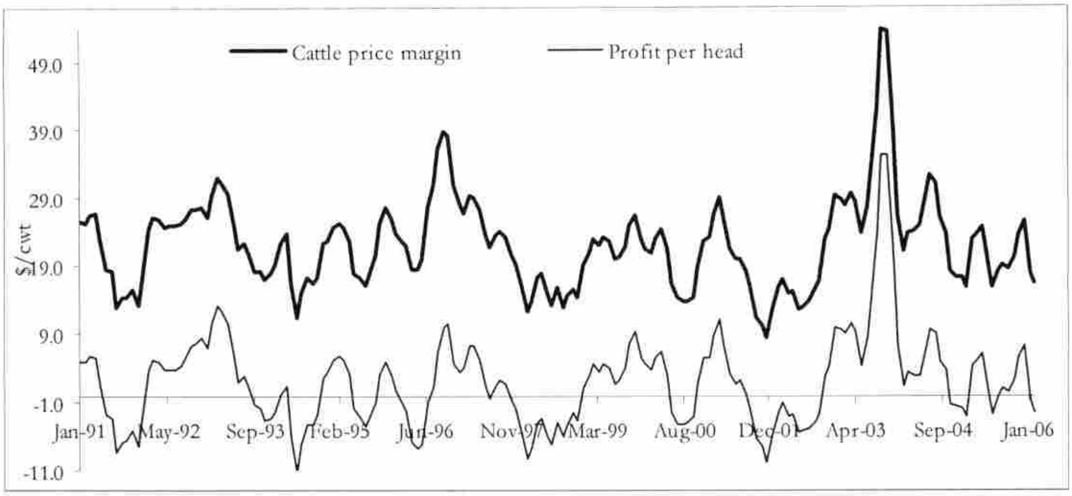

Figure 1.2. Cattle price margin and return to feeding (1991-2006)

Knowing that, cattle producers should focus on maximizing the cattle price margin and buying corn at the lowest possible price. To that end feedlot operators can employ futures markets to manage a future delivery price of live cattle (also called fed cattle) that maximizes the cattle price margin and at the same time reduces the risk involved in the feeding process. In theory, through the use of futures contracts, producers are able to choose at what futures prices for feeder cattle and corn they would be willing to buy and at what futures prices for fed cattle they would be willing to sell in order to reach a certain level of profit.

Despite the fact that live cattle futures contracts have been traded in the US since 1964 and feeder cattle futures contracts started in 1971, it seems that there is a small percentage of cattle on feed that is hedged by producers. Some factors can be listed to explain this: a) as it was pointed out by Riley (1971), some producers have engaged in hedging with unsatisfactory results (i.e. they did not reach the level of profits they were expecting) and as a consequence, stopped using future markets[3], b) there is not enough public research on technical and fundamental analysis and strategies that might increase the likelihood of better hedging the cattle production and therefore attaining higher returns[4], and c) not hedging could be more profitable than hedging.

Numerous empirical studies have investigated the profitability of technical trading rules in a wide variety of markets and many of them found positive effects. These techniques are based on the idea of the existence of temporal violations of the weak form of efficient markets theory described by Fama in 1965. The weak form asserts that all past market prices and data are fully reflected in commodities prices and therefore, technical analysis should not work on defining a trading strategy. The most common technical tools are based on trend analysis (e.g. trend lines, moving averages, and price channels), oscillators and momentums (e.g. the relative strength index), figures formation (e.g. head and shoulders formation, triangles, double tops and bottoms formations and reversal formations) and point and figure charting. More sophisticated analyses include wave theory (e.g. Fibonacci and the Elliot's Wave Theory) although these are more difficult to interpret as pointed out by Winters (2005).

The risk and low margin from feeding cattle have had an impact on the current organization of the feedyard operations. On the one hand, the number of cattle marketed has sharply dropped in the past 20 years (Figure 1.3). On the other hand, feedlots in Iowa have decreased in number but increased in size. As described by Clement (2001), small feedlot operations are fading away while

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[3] In a recent survey for Iowa, Lawrence and Schuknecht (2005) found that 50% of the respondents considered the "ability to manage price risk with futures/options" as an issue that had a positive impact in making a profit in the cattle business.

[4] Most of the strategies on futures markets are developed by financial companies and are used for speculation purposes given the fact that financial companies rarely can alter production decisions.

midsize farms are expanding to increase profitability by lowering costs through economies of scale and by selling a higher volume of cattle. The USDA-NASS reported that in 1984 Iowa had 20,000 feedlots, of which 760 had more than 1,000 head capacity and marketed nearly one million head (around 53% of the total). In 2005, the governmental agency estimated that there were approximately 8,940 feedlots of which 340 had more than 1,000 head capacity and marketed 780,000 head of cattle (nearly 50% of the total).

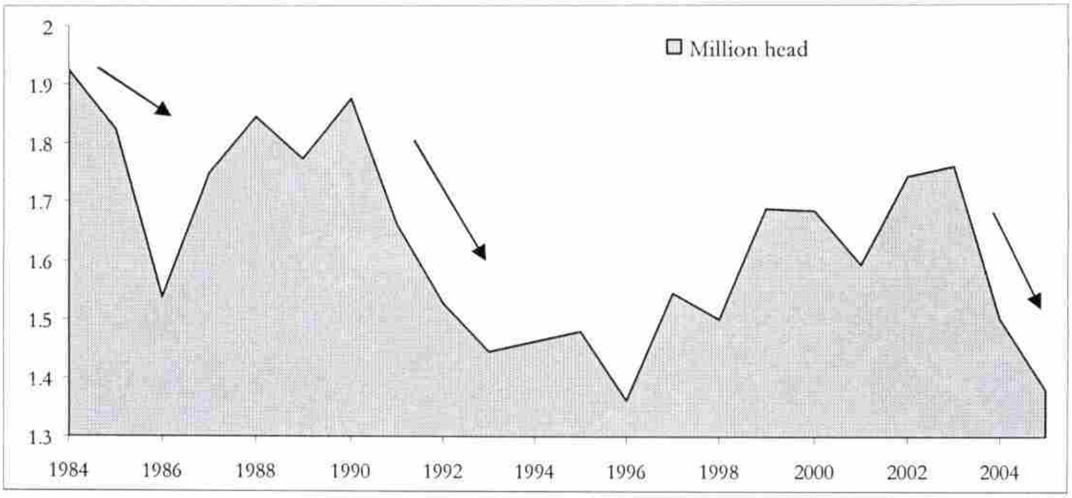

Figure 1.3. Iowa cattle and calves marketed (1984-2005)

The increase in size of the feedyards demands more refined strategies to hedge price uncertainty. The larger the operation, the more likely that sharp fluctuations of input and output prices will drive some feedlot producers out of business if they are not well prepared to assume such a risk. Sandmo (1971) showed that under price uncertainty, the output of larger feedlots tends to be smaller. In addition, the ever present threat of unexpected losses affects the ability of feeders to operate at or near optimal physical efficiency (Spahr and Sawaya (1981)). MacDonald and Korb and MacDonald (2006) observed that by reducing price risks, production and marketing contracts can make it easier for farmers to obtain credit and thus expand operations.

Most of the hedging strategies involve the use of futures markets. Producers that sell live cattle can hedge their production to lock in a certain price (and profit) that is a function of their utility function. This utility function depends on the price of corn, feeder cattle, live cattle, the interest rate, and the technology available at the farm, as well as the fixed cost of the operation. Several studies have addressed the question of what is the theoretical optimal hedged ratio that a feedlot operator should use to hedge the cattle production. In most of those studies, the optimal hedge strategy is based on the expected-utility maximization paradigm and the minimum variance criteria. Other research, in particular the study done by Lien and Tse (2000), focused on improving the estimation of the optimal hedge ratio using nonlinearity in spot and futures returns.

The cattle crush is a mechanism of hedging risk through futures markets that allows cattle feeders to reduce price risk. The cattle crush is formed when at least two live futures contracts are sold and one futures contract of feeder cattle and one of corn are bought to better match contract sizes. This crush can be used either as a pre-placement or as a post-placement hedging tool; therefore, it is closely related to the length of time cattle remain in feedlots.

The trading opportunities of the crush were assessed through the use of some technical analysis techniques such as moving averages, oscillators and momentums. The hypothesis that was tested is that the cattle crush market may not be efficient; therefore, a systematic application of some technical rules may increase the likelihood of producers' reaching a certain level of return, or increasing the actual level of profit due to the composition of the cattle crush and the underlying interactions of its components.

Futures contracts data were obtained from the Chicago Mercantile Exchange (CME), the Chicago Board of Trade (CBOT), barchart.com, and Bloomberg. Cash prices for live cattle, feeder cattle, and corn came from the Livestock Marketing Information Center (LMIC) that compiles information reported by the USDA-AMS for different regional markets (i.e. Iowa and Missouri). Finally, data for Iowa feedlots was obtained from the Iowa Tri-County Steer Carcass Futurity Program Cooperative (TCSCF) [5] for the 2001-2005 period and from the Iowa State University Livestock Enterprise Budget.

Research objectives

The main objective of this thesis is to apply multiple trading methods based on technical analysis to find out if there is an improvement in net returns for cattle feeders. Instead of utilizing these technical strategies on the cash market of each of the component of the cattle production (i.e., corn, feeder cattle and live cattle), a cattle crush spread using futures markets was derived and utilized. This spread assumes that cattle are marketed in April and October after animals were fed for a 170-day period. Both conditions go well with the average behavior of the cattle production in Iowa. In addition, this study makes use of statistical methods to construct a systematic way of evaluating choices that producers can employ to trade the cattle crush spread.

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[5] The TCSCF is governed by a group of beef producers and agribusiness people from SW Iowa and has developed Extension and producer contacts in Georgia, South Carolina, Indiana, Alabama, Virginia, Florida, Tennessee, Mississippi and Missouri that assist with recruiting producers and cattle to be fed in SW Iowa. The program started in 1983 with 35 consignors and 106 steers. In 2005, over 600 consignors evaluated 8,713 head of steers and heifers. Nine custom feedlots were utilized in the program.

Strategies were divided into pre-placement and post-placement hedging tactics with the goal to generate alternative scenarios. Another important objective of this thesis is to determine if there is any difference in benefits for producers that hedge futures sales of fed cattle in October or in April.

Thesis organization

The first chapter of this thesis is the general introduction. The following chapter is a review of literature on the cattle feeding system and the exploration of the theory of hedging risk through futures markets. It also describes the technical analysis methods that are used to develop the trading rules. The objective of the third chapter is to create and evaluate the method of deriving the cattle crush spread and to analyze the resulting time series. Chapter 4 contains the principal findings of using the cattle crush spread as a pre-placement and post-placement hedging tool. It also includes description of the actual rules applied to trade the cattle crush spread. The final chapter contains the conclusions and recommendations for futures researches on this topic.

CHAPTER 2. LITERATURE REVIEW

Feedlot operation

A feedlot is an animal feeding operation (AFO) in which capacity varies from less than 100 head to more that 50,000 head. The basic idea of a feedlot is to provide high-energy feed that promotes low feed-to-meat conversion, high daily weight gain and to encourage the deposit of lean gain and marbling in the animal's muscles prior to slaughter. Generally, cattle in feedlots receive a diet consisting of grain (i.e., corn and corn co-products), protein supplements (i.e., soybean meal or cottonseed) and roughage (i.e., hay, silage or alfalfa) until the cattle reaches an appropriate weight to be brought to market. According to Lawrence et al. (2001), cattle feeding adds value to corn and forage, more fully employs farm resources such as labor, facilities, and machinery, and provides profit opportunities for skillful managers.

A "typical" feedlot operation begins with steers that are 6 to 18 months old and that weight 500 to 900 lb. These animals are fed for 110 to 250 days until they reach a weight that ranges from 900 to 1,400 lb at slaughter (Figure 2.1). Data from January of 2006 shows that Iowa has 920,000 head of cattle on feed, 495,000 of which were in feedlots with 1,000 or more head capacity and the rest remained in smaller feedyards.

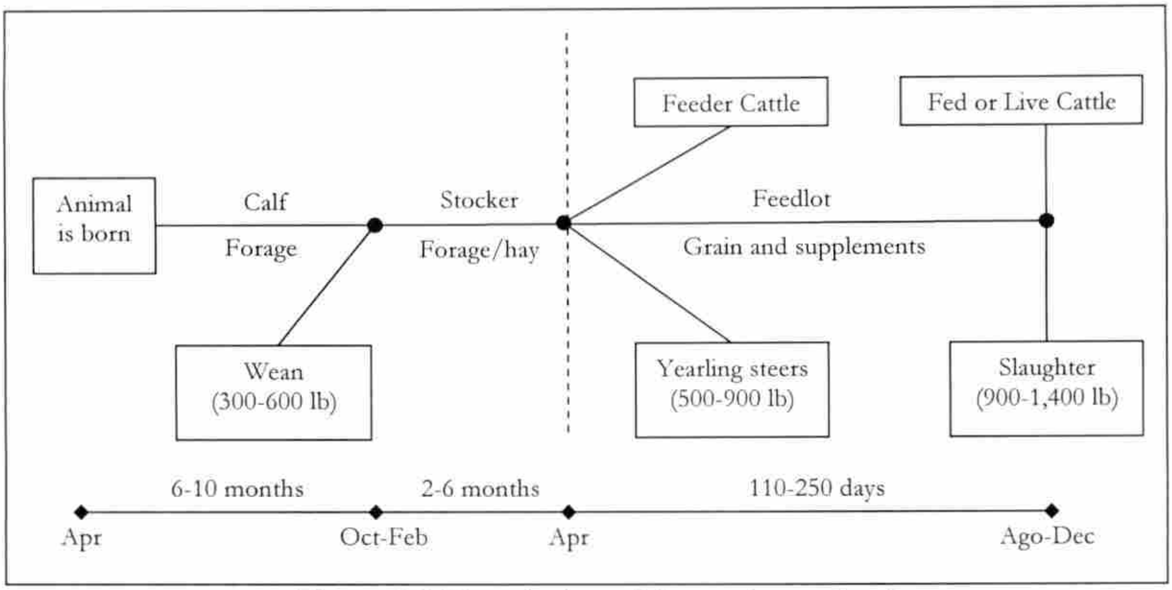


Figure 2.1. Description of the cattle production

Feeder cattle are the "initial investment" made in feedlot operations in order to produce fed cattle. These feeder steers that are placed in feedlots can be: a) bought in the spot market (e.g. feeder cattle auctions, direct from the ranch or through intermediaries), b) raised from a cow/calf operation linked to the feeder process, and c) placed by live cattle producers to be custom fed while retaining ownership.

Corn is the main feed used in the production of cattle. In Iowa corn accounts for about 73% of the feeding cost while corn silage accounts for about 19%. Iowa has the advantage of the availability of corn and corn byproducts. According to Lawrence et al. (2001), during the 1990s, north central Iowa corn prices averaged from as little as $0.10/bu under southwest Nebraska prices, to as much as $0.35/bu less than in parts of the Texas cattle feeding region. This represents an advantage for Iowan cattle producers because margins can reach higher levels when there is cheap feed and strong product demand. For this reason, it is reasonable that some cattle feeders grow their own corn with the objective to benefit from the comparative advantage and from the reduction on price uncertainty that comes with storing the grain. However, this situation seems to be changing and currently most Iowa crop farmers do not own livestock and most livestock producers do not grow crops. According to Babcock (2005), this is a result of many factors, the most important ones are: a) the size of minimum-cost livestock production operations have increased and relatively small cattle feeding operations that characterized Corn Belt agriculture have been largely replaced by huge operations in Kansas, Oklahoma, and Texas, and b) many crop farmers are happy to let the livestock go because new equipment and crop production methods have increased the per-bushel cost advantage of larger operations. Additionally, larger operations are easier to manage without the worry of livestock. Expanded crop insurance options and generous commodity programs greatly reduced the risk for farmers who switched to crop specialization while removed most of the advantages that diversified farmers enjoyed in the past.

Length of time in the feedlot

There is a large variety of feeding plans since feeding processes vary greatly depending upon the animal weight gain, marketing price, final grade desired for the cattle, weight and age of the cattle, and size of feedlot and feed availability. The effects of some of these variables on the number of days on feed are as follows: a) daily gain. Animal genetics predetermine the limits of the cattle daily weight gain therefore animals sold have different feeding requirements and have different weight at slaughter, b) marketing price. If a feedlot operator expects high future prices on live cattle he or she may feed heavier steers in order to capture those higher market prices. On the contrary, a producer can sell lighter steers if the actual live cattle prices are more attractive than the expected futures prices. As Jarrige and Béranger (1992) pointed out, higher weight gain and feed prices cause feedlot operators to look at heavier feeder cattle which will permit a shorter grain-feeding phase, and c) Cattle grading. According to the Arkansas Steer Feedout Program (2003), a factor that affected the relationship between days on feed and feedlot net return was the price difference between Choice and Select quality grades. Three main factors that affect marbling are: a) the genetic ability to marble and the ability of the breed to grade Choice, b) the maturity or the physiological age, not the chronological age, and c) ration of feed provided.

Profit function for the feeding cattle process

With the knowledge of the inputs and outputs of the feeding cattle enterprise, a profit function for a 6-month feeding period can be stated as follows:

$$\pi(q_{live,t+6}) = p_{live,t+6} \times q_{live,t+6} - (p_{corn,t} \times q_{corn,t} + p_{feeder,t} \times q_{feeder,t}) + f + \varepsilon_{t+6}$$

Where π is the profit of selling q pounds of live cattle at price p in $t+6$ months from month t, minus the sum of the most significant costs incurred at month t: corn and feeder cattle. Other costs are described by f (fixed, labor, transportation, etc.). Lastly, the random effects of the price output are condensed in the variable ε which is assumed to follow a normal distribution with mean and variance of zero and σ^2_a.

Market information and efficiency in the cattle market

Fama (1965) defined an efficient market as one where there is a large number of rational, profit-maximizers agents that actively compete with each other and try to predict future market values of individual securities in markets where important current information is almost freely available to all participants. In an efficient market, competition among the many informed participants leads to a situation where at any point in time the actual prices of an individual commodity already reflects the effects of information based on events that have already taken place and on events which, as of that moment, the market expects to occur in the future. Similarly, Lucas (1972) noticed that the way in which expectations are formed changes when the behavior of the forecasted variable changes. Both theories suggest that when the market figures out that a commodity price follows a certain pattern, no abnormal profits can be made by using this information.

Fed cattle that are sold today were feeder cattle in the past. This characteristic of the beef market should allow cattle feeders to better forecast the future price on the cattle that they market. However, when it comes to cattle selling prices this "pipeline" approach may work for estimating the amount of cattle that will be sold in the future but not for forecasting prices. In theory, there are some of leading indicators that should help predict the future behavior of live cattle prices, some of them are:

- **Cattle on feed and live cattle futures prices.** Cattle on feed have a well defined cyclical and periodic pattern (Figure 2.2). Cattle placed on feed today become the cattle slaughtered in the future. In theory, high placements of cattle should lead to lower prices of live cattle futures contracts (ceteris paribus). Yet Figure 2.2 shows that the live future prices (lagged 6 months) were negatively correlated to the amount of cattle placed on feed only in some periods[6]. Then, the relationship of cattle on feed and live cattle prices in the futures is not clearly defined.

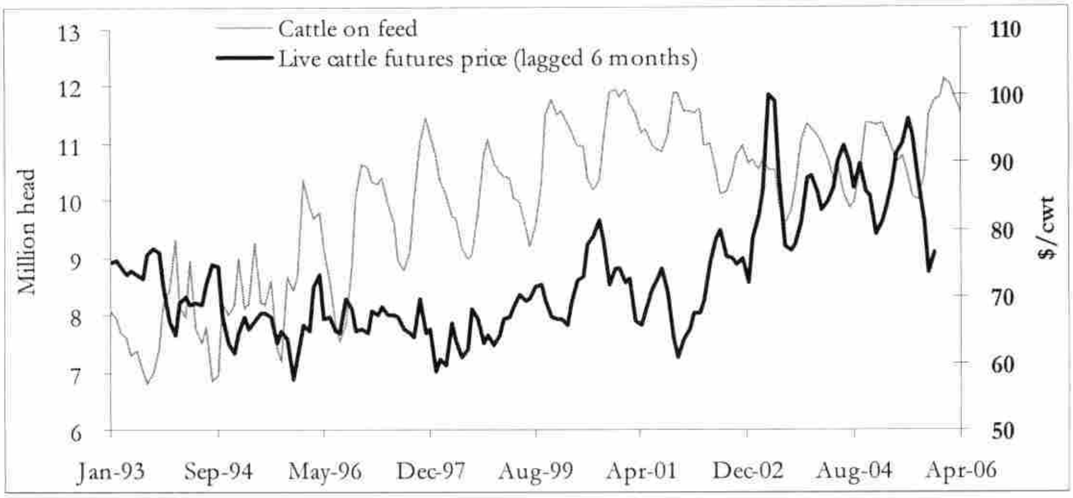


Figure 2.2. Monthly US placement of cattle (1,000+ capacity feedlots) and futures prices

- **Price of corn today affects future price of fed cattle.** Cattle prices should reflect the increase (decrease) in the price of feed. In theory, periods of high corn price should push the price of future fed cattle up. However, Figure 2.3 shows that the relationship works only when corn price skyrocketed in 2004 and that in general there were more periods when that correlation was very low or negative. Then, cattle feeder can not take advantage of this indicator to determine when to start a feeding process.

[6] In the graph feedlots with 1,000+ capacity were compared to live cattle futures prices. Notice that the feedlots with 1,000+ capacity account for 85% of the total fed-cattle market, then cattle that are fed in small feedlots with less than 1,000 head were not included in this calculation (CME (1995)).

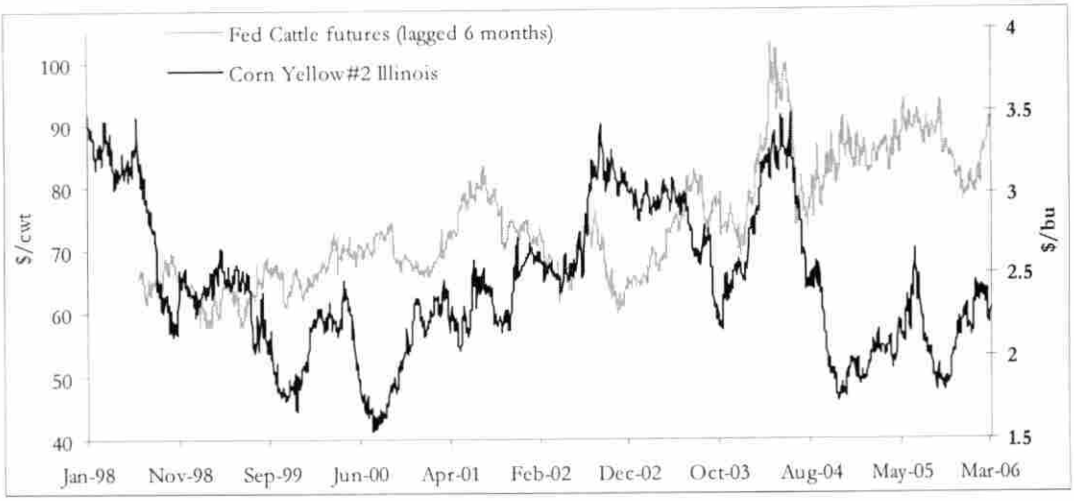


Figure 2.3. Corn prices and live cattle futures contract prices

- **Corn and feeder cattle prices.** These two production inputs were negatively correlated (ϱ=-0.29 for the period 1998 to 2006). As Dhuyvetter et al. (2001) pointed out, buyers pay a higher price per pound for lightweight feeder cattle relative to heavier feeder cattle because the cost of adding weight (i.e., cost of gain) is generally less than the value of additional weight. Therefore, high corn prices leads to a lower price paid for feeder cattle (Figure 2.4).

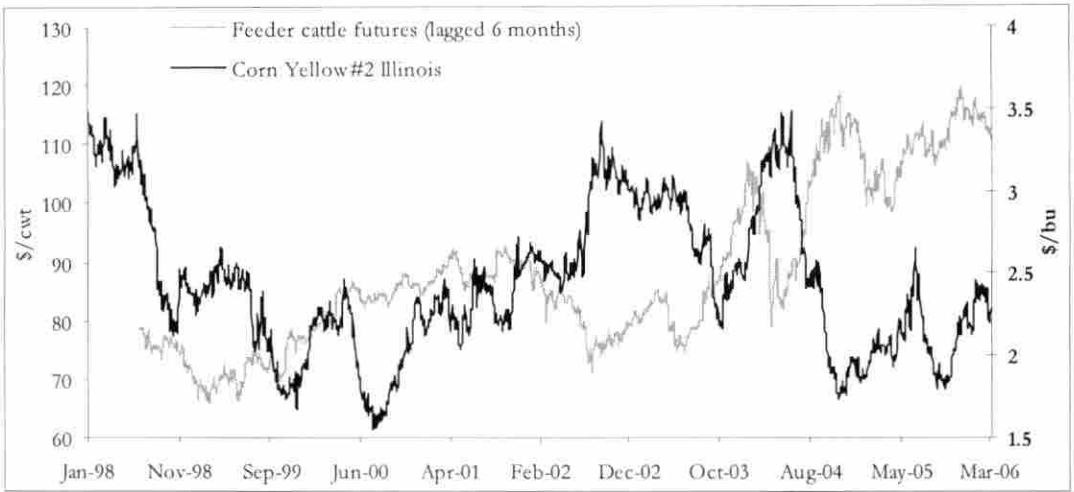


Figure 2.4. Corn prices and live cattle futures contract prices

Having analyzed these two important relationships, it becomes apparent that a number of other factors (i.e. changes in domestic and foreign supply and demand, price variation of beef's substitutes, days that animals remain on feed, etc.) have significant impact on the evolution of live cattle prices and, in addition, they can not be easily followed and predicted by producers. That is to say that with the use of this information it would not be possible to create trading rules that can help producers to obtain abnormal profits from marketing cattle. In consequently, two conclusion can be drawn: a) even if they want to, producers are not well informed about all the variables that affect the future price of live cattle, which implies that their decision-making varies (and some producers can act irrationally), and b) producers may fail to gather and analyze all the fundamental information that affects the cattle market, therefore a technical tool should be use to complement the study of the cattle market.

Risk management in the cattle production

Theoretically speaking, the motivation for risk management in cattle production comes from the fact that future prices of production inputs and outputs have a random component that follows an unknown path. That is to say, producers are not certain about the parameters that influence the costs and the returns in the cash flow process. For example, the effect of weather on the corn yields and prices can add uncertainty to the future price of fed cattle. A drought can decrease the corn supply and consequently lead to an increase in corn prices that can affect the price of feed used to feed steers. At the end of the day, live cattle producers will have higher production costs and may try to seek higher selling prices for the cattle they fed as a compensation for higher input prices.

One way to manage risk of fluctuating cash prices is with futures markets. Hull (2005) defined a future contract as an agreement between two parties to buy or sell an asset for a certain price at a certain time in the future. Futures markets make it possible for producers and consumers to plan ahead by locking in the price they will pay or receive in the future and enabling them to reduce the risk of price fluctuation. A commodity producer (say, a live cattle producer) would agree to sell his cattle at a certain price (K) at a stated time in the future, and the user of the commodity (say, a meat packer) would consent to buy them.

By agreeing on a price, quantity, and delivery date, producers reduce uncertainty into their operations and reduce risk. In this case the cattle producer has assumed a short hedge (or sell) on live cattle futures contracts because he or she already owns the cattle and expects to market it in the future and wants to lock in a certain price at some time in the future. A short futures position generates a loss if the live cattle increases in price and a gain if it decreases in price (see panel (a), Figure 2.4). Conversely, cattle producers can assume a long hedge (or buy) on corn and feeder cattle futures contracts to protect themselves from the uncertain input prices the next time they feed cattle. If the price of corn increases abruptly (as it did in 1996 and 2004) above that price defined by the futures contract, the hedge pays off because the live cattle producer saves money by paying the lower price. However, if the price of corn goes down, live cattle producer is still obligated to pay the price specified in the contract and in this case looses (see panel (b), Figure 2.4).

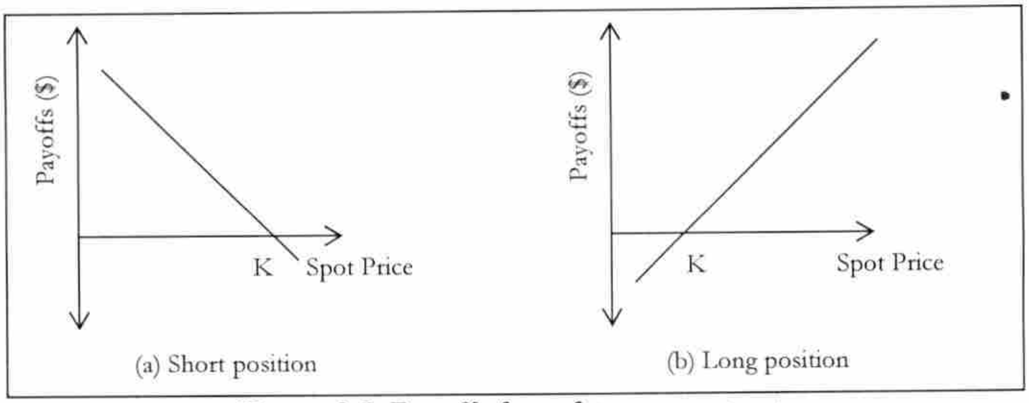


Figure 2.5. Payoffs from futures contracts

Despite the large amount of research on the effects that hedging inputs and outputs has on risk and on the production margin, there seems to be no consensus on this issue. Bullock and Logan (1970), Shafer et al. (1978) and Spahr and Sawaya (1981) showed that some selected hedging strategies on the cattle market can lead to lower variability on the profit variance and, in some cases, and improvement in the dollar return on head produced. In contrast, Tooman (2001) and Brorsen and Fofana (2001), suggested that in the event that cash market movements do not mirror movements in the futures markets perfectly over the life of a hedge, large and unforeseen losses may result. In addition, costs related to the capital required to maintain futures margins accounts that are non-trivial can be associated with losses from using the futures markets.

Both size and delivery date of the futures contracts are standardized which ensure liquidity in the market. The frequency of the delivery of the future contracts is high, which guarantees the liquidity of the contracts on the market. Table 2.1 depicts specifications of futures contract for corn, feeder cattle, and live cattle in the Chicago markets.

Table 2.1. Selected futures contract specifications

Contract Characteristics	Corn futures (CBOT)	Feeder Cattle (CME) [b/]	Live Cattle (CME)
Contract size	5,000 bushels	50,000 pounds	40,000 pounds
Months traded	Dec, Mar, May, Jul, Sep	Jan, Mar, Apr, May, Aug, Sep, Oct and Nov	Feb, Apr, Jun, Aug, Oct, Dec (seven months in the even monthly cycle). Jan, Mar, May, Jul, Sep, Nov (three months in the odd monthly cycle).
Price quoted	Cents/bushel	Cents/pound	Cents/pound
Delivery day	Second business day following the last trading day of the delivery month [a/]	All contracts open as of the termination of trading shall be cash settled based upon the CME Feeder Cattle Index™ for the seven days ending on the Thursday on which trading terminates [c/]	Delivery may be made on any business day of the contract month, and on the first seven business days in the succeeding calendar month
Type of delivery	Commodity	Expire to a cash index price	Commodity

[a/] Last trading day is the business day prior to the 15th calendar day of the contract month.
[b/] The CME feeder cattle contract covers cattle that enter the feedlots in the 650-849 pound range for finishing to market weight.
[c/] Trading terminates on the last Thursday of the contract month.

Basis risk

The price difference between the futures and the cash markets is called the basis and should be less than the delivery cost of the underlying commodity. The futures price represents the national price, while cash prices in each local area vary by the specific demand and supply conditions. Basis risk refers to the possibility that this difference will change during the life of a contract resulting in an unexpected loss or gain (Baggett and Ward (2002)). The basis in a hedging situation is defined as follows:

$$\textit{Basis} = \textit{Cash price of the asset to be hedged} - \textit{Future price of the contract used}$$

According to Errera and Brown (1999), there are two principles of futures prices that affect basis: a) parallelism: changes in the cash and in the futures market prices have a tendency to correlate highly with one another and should remain stable, and b) convergence: cash and futures prices are the same (converge) at the expiration of the futures contract, thus basis must be zero at expiration at the delivery point of the futures contract (except for delivery cost).

Basic risk can change due to variations in domestic and foreign supply and demand that affect prices in the cash market, amount of commodities in storage that is carryover, storage and transportation costs. According to Chance (2002), hedging in the non-contract months can also create basis risk. For example, a cattle feeder unable to match the actual date in which the cattle are place in feedlots with the month of delivery of corn or feeder cattle generates basis risk. Figures 2.5 to 2.7 displays the paths of the basis between Iowa cash corn, feeder cattle and fed cattle and their respective futures contract prices.

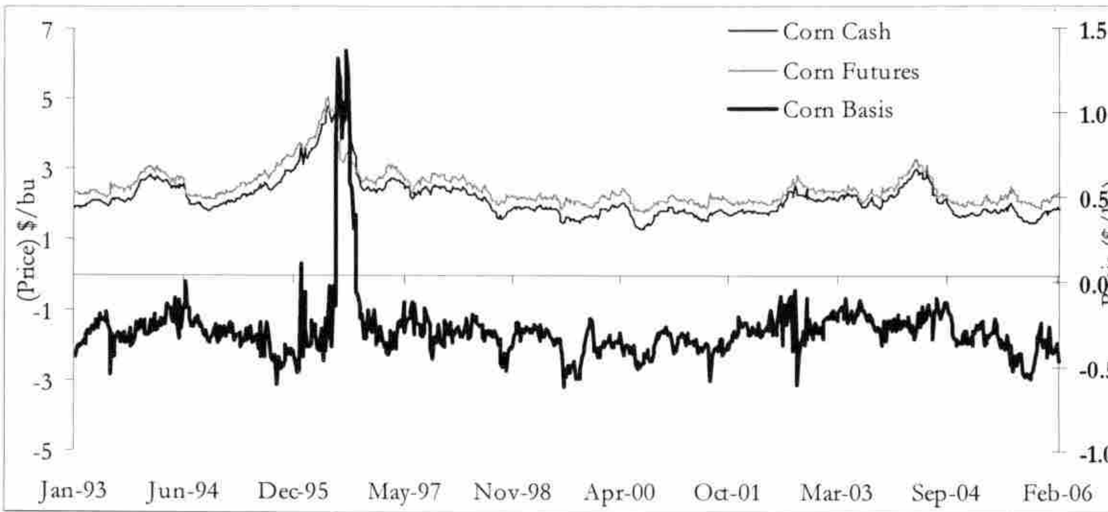


Figure 2.6. Basis between Central Iowa corn and nearby corn futures price (1993-2006)

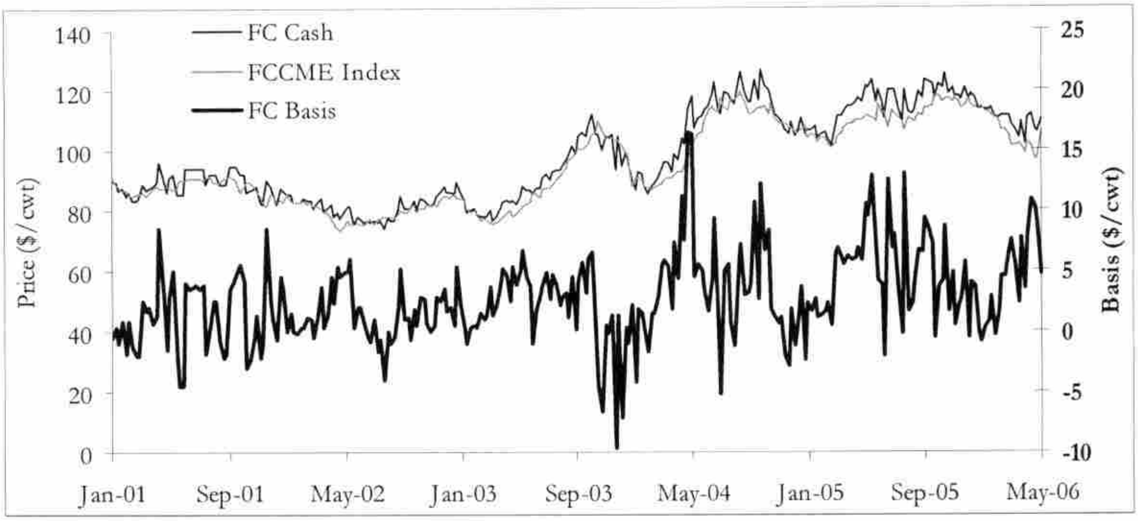


Figure 2.7. Basis between St. Joseph (MO) FC and the FCCME Index (1991-2006)

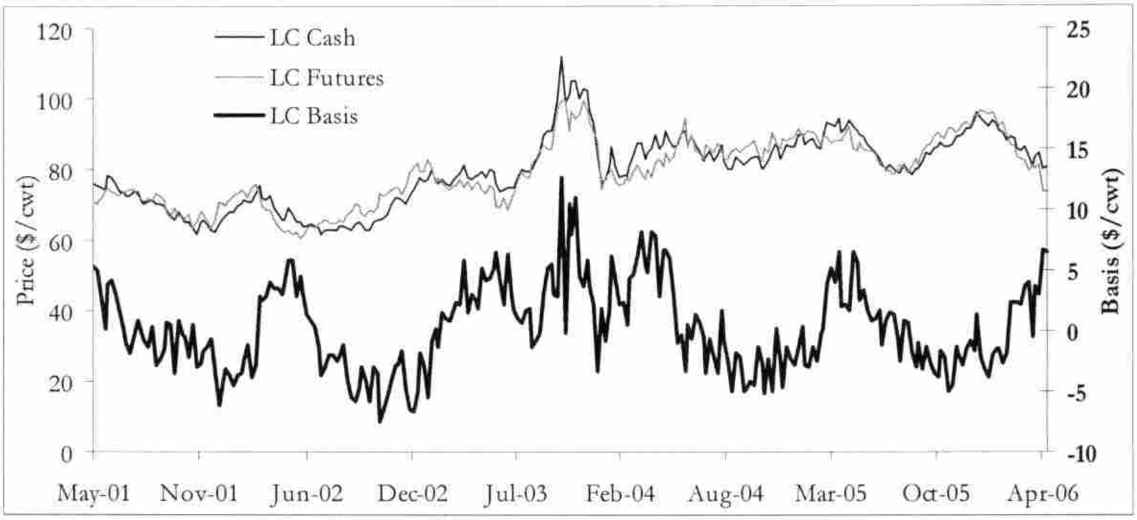


Figure 2.8. Basis between Iowa fed steers and nearby LC futures price (2001-2006)

Corn basis data (1993-2006) shows that Iowa corn priced on the cash market runs $0.28/bu below the CBOT nearby corn futures price (only 2% of the times the value was positive). The feeder cattle average basis for the period analyzed (1993-2006) was $2.71/cwt (only 25% of the time this basis was negative). Lastly, live cattle basis average during 2001-2006 was $0.26/cwt (20% of the time this basis was negative)[7].

Table 2.2 displays the implications of basis risk. Let's suppose that a cattle feeder shorts hedge one October live cattle futures contract at $84.47/cwt as soon as animals are placed on the feedlot. This means that the producer commits to deliver 40,000 lb of cattle in October at $84.47/cwt. Just before delivery, the cattle feeder offsets the live cattle futures contract position by buying back the contract. Under scenario 2, the cattle feeder buys back the futures contract at $85.98/cwt which means that he or she realized a lost of $1.51/cwt from this futures position ($84.74/cwt-$85.98/cwt). Then, the producer sells the cattle in the cash market at $88.20, which implies that the net selling price was $86.69, which fortunately is higher than the $84.74 that the producer found acceptable six months ago. This extra gain comes from the strengthening of the basis. However, this does not always happen and cattle feeders can lose unexpected money from a weakening on the basis as shows in Table 2.2.

[7] Feeder cattle futures have been settled in cash since 1986. The reasons behind this were the elimination of disputes associated with grading, the reduction of basis risk which, according to Elam and Davis (1990), was noticeably large even for par grade and weight steers, reducing costs of settling the futures position, and eliminating the need to transport the cattle.

Table 2.2. Live cattle buying hedge

Date	Cash Price	Future Price	Basis[a/]	Net Selling Price	Change in Cash and Futures Price	What Happened?
Today	$83.19	$84.47	-$1.28		--	Feeding process begun
6 months after - Scenario 1	$86.19	$87.92	-$1.73	$82.74	$\Delta^{+}_{Cash}<\Delta^{+}_{Futures}$	Basis weakened
6 months after - Scenario 2	$88.20	$85.98	$2.22	$86.69	$\Delta^{+}_{Cash}>\Delta^{+}_{Futures}$	Basis strengthened
6 months after - Scenario 3	$82.29	$83.72	-$1.43	$83.04	$\Delta^{-}_{Cash}<\Delta^{-}_{Futures}$	Basis weakened
6 months after - Scenario 4	$85.12	$83.41	$1.71	$86.18	$\Delta^{-}_{Cash}>\Delta^{-}_{Futures}$	Basis strengthened

[a/] Negative sign means that futures are greater than cash prices.

Technical analysis

As described by Greenfinch (1999), technical analysis assumes that markets have memory. If so, past prices or the current price momentum can give an idea of the future price evolution and may be also possible to extract above-normal gains by using some trading techniques (Garcia et al., 1988). Technical analysis is a tool that helps forecast future market activity and to detect whether a trend would persist or whether it would change. This type of analysis uses statistical and mathematical methods (e.g. confidence intervals, percentages changes, and volatility) as well as the use of visual presentations of the graphic signals (e.g. trends, patterns, and geometric figures formation) to forecast price movements. This kind of analysis is commonly used along with fundamental analysis, though, very often traders rely on technical analysis to study short term periods and depend on fundamental analysis to forecast long term processes.

Even though Fama's theory of efficiency markets have been around for many years and have received support from academics, some traders still doubt those type of markets exist. Perhaps, as it was described by Ball (2003), the theory of efficient markets is, like all theories, an imperfect and limited way of viewing financial markets. The disagreement is impossible to solve completely as long as there are so many binding limitations to the asset pricing models that underlie empirical tests of market efficiency. Moreover, excessive volatility, regulations (i.e. margin calls, stop loss limits, etc.), seasonal patterns, price overreactions, and asymmetry of information assimilation can make one question the existence of efficient markets. On top of that, market participants do not always behave rationally especially when they are not completely certain of the performance of the trading strategies that they apply (i.e. hedging tools to reduce price risk). Therefore, they don't necessarily make the decisions that could help them reach the expected profit (or at least the average profit) if using the futures market.

Despite the limitations, traders very often follow certain rules that allow them manage risk that accompany trading. Blackman (2004), for example, defines a trader's "perfect master plan" as one that has at least the following 10 essential concepts. A trader has to: a) be confident about the trading signals of the strategy, b) be mentally prepared to trade, c) set a risk level for the transactions that he or she is willing to tolerate, d) set realistic targets for a profit and risk/reward ratios, e) study the fundamentals that may affect the market in which the trader is going to operate (professional traders use probabilities and do not gamble), f) set alerts for entry and exit signals and make sure all signals can be easily seen or detected with a clear visual or auditory signals (i.e. label major and minor support and resistance levels), h) set entry rules, g) set exit rules, i) keep excellent records, and j) keep a trading journal for later reference.

Researches have often focused on evaluating the effect that applying technical tools has on profitability. Franzmann (1976), Enen (1979), and Gorman et al. (1985) found that proper use of technical tools can lead to a positive profit and to a better use of hedging strategies. They also pointed out that carefully chosen strategies reduce the average loss and volatility of the returns in the cattle market. In addition, Park and Irwin (2005) showed that the best trading rules identified generated positive annual mean net returns, though, technical trading rules were not profitable after correcting for transaction costs, risk, and data snooping biases during the period from 1985 to 2004.

Long and short moving averages

According to Barnes (1979), the basic assumption of the (arithmetic) moving-average approach is very similar to that of the trend line method for charting; the growth of the trend line is considered to be linear. However, the simple moving average method based the trend's growth line on the latest price, and not on the very first as trend lines do. This implies that the growth line may change and is only related to the latest prices. The moving-average method gives equal weight to each price used in determining the growth line, while the trend line technique gives weight to the growth line determination for only those (two) price points that form the two tops and bottoms in the price series.

Mathematically, the simple moving average is equal to the mean of the previous *n* values in a sequence of data. Moving averages are used to smooth the data and to generate more clarity in the trends. According to Kenney and Keeping (1962), given a sequence $\{a_i\}_{i=1}^{N}$, an *n*-moving average m_i is a new sequence $\{d_j\}_{i=1}^{N-n+1}$ defined from the d_j sequence by taking the average of the subsequences of *n* (*n* is the number of the periods for calculating the moving average) terms as follows:

$$m_i = \frac{1}{n} \sum_{j=i}^{i+n-1} d_j$$

The long average shows the trend and the short average helps to describe the changes in the trend. As Barnes (1982) described, the underlying assumption is that the moving average line of current prices represents the current growth line of the trend. If the actual price diverges significantly from this growth trend, for example, if it goes below the line in a bull trend or above the line in a bear trend, the current trend itself is then believed, and a change in the actual prices to a new, oppositely directed trend has probably occurred.

Quite often traders dealing with moving averages use two of them– long and short. The short average is based on fewer days' raw data than the long average. If the short average crosses the long average from above, then the market is considered to assume a downtrend. In contrast, an increase in the price of the commodity is expected when the short average crosses the long average from below (Figure 2.8). In other words, a crossing on the upside causes a buy signal, and a crossing on the downside generates a sell signal (Brown (1999)).

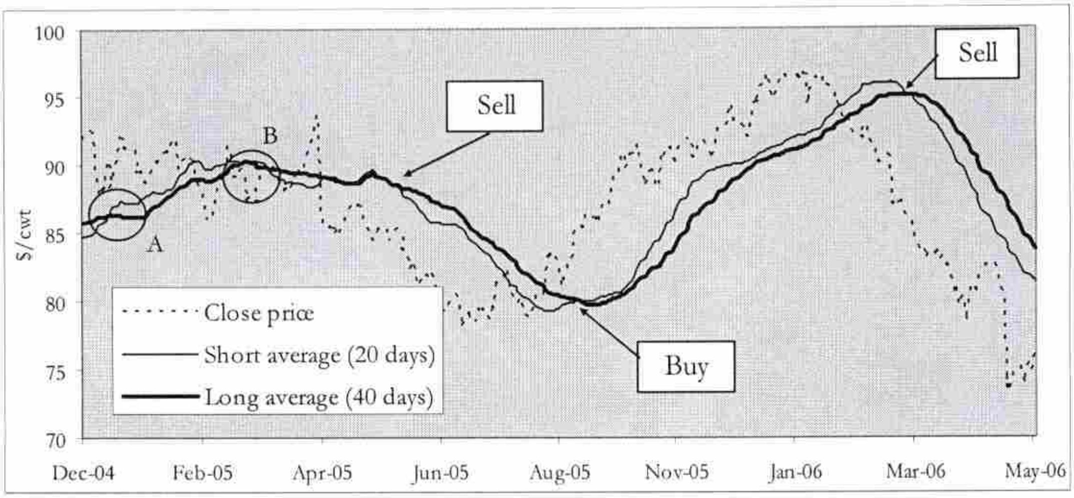


Figure 2.9. Moving averages on the live cattle futures markets

It is important to notice that buying and selling signals are not always correct. As depicted in Figure 2.8, when the buy signal appeared (point A) the price of the live cattle futures contract was higher than when the sell signal took place (point B) and money would have been lost if the strategy was applied in the actual trading decision.

Momentums and oscillators – Mean and standard deviation

Kaufam (1978) defined the study of momentum and oscillators as the analysis of changes in price rather than price levels. It establishes the pace of the commodity, the rate of ascent or descent. A system that takes advantage of the momentum extremes must be able to measure them. The simplest way is to represent two horizontal lines above or below the "zero" line in such a way that the tops and bottoms of major moves are isolated. A statistical approach to this measure involves the use of the average price of the asset past data as the "zero" line, plus/minus a certain constant (often subjective) that multiplies the standard deviation from the past of the asset price to generate the trading band. In theory, prices of the commodity should return back to the mid price after going outside the band. Figure 2.9 depicts this type of strategy for the daily live cattle futures close prices and uses the average of the previous two years as the "zero" line; the limits are defined as the average plus/minus one standard deviation during the mentioned period.

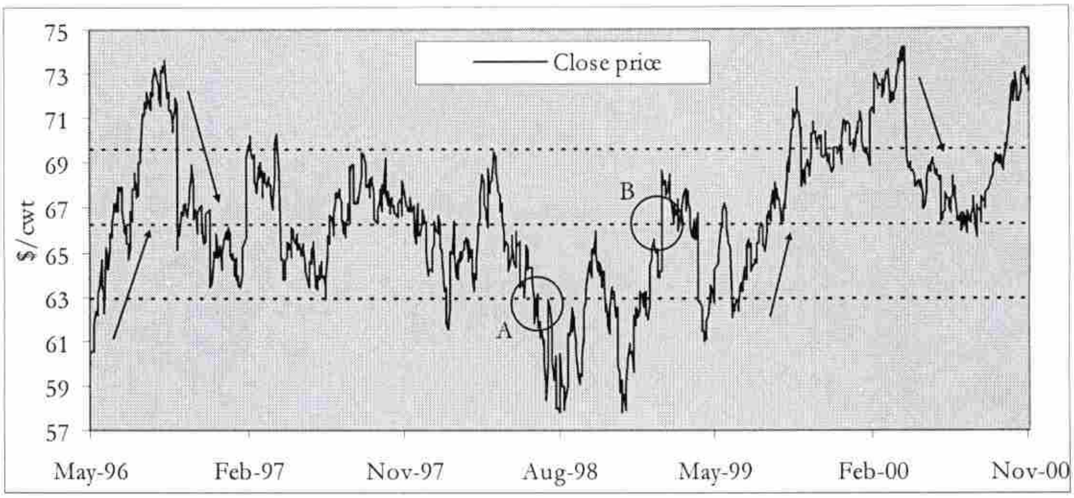


Figure 2.10. Corresponding momentum in the live cattle futures markets (1996-2000)

This strategy, although based on statistical analysis, is not simple and requires constant inspection and financial muscle from the agent that uses it. The analyst must define the kind of average that will be used as a "zero" line as well as the number of standard deviations to calculate the upper and lower limits. In addition, traders that use this kind of strategy should have enough monetary resources to hold the position until the expected market movement occurs. As Figure 2.9 illustrates, traders that took positions on live cattle futures contracts in July of 1998 (point A) had to wait for four months until the stock touched the "zero" line (point B). Without the proper financial strength some of them may have sold their position before the end of the fourth month and, therefore, incurred a loss. In contrast, a trader who had enough funds to hold the position during those four months would have earned 5.25% on that particular trade.

Momentums and oscillators – Relative Strength Index (RSI)

The relative strength index is called an oscillator because it is an index (ranges from 0 to 100) that tends to bounce around between the value of the lower and the upper limits. As described by Murphy (1999) it uses the information on gains and losses during a certain period of time to define whether a market is oversold or overbought. The RSI is calculated as follows:

$$RSI = 100 - \frac{100}{1 + RS}, \qquad \text{where} \qquad RS = \frac{\textit{Average of n days' up closes}}{\textit{Average of n days' down closes}}$$

The number of days used (*n*) for the calculation of the relative strength (RS) depends on the sensitivity that the annalist wants to give to the index. The shorter the time period, the more sensitive the oscillator becomes and the wider its amplitude is. Three important features of the RSI are: a) it provides certain smoothing of the time series studied, b) it creates a constant vertical range of 0 to 100, and c) if the average loss ever becomes zero, RSI becomes 100 by definition. In Figure 2.10 the data for the live cattle futures market was used to calculate the RSI while a 28-day period was used to smooth out the RSI.

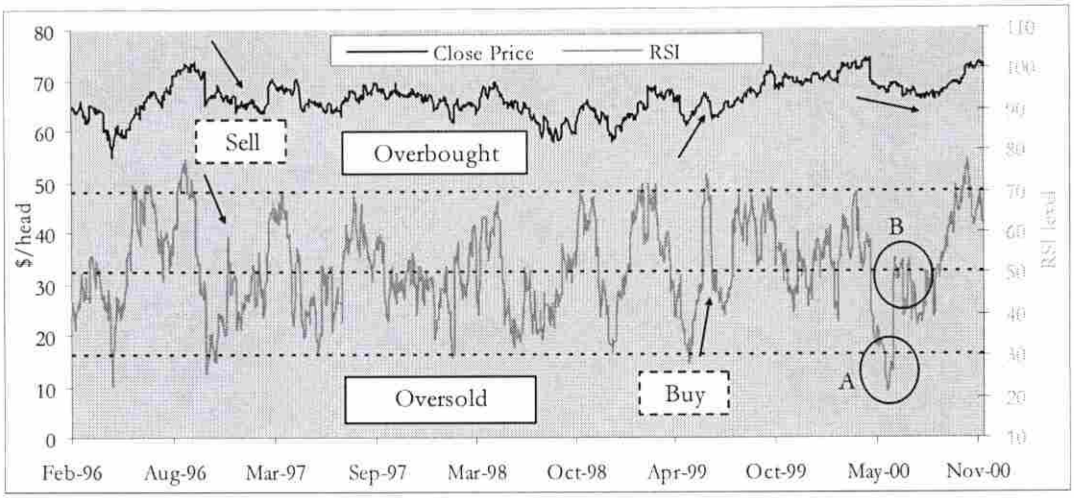


Figure 2.11. RSI (n=28) for the live cattle futures markets (1996-2000)

The band in the previous figure was set using 70 and 30 as overbought and oversold levels, respectively. Usually, if the RSI crosses the 30 line it is considered a warning for bullish tendency for the asset. If the RSI crosses the 70 line it is a warning for a bearish market. In other words, in an oversold market a crossing back above the 30 line it is taken by many traders as a confirmation of an uptrend. In contrast, in an overbought market a crossing back under the 70 line can be used as a sell signal. In addition, the 50 level is also used by many traders as a market indicator. When the RSI crosses above 50 it can be interpreted as a buy signal, and when the RSI falls under 50 it can be considered as a sell signal.

One disadvantage of this strategy is that large increases and drops in a commodity price may affect the RSI by creating false buy or sell indicators, as it is showed by in Figure 2.10 (the RSI level wrongly suggested buying the futures contract at point A at $68.83 and selling it latter at point B at $67.53).

CHAPTER 3. DATA CONSTRUCTION

Description of the cattle crush spread (CCS)

The cattle crush spread is an intermarket spread in which, in theory, a transaction is made for a particular crush value rather than making individual trades in each of the spread components. It is defined as the difference between the sales value of live cattle and the combined cost of corn and feeder cattle at a certain point in time. In the futures market, the minimum cattle crush that can be negotiated involves going long in one corn and one feeder cattle futures contract and going short in two live cattle futures contracts to try to more closely match quantities.[8] Producers benefit if spot prices of corn and feeder cattle at the maturity of the contract exceed the delivery prices K_{CO} and K_{FC}, respectively. They also benefit if the spot price of live cattle at the maturity of the contract falls below the delivery price K_{LC} (position diagrams are depicted in Figure 3.1).

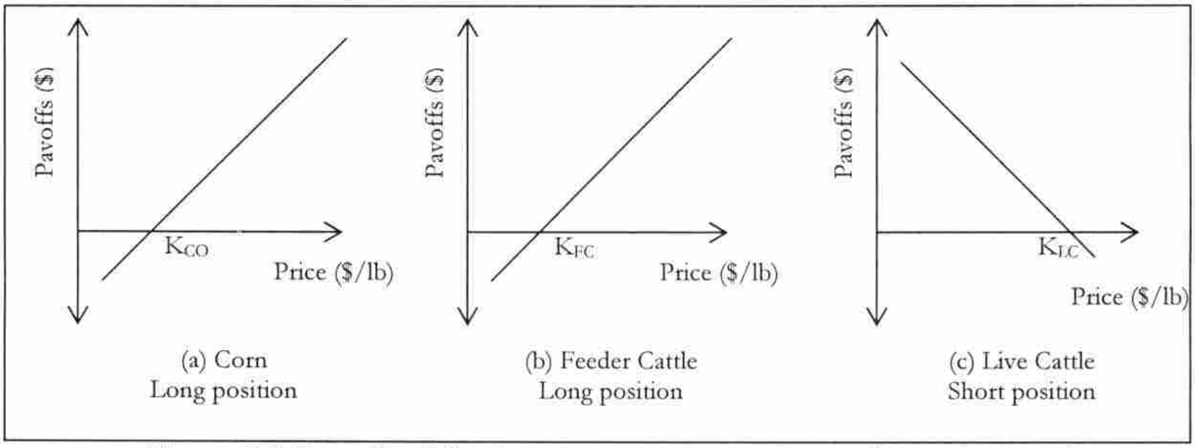


Figure 3.1. Payoffs of the futures contracts on the cattle crush spread

[8] For clarity purposes selling (or going short) the crush will mean buying one corn and one feeder cattle futures contracts and selling two live cattle futures contracts. Conversely, buying (or going long) the crush will mean selling one corn and one feeder cattle futures contracts and buying two live cattle futures contracts (this is also called reversing the crush).

In essence, producers try to sell the crush for as much as they can and attempt to buy it back (unwind the position) for as little as they can. In the case of a successful execution of this strategy, a producer receives extra benefits from trading the contracts before the cattle are fed. This additional benefit is added to feeding returns once the cattle are actually sold on the market. When a cattle feeder trades the crush, specific amounts of inputs and outputs are hedged. The head coverage for a 170-day feeding period that an Iowa cattle feeder receives when trading the crush are depicted in Figure 3.2.

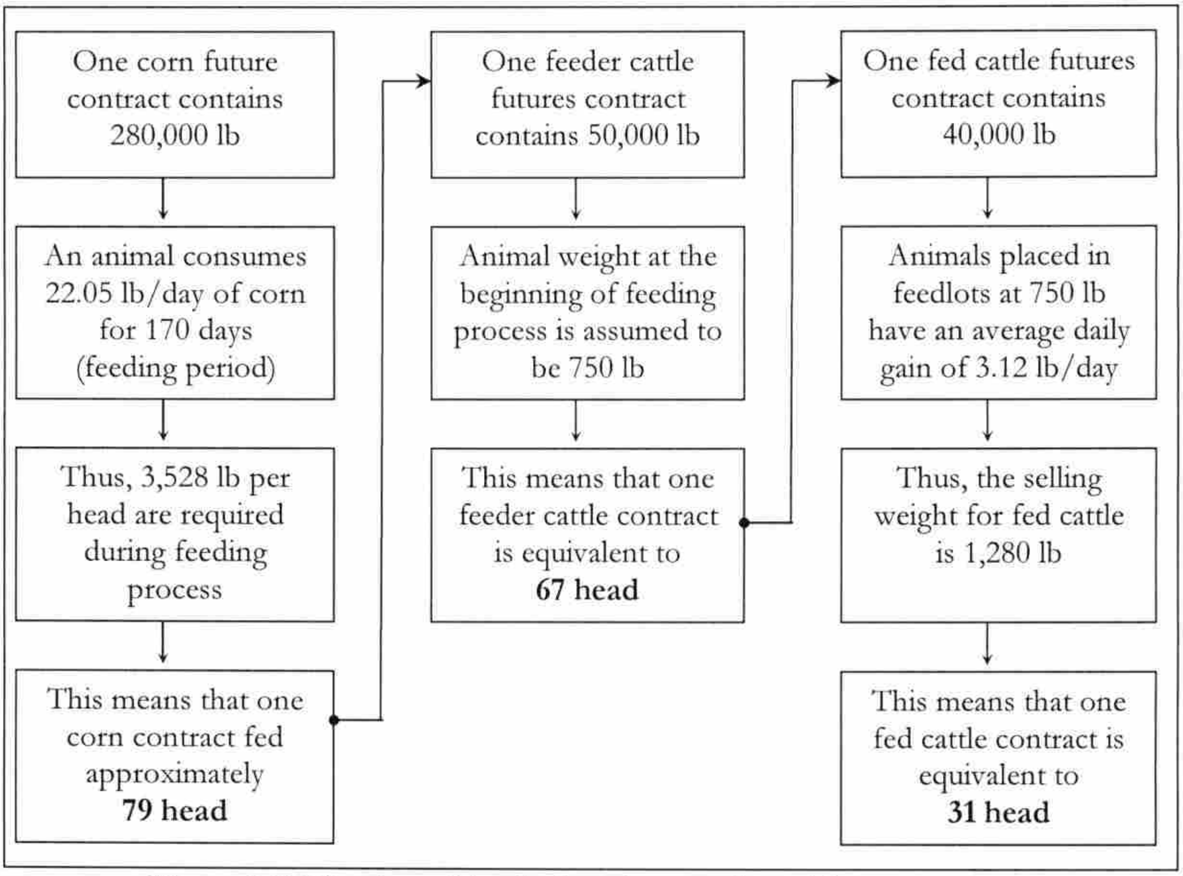


Figure 3.2. Number of head of cattle per selected futures contract

There is an issue that is important to mention here. Entering in the crush defined in figure 3.2 implies that an Iowa producer will have a coverage ratio of 79:67:62 head or 0.74:0.94:2

contracts of corn, feeder cattle, and live cattle, respectively. However, producers can not buy fractions of futures contracts and therefore, the minimal amount that they can use is 1:1:2 to hedge 62 head. This generates coverage risk because corn and feeder cattle are not perfectly hedged (i.e. over-hedged). In addition, the size of the futures contract can also be problematic for producers. In an empirical study Gordam et al. (1982) called attention to the fact that the pens of cattle rarely match up exactly with a total weight of 40,000 pounds of the futures contract. As they pointed out, a pen containing 100 head of steers that are expected to weigh on average 1,050 pounds each when sold is equivalent to 105,000 pounds of live cattle. The nearest total weight of a futures contract that could be obtained was three (40,000 pounds × 3 = 120,000 pounds). This means that producers finish up having 15,000 more pounds in futures than they have in live cattle.

Since cattle have to reach a particular weight before they can be sold, the time they spend in the feedlot and the feed provided has a direct effect on the number of contracts of corn and feeder cattle that are required to hedge the production. Indeed, animals that stayed in feedlots for longer periods entered the feedlot lighter than those that remained there for shorter periods. This also generates disparities on the cattle crush proportion as described at the bottom of Table 3.1.

Table 3.1. Cattle crush proportion calculation for Iowa*

Corn Futures Contract			
Days on feed	110	170	250
Corn needed (lb/day)	25.20	19.60	20.04
Total corn needed (lb)	2,772	3,332	5,010
Contract size (lb)	280,000	280,000	280,000
Head fed per contract	101	84	56
Feeder Cattle Futures Contract			
Contract size (lb)	50,000	50,000	50,000
Initial weight (lb)	797	750	567
Head per contract	63	67	88
Live Cattle Futures Contract			
Contract size (lb)	40,000	40,000	40,000
Average gain (lb/day)	3.63	3.12	3.02
Slaughter weight (lb)	1,196	1,280	1,322
Head per contract	33	31	30
Cattle Crush Proportion			
Corn futures	0.66	0.74	1.08
Feeder cattle	1.07	0.94	0.69
Live cattle	2.00	2.00	2.00

* Data for the 110 and 250 days scenarios were calculated from the TCSCF data.

Uses of the cattle crush spread

The cattle crush spread is a tool that can be employed in two different ways to avoid exposure to the risk of variable prices (Figure 3.3):

- **As a pre-placement hedging tool.** Cattle feeders that have an ongoing operation can trade the spread during a certain period before animals are placed in feedlots (circa 138 business days). In doing this, producers hedge the risk of input price variation and get a profit (loss) from trading the crush. Once animals enter the feedlot producers can: a) decide not to hedge the cattle that are being fed in the feedyard (cash market strategy), or b) unwind the total of the crush and go short in a new live cattle futures contract.

- **As a post-placement hedging tool.** Cattle feeders can leave active the live cattle futures contract that was shorted during the pre-placement period. They then receive profit (losses) from shorting live cattle contracts for a longer period and from trading the crush during the pre-placement period.

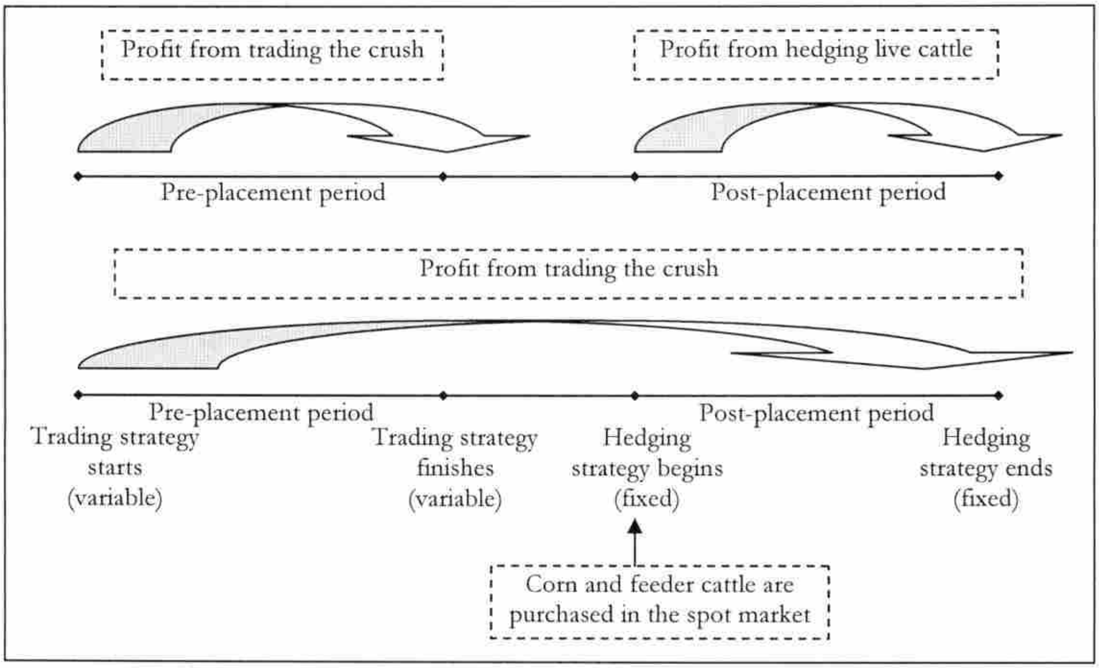
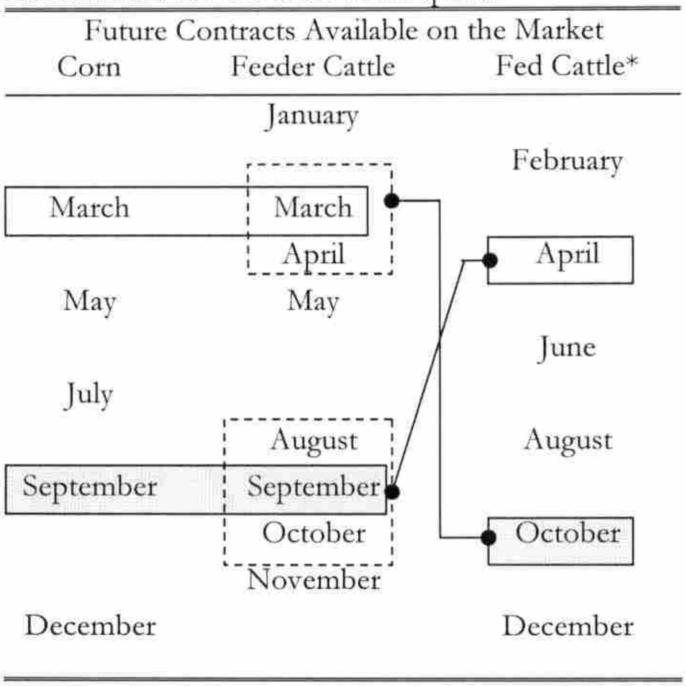


Figure 3.3. Pre-placement and post-placement strategies

Cattle crush futures contract combinations

Now it is necessary to determine the months in which the future contracts will be traded if a feeding period of six months (i.e. 170 days) is assumed. To deal with this subject various arrangements of futures contracts can be used, though, this study focuses on the combinations that involve marketing fed cattle in April and October (Table 3.2)[9]. The April and October strategy for yearling steers in Iowa kept the feedlot full by selling finished cattle and immediately buying feeder cattle. This was the most profitable strategy on average for the period 1994 to 2004 (Aguiar and Lawrence (2005)).

Table 3.2. Contracts combinations for the cattle crush spread



* Contract for the even monthly cycle.

Subsequently, the arrangement of March futures contracts of corn and feeder cattle with October live futures contracts, and the September futures contracts of corn and feeder cattle with April live futures contracts were the ones analyzed in this study (from now on these combinations will be called mar/mar/oct and sep/sep/apr).[10] It is important to notice that a feedlot operator that starts feeding steers in April is assumed to use the March corn contract

[9] In doing this, cattle producers are assumed to use the March and September live cattle futures contracts.

[10] The mar/apr/oct, sep/aug/apr, and sep/oct/apr contract combinations can also be suitable for the 170-days feeding period. However, these crushes are highly correlated (ρ>0.8) to the mar/mar/oct and sep/sep/apr, respectively.

given the absence of the future contract for April. Table 3.3 depicts the delivery dates in 2006 for producers that trade the commodities hedged by the crush.

Table 3.3. Delivery dates for selected futures contracts

Expected Delivery (or Ending) Month of the Contract		Days on Feed	Ready to Sell Cattle on	Nearest Live Cattle Contract
Corn	Feeder Cattle			
Mar 16, 2006	Mar 30, 2006	170	Sep 16, 2006	Oct, 2006
Sep 18, 2006	Sep 28, 2006	170	Mar 17, 2007	Apr, 2007

Cattle crush spread calculation

The cattle crush spread is calculated using the market prices of the futures contracts. The following equation describes the way to assess the spread from the crush.

$$CCS_{t,m/m/m+6} = \frac{[2\times\frac{LC_{t,m+6}}{100}\left(\frac{\$}{lb}\right)\times 40{,}000\,lb - 1\times\frac{FC_{t,m}}{100}\left(\frac{\$}{lb}\right)\times 50{,}000\,lb - 1\times\frac{CO_{t,m}}{100}\left(\frac{\$}{bu}\right)\times 5{,}000\,bu]}{500}$$

Where $CCS_{t,m/m/m+6}$ stands for "cattle crush spread" at day t for the $m/m/m+6$ futures contracts combination and it is reported in \$/cwt of feeder cattle (or 500 cwt that are equivalent to 67 head). $LC_{t,m+6}$ is the live cattle futures contract price at day t for the month $m+6$, $CO_{t,m}$ is the corn futures contract price at day t for the month m, and $FC_{t,m}$ is the feeder futures contract price at day t for the month m. As mentioned earlier, two live cattle contracts, one feeder cattle futures contract, and one corn futures contract were assumed to compute the cattle crush (1:1:2 coefficients in the equation).

Figures 3.4 and 3.5 show plots of the evolution of the selected cattle crush spreads from 1995 to 2006. These graphs do not represent a continuous time series because the cattle crush was built according to the life of the contracts for each combination.

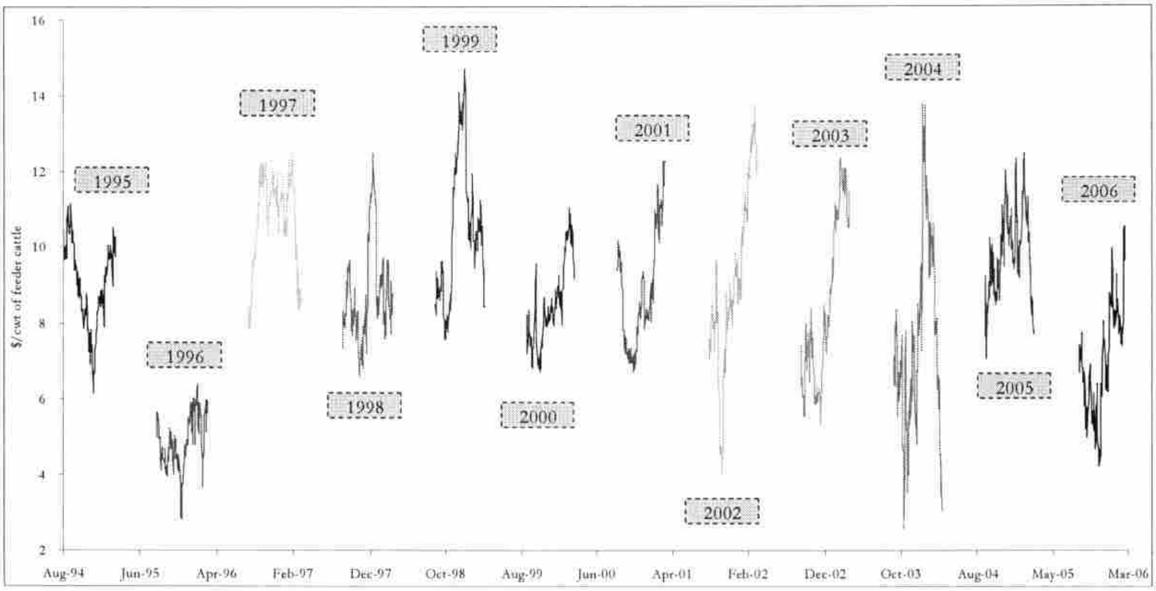


Figure 3.4. Cattle crush spread for the mar/mar/oct combination (1995-2006)

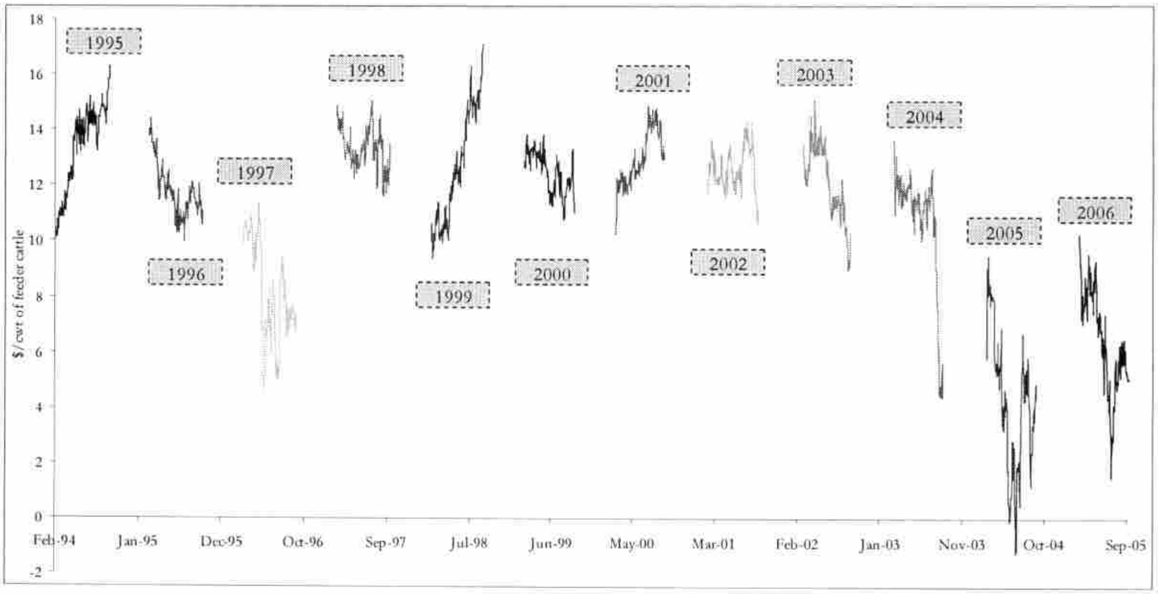


Figure 3.5. Cattle crush spread for the sep/sep/apr combination (1995-2006)

After analyzing the evolution of the time series, a number of conclusions can be drawn: a) after a graphical analysis of the results no seasonal behavior was found in the data, b) there is not a consistent correlation between the value of the crush and the price of the live cattle futures contracts (Table B.1), c) high prices for corn in 1996 had an impact on the level of the spread in 1996 and 1997 due to the fact that live cattle futures prices did not increase to compensate for the higher cost of production inputs, d) the lack of liquidity on the futures market at the end of the spread life might be the cause of the high volatility of the crush at the end of the majority of the years (especially 1999 and 2004), and e) negative cattle crush spreads can be possible as they happened on five occasions in June of 2005 for the sep/sep/apr combination due to a rapid rise in the price of feeder cattle while live cattle futures contract prices remained virtually the same over the course of that month.

Cattle crush spread comparative statistics

As explained in Table 3.4, the way that contracts are combined has an effect on the level of the cattle crush spread. Indeed, for the sep/sep/apr the average spread was larger that the one observed for the mar/mar/apr ($10.91/cwt vs. $8.6/cwt). Besides, both combinations depicted similar volatility (near $1.5/cwt) and were negatively correlated (ϱ=-0.09). It is important to clarify that the spread that was calculated here is based on the ratio 1:1:2, which as it was shown at the beginning of this chapter, means that producers incurred an extra production cost from over-hedging corn and feeder cattle that is not reflected in the number of cattle sold. This negatively affects the level of the spread.

Table 3.4. Cattle crush spread summary of results ($/cwt of feeder cattle)

Futures Contacts Combination	Year	Trading Period Initial	Trading Period Final	Pre-placement Business Days	Spread Max	Spread Min	Spread Average	Spread Std. Dev.
Mar/Mar/Oct	1995	31-Aug-94	22-Mar-95	141	11.16	6.16	8.97	1.09
	1996	30-Aug-95	21-Mar-96	142	6.42	2.83	4.86	0.74
	1997	26-Aug-96	19-Mar-97	143	12.45	7.80	10.76	1.20
	1998	02-Sep-97	20-Mar-98	139	12.47	6.58	8.83	1.27
	1999	03-Sep-98	22-Mar-99	137	14.70	7.58	10.44	1.87
	2000	07-Sep-99	14-Mar-00	132	11.03	6.73	8.50	1.10
	2001	01-Sep-00	14-Mar-01	133	12.31	6.72	8.84	1.51
	2002	05-Sep-01	14-Mar-02	130	13.80	4.02	9.14	2.32
	2003	03-Sep-02	14-Mar-03	133	12.35	5.28	8.49	2.15
	2004	05-Sep-03	12-Mar-04	131	13.78	2.53	7.55	2.42
	2005	01-Sep-04	14-Mar-05	133	12.48	7.05	9.90	1.11
	2006	12-Sep-05	14-Mar-06	127	10.52	4.22	6.98	1.42
			Mean	**135**	**11.95**	**5.63**	**8.60**	**1.52**
Sep/Sep/Apr	1995	22-Feb-94	21-Sep-94	148	16.30	10.04	13.31	1.56
	1996	22-Feb-95	20-Sep-95	145	14.38	9.98	11.79	0.97
	1997	23-Feb-96	19-Sep-96	146	11.37	4.65	8.21	1.76
	1998	24-Feb-97	19-Sep-97	146	15.05	11.58	13.31	0.75
	1999	02-Mar-98	21-Sep-98	142	17.09	9.35	12.64	2.03
	2000	04-Mar-99	21-Sep-99	140	13.85	10.78	12.47	0.73
	2001	01-Mar-00	14-Sep-00	138	14.86	10.24	12.98	1.01
	2002	01-Mar-01	14-Sep-01	136	14.27	10.61	12.67	0.74
	2003	13-Mar-02	13-Sep-02	129	15.10	8.92	12.14	1.35
	2004	03-Mar-03	11-Sep-03	135	13.60	4.33	10.71	2.12
	2005	01-Mar-04	14-Sep-04	137	9.45	-1.25	4.23	2.50
	2006	01-Mar-05	14-Sep-05	138	10.25	1.46	6.47	1.83
			Mean	**140**	**13.80**	**7.56**	**10.91**	**1.45**

The distribution of the spread proved not to be normal with an estimated mean of $9.76/cwt and standard deviation of $3.03/cwt (Kolmogorov-Smirnov test statistic was 0.0645) which may be a sign of an imbalance that exists between buyers and sellers generating three different levels of spreads (circles in Figure 3.6). In addition, the distribution of the first difference of prices was more similar to the "bell-shaped" curve; though, the true cumulative distribution function was not a normally distributed one with an estimated mean of -0.0041 and a standard deviation of 0.45 (Kolmogorov-Smirnov test statistic was 0.0368). It is important to notice that there was still a number of observations located close to the tails which may be a sign of some abnormal behavior that some traders would use as a trading advantage (Figure 3.7).

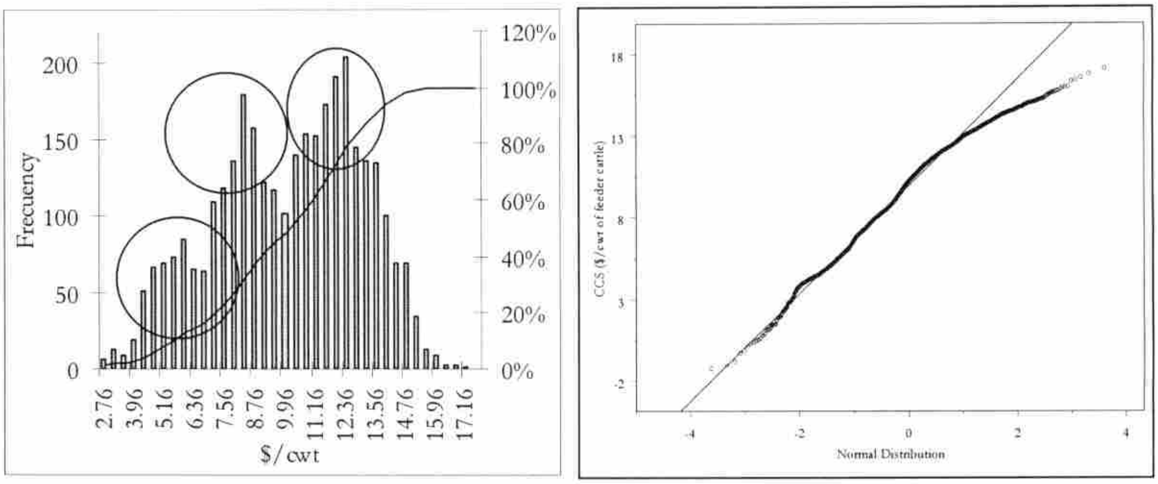


Figure 3.6. Distribution of the crush spreads (170-day feeding period)

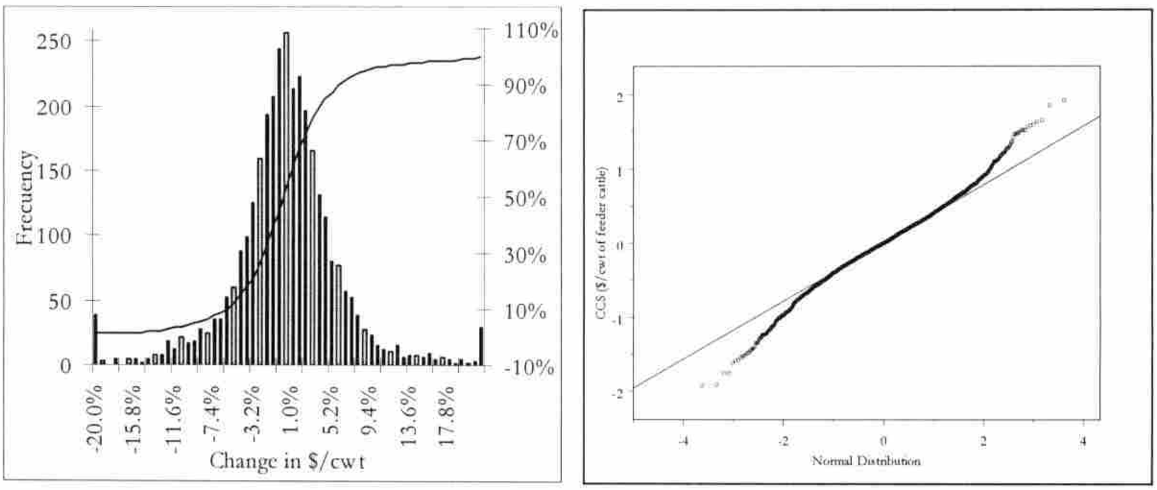


Figure 3.7. Distribution of the crush spreads daily variation (170-day feeding period)

An example of trading the crush

Suppose that in 2004 an Iowa feedlot operator put together a plan to start feeding steers at the beginning of April of 2005 to then market the cattle in mid September of the same year. The cattle crush spreads that suited this plan was the mar/mar/oct combination, which became available on September 1st, 2004 (i.e. 133 days before cattle were placed in the feedlot) at $7.65/cwt. Let's suppose that the producer, based on previous behavior of the crush, decided that it would be beneficial to sell the crush as soon as it exceeded $11/cwt. This happened on November 19th of 2004 when it reached $11.02/cwt. Similarly, the producer had the rule of unwinding the position as soon the spread fell under $8/cwt. This took place on March 11th of 2005 when it worth $7.99/cwt. The preceding operation means that the cattle feeder accepted delivery of 280,000 lb of corn and 50,000 lb of feeder cattle in March and committed to deliver 80,000 lb of live cattle in October at a spread of $11.02/cwt. However, he or she offset the crush before the delivery date of the underlying commodities by buying it back at $7.99/cwt. As it can be observed in Table 3.5, the producer obtained a significant profit from selling corn and feeder cattle futures contracts at a higher price than they were bought for, while there was a money loss for trading the live cattle futures contracts due the fact that the two contracts were bought back at a higher price than the purchase price. Despite of that loss, the producer ended up making a net profit of 27.46% or $3.03/cwt from trading the crush.

Table 3.5. Example of payoffs from trading the mar/mar/oct cattle crush spread

Future Contract	November 19, 2004			March 11, 2005			CCS Profit
	Action	Contract Price	CCS Component	Action	Contract Price	CCS Component	
Live Cattle	Sell	80.10	128.16	Buy	84.15	134.64	-6.48
Feeder Cattle	Buy	96.12	96.12	Sell	104.9	104.90	8.78
Corn	Buy	210.25	21.03	Sell	217.5	21.75	0.73
CCS	**Sell**	-	**11.02**	**Buy**	-	**7.99**	**3.03**

CHAPTER 4. DATA ANALYSIS AND INTERPRETATION

This chapter presents an evaluation of the strategies and rules based on the technical analysis methods described in chapter 2. This chapter is divided in two parts: a) the first part contains an evaluation of the trading strategies applied on the cattle crush before the cattle are placed in the feedlot, b) the second part discusses the strategies that are applied at any time after that and up to the day the cattle are marketed. The methods described here were applied to the cattle crush spread resulting from the contract combinations mar/mar/oct and sep/sep/apr (Table 4.1).

Table 4.1. Summary of rules used to trade the spread during the pre-placement period

Trading Strategy	Sell Cattle Crush When…	Buy Back Crush When…
Naïve (Figures A.4 and A.9)	It becomes available	Last day of availability of the corn futures contract
Threshold* (Figures A.5 and A.10)	For mar/mar/oct when CCS>\$11.15/cwt; for sep/sep/apr when CCS>\$13.59/cwt	For mar/mar/oct when CCS<\$7.80/cwt; for sep/sep/apr when CCS<\$11.62/cwt
Moving Averages (Figures A.6 and A.11)	MA(5) penetrates MA(15) from the top	When MA(5) crosses MA(15) from the bottom
Momentum (Figures A.7 and A.12)	Cattle crush overshoots the upper limit defined by $\overline{X}_{1995} + \frac{2}{3}\sigma_{1995}$	Cattle crush crosses the "zero" line
RSI (Figures A.8 and A.13)	Cattle crush spread level exceeds the 70 value for two consecutives days	Cattle crush spread level was under the 50 value for two consecutives days

* Recall that the values of the CCS are expressed in \$/cwt of feeder cattle.

To assess the trading profits, it was assumed a commission and fee cost of negotiation of one futures contract of \$36 round-turn (this is equivalent to \$0.29/cwt per crush negotiated). In addition, no margin accounts were assumed in this evaluation, and therefore, there were no margin calls and no interest earned. Lastly, the initial days of trading varied with the type of strategy used (see tables B.2. and B.3).

Pre-placement strategies

The following are the descriptions of the trading strategies applied on the cattle crush spread. Numerical outcomes of these strategies can be found in Tables 4.2 and 4.3 while Figures A.4 to A.12 in the appendix are the corresponding graphical representations.

- **Naïve strategy.** The cattle crush spread was shorted the first available trading day and bought back the last negotiation day. Recall that the cattle crush spread becomes available when the live cattle futures contract does, while the last trading day of the crush matches the last trading day of the corn futures contract (which ends around two weeks before the feeder cattle futures contract). Under this fixed strategy, only a crush downtrend (measured from beginning point to end point) is profitable (before trading costs). This positive behavior happened only three times for the mar/mar/oct combinations, but it happened nine times for the sep/sep/apr arrangement.

- **Threshold strategy.** Two threshold levels were calculated as the best possible entry and exit values in each of the crushes analyzed. A simulation was conducted to find the values of the limits that maximized the average profit of the years analyzed subject to the fact that the rule has to be applicable on all of the 12 years studied. The limits used for the mar/mar/oct were: a) the crush was sold when the crush value exceeded $11.15/cwt and bought back as soon as the crush was under $7.80/cwt, or b) the crush was bought as soon as the crush value dropped under $7.80/cwt and was sold when crush value exceeded $11.15/cwt[11]. The limits used for the sep/sep/apr were: a) the crush was sold when its value exceeded $13.59/cwt and bought back as soon as its value was under $11.62/cwt, or b) the crush was bought as soon as the crush value fell under $11.62/cwt and was sold when crush value exceeded $13.59/cwt. Lastly, if it happened that only one of the levels was penetrated and the position was left open, it was offset on the last trading day of the cattle crush.

The addition of entry and exit limits as well as the possibility for producers to go short or long on the crush made this strategy flexible and improved the returns that were obtained. Indeed, 11 out of the 12 years analyzed showed positive returns (before and after commissions) for the mar/mar/oct combination while nine of the returns (before and after commissions) for the sep/sep/apr were positive.

- **Moving averages strategy.** Short-term (5 days) and a long-term (15 days) moving averages were calculated to create a trading rule. Under this, the crush was sold when the MA(5) crossed the MA(15) from the top and bought back when the MA(5) penetrated the MA(15) from the bottom. This strategy was applied as many times as the signals were generated. Again, if it happened that the last negotiation signal left the position open, the crush was sold or bought (depending on the last action taken) on the last trading day of the cattle crush.

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[11] If a higher value for the upper limit were used (say $11.16/cwt) the rule would not have been applicable for 1996. On contrast, if a lower number for the upper limit were used (say $7.79/cwt) average profit would not have been the maximum.

The performance of the moving average was somewhat disappointing because trading costs and the sharp movement of the crush's level both hurt the returns. For the mar/mar/oct combination, seven years showed positive returns (before commissions) and only three years proved to be positive returns (before commissions) for the sep/sep/apr. When the trade cost was added, those numbers dropped to two and zero respectively.

- **Momentum strategy.** The "zero" line and the standard deviation were calculated using the 1995's cattle crush spread data. For both futures contract combinations the upper and the lower limits were calculated adding and subtracting 2/3 of 1995's cattle crush spread standard deviation. Cattle feeders were assumed to short the crush as soon as it was available on the market. [12] This initial short position was offset when either of the following two happened: a) the crush value crossed the "zero" line, or b) the current value of the spread was larger than the initial value of the spread plus/minus 1/2 of the year 1995 standard deviation (gain level and stop loss level). Once the initial short position was unwound, the crush was: a) bought if its value crossed the lower limit, or b) sold if its value crossed the upper limit. Both positions were offset as soon as the spread crossed the "zero" line or the stop loss level was reached.

To prevent the crush spread from being outside the trading area, the "zero" line was recalculated every time the crush spread remained outside the band for 30 consecutive trading days. When this happened a new "zero" line was computed using the average for the previous five business days of the crush negotiation (the standard deviation remained the

[12] This initial short position was created with the objective of taking advantage of possible reductions of the price of the crush in the first days of its trading life.

same). If it happened that the last trading signal left the position open the crush was sold or bought (depending on the last position assumed) on the last day of the crush negotiations.

This was a more elaborate strategy that mixed dynamics with static rules and required trading skills. The performance of the strategy was fine, although the volatility of returns increased. Both combinations of futures contracts showed 10 years of positive returns.

- **RSI strategy.** The crush was: a) sold if the RSI stayed above the 70 level (overbought line) for at least two consecutives days and bought back if the RSI stayed under the 50 level for at least two consecutives days, or b) bought if the RSI stayed under the 30 level (oversold line) for at least two consecutives and was sold back when the RSI stayed above the 50 level line for at least two days. The mar/mar/oct combination showed eight years of positive returns while there were seven for the sep/sep/apr arrangement.

Additional results of trading the mar/mar/oct combination

As it is shown in Table 4.2 three of the strategies evaluated showed positive benefits (threshold, momentum and RSI), however, when trading costs were taking in account only the threshold strategy and the momentum strategy remained positive. The threshold strategy was the one with better performance at a lower cost although its lack of flexibility reduced its hedging power. Indeed, the pre-placement hedging from this strategy covered in average only 90 of the 145 business days that the crush was available before cattle entered the feedlot, letting the producer exposed to price variability of inputs for 55 days before animals were placed.

Interestingly, the moving average strategy was the most expensive one to implement and it had the worst performance even though it was an easy-to-follow dynamic strategy. The largest net losses from applying this method happened in 2006 ($8.28/cwt of feeder cattle was the loss). The moving average strategy did not perform well when the market tendency was flat although volatile. In contrast, the highest net return was reached in 2006 using the momentum strategy (net profit reached $5.15/cwt of feeder cattle)[13].

Table 4.2. Returns from trading the mar/mar/oct crush combination ($/cwt of feeder cattle)

Year	Naïve			Threshold			Moving Averages			Momentum			RSI		
	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit
1995	0.29	0.69	0.40	0.29	3.50	3.21	2.30	1.07	-1.23	1.44	2.86	1.42	0.86	0.68	-0.18
1996	0.29	-0.67	-0.96	0.29	-0.67	-0.96	4.03	-4.07	-8.10	1.44	4.40	2.96	1.15	0.19	-0.97
1997	0.29	-0.87	-1.16	0.29	3.37	3.09	2.88	1.26	-1.62	1.44	-0.29	-1.73	1.15	-0.56	-1.71
1998	0.29	-1.44	-1.73	0.29	3.94	3.65	2.88	1.05	-1.83	3.46	6.08	2.63	0.58	1.04	0.47
1999	0.29	0.07	-0.22	0.29	3.85	3.56	2.30	2.33	0.02	2.02	0.56	-1.46	0.86	-1.52	-2.38
2000	0.29	-0.94	-1.23	0.29	1.95	1.66	2.88	-0.94	-3.82	1.87	1.78	-0.09	0.86	1.16	0.30
2001	0.29	-2.91	-3.20	0.29	3.81	3.52	1.73	1.80	0.07	2.02	-1.50	-3.52	0.86	-0.68	-1.54
2002	0.29	-4.86	-5.15	0.29	4.39	4.10	2.88	1.43	-1.45	2.30	2.54	0.24	0.86	0.31	-0.56
2003	0.29	-4.07	-4.36	0.29	3.88	3.59	2.88	2.48	-0.40	1.30	3.86	2.57	0.29	-3.73	-4.01
2004	0.29	4.08	3.79	0.29	4.10	3.81	2.88	-5.40	-8.28	2.30	2.74	0.43	0.86	1.43	0.57
2005	0.29	-0.06	-0.35	0.29	4.03	3.74	2.88	-4.39	-7.27	2.88	6.03	3.15	0.29	0.94	0.65
2006	0.29	-2.94	-3.22	0.29	2.94	2.65	2.88	-4.83	-7.71	2.16	7.31	5.15	0.86	2.43	1.57
Mean	0.29	-1.16	-1.45	0.29	3.26	2.97	2.78	-0.68	-3.47	2.05	3.03	0.98	0.79	0.14	-0.65
Std Dev.	0.00	2.38	2.38	0.00	1.39	1.39	0.54	3.08	3.39	0.64	2.68	2.47	0.28	1.61	1.56
Years(+)	-	3	2	-	11	11	-	7	2	-	10	8	-	8	5
Max	0.29	4.08	3.79	0.29	4.39	4.10	4.03	2.48	0.07	3.46	7.31	5.15	1.15	2.43	1.57
Min	0.29	-4.86	-5.15	0.29	-0.67	-0.96	1.73	-5.40	-8.28	1.30	-1.50	-3.52	0.29	-3.73	-4.01

Additional results of trading the sep/sep/apr combination

The sep/sep/apr combination of the crush brought more profit when traded than the mar/mar/oct combination and four out of the five strategies showed positive net returns (Table 4.3). The momentum strategy was the most profitable (net average gain of $2.41/cwt) although

[13] A profit of $5.15/cwt of feeder cattle is equivalent to a profit of $41.53/head sold (= $5.15/cwt × 500/62 head sold) or $3.24/cwt (=$41.53/head × 100/1,280 lb).

net returns from the naïve and threshold strategy were fairly large (around $0.86/cwt on average). However, it is worth mentioning that the positive return from the naïve strategy was associated with a highest variation of the returns from trading which may be seen as a warning signal by feedlot operators that decide to use this tactic. The moving average strategy showed the worst performance with an average net loss of $5.27/cwt of feeder cattle during the period analyzed (1998 was the worst year for this strategy when a net loss of $12.86/cwt was realized).

Table 4.3. Returns from trading the sep/sep/apr crush combination ($/cwt of feeder cattle)

Year	Naïve			Threshold			Moving Averages			Momentum			RSI		
	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit	Trade Cost	Profit	Net Profit
1995	0.29	-6.26	-6.55	0.29	3.70	3.41	3.46	1.73	-1.73	1.15	0.89	-0.26	0.58	-0.66	-1.24
1996	0.29	2.70	2.41	0.29	2.31	2.02	3.46	-3.40	-6.85	1.15	3.44	2.29	0.58	0.63	0.05
1997	0.29	3.09	2.80	0.29	-3.09	-3.38	3.46	2.48	-0.98	1.73	7.58	5.86	1.15	8.04	6.89
1998	0.29	1.40	1.12	0.29	3.32	3.03	3.46	-9.40	-12.86	1.73	7.88	6.15	0.29	0.49	0.20
1999	0.29	-7.11	-7.39	0.29	3.63	3.34	2.30	0.33	-1.98	1.15	-0.56	-1.71	0.58	-0.23	-0.80
2000	0.29	1.24	0.96	0.29	2.49	2.20	2.88	-3.07	-5.95	0.58	-2.20	-2.77	0.58	1.09	0.52
2001	0.29	-3.00	-3.29	0.29	3.53	3.24	3.46	-0.71	-4.17	1.15	3.22	2.07	0.58	0.86	0.29
2002	0.29	0.77	0.48	0.29	2.06	1.77	3.46	-2.10	-5.56	1.15	1.53	0.38	0.29	0.44	0.15
2003	0.29	3.24	2.95	0.29	2.43	2.14	3.46	-4.10	-7.55	1.73	4.76	3.03	0.58	-0.11	-0.69
2004	0.29	8.77	8.48	0.29	2.35	2.06	2.30	-0.73	-3.03	1.73	6.63	4.90	0.58	-4.36	-4.93
2005	0.29	4.36	4.07	0.29	-4.36	-4.65	3.46	-5.23	-8.69	2.02	9.82	7.81	1.15	4.83	3.68
2006	0.29	5.06	4.77	0.29	-5.06	-5.34	2.88	-0.99	-3.87	1.44	2.64	1.20	0.58	-3.06	-3.63
Mean	0.29	1.19	0.90	0.29	1.11	0.82	3.17	-2.10	-5.27	1.39	3.80	2.41	0.62	0.66	0.04
Std Dev.	0.00	4.62	4.62	0.00	3.26	3.26	0.46	3.25	3.41	0.40	3.65	3.28	0.27	3.22	3.04
Years(+)	-	9	9	-	9	9	-	3	0	-	10	9	-	7	7
Max	0.29	8.77	8.48	0.29	3.70	3.41	3.46	2.48	-0.98	2.02	9.82	7.81	1.15	8.04	6.89
Min	0.29	-7.11	-7.39	0.29	-5.06	-5.34	2.30	-9.40	-12.86	0.58	-2.20	-2.77	0.29	-4.36	-4.93

Post-placement hedging strategies

The impact of trading the crush in the pre-placement period was studied and discussed in the previous section. In this new section the effects on the returns of hedging and not hedging the cattle put on feed were calculated. In doing so, three different post-placement scenarios were evaluated: a) the cattle feeder carried on without hedging and therefore profit was subject to the behavior of the cash market (CCS + No hedge)[14], b) the cattle producer shorted the cattle once they entered the feedlot, thus, the producer received an extra profit (loss) from this hedging strategy (CCS + Hedge LC), and c) the feedlot operator only offset the corn and feeder cattle futures of the cattle crush that was established prior to the animals' placement in the feedlot and then the producer received an extra profit (loss) from this hedging strategy (CCS + Keep LC). Tables 4.4 and 4.5 summarize these findings.

Results for the mar/mar/oct combination

To evaluate this scenario the assumption was made that cattle were hedged as soon as they entered the feedlot (which happened on the first trading day of April of each year) and were then sold 170 days after the placement (i.e. on September 18th of each year). In general, the use of the trading strategies on the cattle crush spread and then carrying the cattle without hedging, did not assure a reduction in the net return volatility. However, the cattle crush spread together with some of the two types of post-placement hedging systematically reduced price volatility across these trading strategies.

When post-placement hedging strategies were used, profit only increased 20% of the time. In the years where net returns from yearling steers were negative (1998, 2000, 2001 and 2004), trading the crush along with any of the two post-placement tactics helped producers to cut losses by nearly $0.66/cwt on average per year. In contrast, when pre-placement and post-

[14] Cash price used to calculate the profit were for the Central Iowa corn, St. Joseph-Missouri feeder cattle and Iowa-Minnesota fed cattle.

placement strategies were used in years of positive profits, producers forgo \$3.91/cwt of the profit[15].

Table 4.4 also contains a column called non-crush cost which incorporates the cost of supplement, salt & minerals, 50% of corn silage, operating and overhead, transportation and labor. When the value of the pre-placement and post-placement strategy was larger than the value of the non-crush cost, a net gain from applying the strategy was realized. 2001 and 2002 were the worst years with net losses that ranged from \$12.55/cwt to \$3.70/cwt. On the contrary, 2003 was the most profitable year with net gains that ranged from \$44.77/cwt to \$66.11/cwt.

[15] \$3.91/cwt of feeder cattle are equivalent to \$31.53/head sold (= \$3.91/cwt × 500/62 head sold) or \$2.46/cwt (=\$31.53/head × 100/1,280 lb).

Table 4.4. Pre-placement and post-placement returns for the mar/mar/oct crush ($/cwt of feeder cattle)

Year	Non-Crush Cost*	Cash Market Profit**	Naïve			Threshold			Moving Averages			Momentum			RSI		
			CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC
1995	15.44	20.37	20.77	17.67	22.25	23.58	20.48	23.79	19.13	16.04	19.14	21.78	18.68	23.27	20.18	17.09	19.99
1996	16.06	29.58	28.62	21.35	19.33	28.62	21.35	19.33	21.47	14.20	14.28	32.53	25.26	23.25	28.61	21.34	19.78
1997	15.45	18.75	17.59	17.21	16.64	21.83	21.46	20.56	17.12	16.75	16.56	17.01	16.64	16.06	17.04	16.66	15.54
1998	14.84	5.26	3.53	8.15	11.46	8.90	13.53	16.83	3.43	8.05	8.44	7.88	12.51	15.81	5.72	10.34	13.01
1999	14.08	23.01	22.79	20.92	18.40	26.57	24.69	25.21	23.03	21.16	21.08	21.55	19.68	17.16	20.63	18.76	19.04
2000	15.11	5.84	4.62	8.17	6.17	7.50	11.05	8.25	2.02	5.57	5.55	5.75	9.30	7.30	6.14	9.70	7.46
2001	15.18	6.05	2.85	4.75	3.98	9.58	11.48	10.83	6.12	8.03	8.49	2.54	4.44	3.66	4.51	6.42	5.84
2002	13.69	16.62	11.47	11.04	16.20	20.72	20.29	22.99	15.17	14.74	15.97	16.86	16.43	21.59	16.06	15.63	15.42
2003	13.56	76.08	71.72	58.27	58.63	79.67	66.22	66.58	75.68	62.22	61.97	78.65	65.19	65.55	72.07	58.61	60.65
2004	14.32	14.00	17.79	10.88	9.36	17.82	10.90	9.38	5.73	-1.19	-2.05	14.44	7.52	6.00	14.57	7.66	6.30
2005	14.84	21.82	21.47	20.22	18.74	25.56	24.31	22.83	14.55	13.31	12.88	24.98	23.73	22.25	22.48	21.23	19.60
2006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mean	14.78	21.58	20.29	18.06	18.29	24.58	22.34	22.42	18.50	16.26	16.57	22.18	19.94	20.17	20.73	18.49	18.42
Std. Dev.	0.79	19.71	19.09	14.54	14.59	19.72	15.49	15.84	20.35	16.45	16.45	20.69	16.36	16.64	18.64	14.30	15.04
Max	16.06	76.08	71.72	58.27	58.63	79.67	66.22	66.58	75.68	62.22	61.97	78.65	65.19	65.55	72.07	58.61	60.65
Min	13.56	5.26	2.85	4.75	3.98	7.50	10.90	8.25	2.02	-1.19	-2.05	2.54	4.44	3.66	4.51	6.42	5.84

* This cost includes: 50% of corn silage, supplement, salt & minerals, operating and overhead, transportation and labor. ** Over corn and feeder cattle.

Results for the sep/sep/apr combination

For this scenario it was assumed that cattle entered the feedlot the first trading day of October of each year and was marketed 170 days after the placement (i.e. March 20th of each year). In general, using the cattle crush trading strategy along with some of the two types of hedging proved to be superior strategies that increased gains from feeding cattle. Additionally, trading the spread along with hedging live cattle once animals entered the feedlot had a beneficial effect on the variability of returns among trading strategies. In contrast, keeping the live cattle contract on the crush that was traded in the pre-placement period considerably increased the volatility of returns under the threshold and moving averages strategies. In most cases, keeping the live cattle futures contract was more profitable than shorting a new live cattle contract or carrying the cattle without hedging.

In years were net returns from yearling steers were negative (1998, 2005 and 2006) trading the crush along with any of the two post-placement strategy helped producers to cut losses in nearly \$2.47/cwt in average per year. On the contrary, when returns were positive producers forgo \$0.49/cwt of the profit when the pre-placement and post-placement strategies were used. When the non-crush costs were included, 2003 finished up being the most profitability year because net returns from the selected strategies were much larger than the non-crush cost of \$13.69/cwt. In contrast, in 2005 and 2006 net returns from the tactics analyzed were lower than the non-crush cost of \$15.01/cwt and \$16.00/cwt respectively. This means that producers incurred in a net loss in those years.

Table 4.5. Pre-placement and post-placement returns for the sep/sep/apr crush ($/cwt of feeder cattle)

Year	Non-Crush Cost*	Cash Market Profit**	Naïve			Threshold			Moving Averages			Momentum			RSI		
			CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC	CCS + No Hedge	CCS + Hedge LC	CCS + Keep LC
1995	15.45	27.37	20.82	19.45	24.45	30.78	29.41	34.41	25.64	24.27	29.19	27.10	25.74	30.74	26.13	24.76	28.66
1996	15.01	17.34	19.75	20.72	22.18	19.35	20.32	21.79	10.48	11.45	11.04	19.63	20.77	22.06	17.39	18.36	18.78
1997	15.23	22.43	25.23	24.43	21.74	19.05	18.25	15.56	21.45	20.65	18.80	28.29	27.37	24.79	29.32	28.52	26.52
1998	15.31	7.74	8.85	14.94	16.13	10.77	16.86	18.04	-5.12	0.97	1.15	13.89	20.98	21.16	7.94	14.03	16.15
1999	14.30	28.96	21.57	20.07	26.42	32.31	30.81	37.15	26.99	25.49	31.29	27.25	25.52	32.10	28.16	26.67	30.85
2000	14.76	27.51	28.47	27.78	26.14	29.71	29.02	27.58	21.56	20.87	19.51	24.74	23.95	22.41	28.03	27.34	25.74
2001	15.11	32.01	28.73	24.95	26.81	35.25	31.47	33.34	27.85	24.07	26.77	34.09	29.71	32.17	32.30	28.52	31.71
2002	15.18	21.70	22.18	23.03	27.55	23.47	24.32	26.74	16.15	16.99	20.67	22.08	23.08	27.45	21.86	22.70	26.22
2003	13.69	33.22	36.17	33.87	35.62	35.36	33.06	32.60	25.66	23.37	23.87	36.25	33.59	35.69	32.53	30.23	27.87
2004	14.83	26.36	34.84	35.20	30.32	28.43	28.78	23.90	23.33	23.68	19.04	31.27	31.69	26.74	21.43	21.78	20.18
2005	15.01	11.38	15.45	15.23	9.66	6.73	6.51	0.94	2.69	2.47	-2.02	19.19	18.95	13.39	15.06	14.85	8.11
2006	16.00	11.08	15.85	20.31	15.65	5.74	10.20	5.54	7.21	11.67	7.74	12.28	17.48	12.09	7.45	11.91	10.70
Mean	14.99	22.26	23.16	23.33	23.56	23.08	23.25	23.13	16.99	17.16	17.25	24.67	24.90	25.07	22.30	22.47	22.62
Std Dev.	0.58	8.58	8.02	6.42	7.07	10.73	8.78	11.43	10.79	8.61	10.69	7.53	5.04	7.32	8.74	6.31	7.79
Max	16.00	33.22	36.17	35.20	35.62	35.36	33.06	37.15	27.85	25.49	31.29	36.25	33.59	35.69	32.53	30.23	31.71
Min	13.69	7.74	8.85	14.94	9.66	5.74	6.51	0.94	-5.12	0.97	-2.02	12.28	17.48	12.09	7.45	11.91	8.11

* This cost includes: 50% of corn silage, supplement, salt & minerals, operating and overhead, transportation and labor. ** Over corn and feeder cattle.

CHAPTER 5. CONCLUSIONS

Summary

The cattle crush spread is an easy-to-understand variable that can help cattle feeders to better hedge. Because producers own the cattle and need to buy corn and feeder cattle, trading the cattle crush spread gives them an opportunity to compress three market futures contract prices into one. Analyzing its behavior and evaluating its trajectory help producers make better hedging decisions and make an extra profit. In addition, using the cattle crush spread helps to gauge the relative cost of production and helps them make better investment decisions. The issue with the crush is that Iowa producers have to be aware that they can not buy fractions of futures contracts to cover their 0.74:0.94:2 ratio and therefore, the minimal amount that they can use is 1:1:2 to hedge 62 head. This generates coverage risk because corn and feeder cattle are not perfectly hedged.

The cattle crush spread can be constructed assuming different length of feeding periods. This will affect the futures contract combinations and, subsequently, the level of returns. In this research, it was showed that the cattle crush combination sep/sep/apr was more profitable than the mar/mar/apr combination. However, the variation in the profit level is not considerably large when the mar/apr/oct, sep/aug/apr, and sep/oct/apr contract combinations were used to suit the 170-days feeding period analyzed in this thesis. These contracts were highly correlated with the mar/mar/oct and sep/sep/apr respectively. Therefore, cattle feeders may expect to find values closer to the ones found in this research if they decide to use the feeder cattle futures contracts of the months of April, August, and October.

After analyzing the evolution of the cattle crush spread time series, a number of conclusions can be drawn: a) no seasonal behavior was found in the data, b) there is a not consistent correlation between the value of the crush and the price of the live cattle futures contracts, c) high prices for corn in 1996 had an impact on the level of the spread in 1996 and 1997 due to the fact that live cattle futures prices did not increase to compensate for the higher cost of production inputs, d) the lack of liquidity on the futures market at the end of the spread life might be the cause of the high volatility of the crush at the end of the majority of the years (especially 1999 and 2004), and e) negative cattle crush spreads can be possible as they happened on five occasions in June of 2005 for the sep/sep/apr combination due to a rapid rise in the price of feeder cattle while live cattle futures contract prices remained virtually the same over the course of that month. Additionally, the distribution of the cattle spread values proved not to be normal, which may be a sign of an imbalance that exists between buyers and sellers, generating three different levels of spreads. The distribution of the first difference of prices was more similar to the "bell-shaped" curve; though, the true cumulative distribution function was not a normally distributed one. The values located close to the tails of the last distribution may be a sign of some abnormal behavior that some traders would use as a trading advantage.

Obtaining benefits from negotiating the cattle crush spread requires a consistent set of trading rules that let producers take advantage of the variations in the crush spread. A carefully applied trading plan proved to be beneficial for cattle feeders in terms of extra returns from the trading and also from the reduction in price variation that comes from hedging. For the mar/mar/apr combination, three of the trading strategies evaluated depicted positive benefits (threshold, momentum and RSI), however, when trading costs were taking in account only the threshold strategy and the momentum strategy remained positive. For the sep/sep/apr combination, four out of the five strategies showed positive net returns. Momentum strategy was the most profitable, although, net returns from the naïve and threshold strategy were fairly large. The moving average technical strategy was the one with the poorest performance in both futures contract combinations. This strategy did not do well when sharp variations on the crush value were present. In addition, trading costs were the highest among all strategies analyzed. In consequence, applying trading strategies may be problematic for some cattle producers. On the one hand, it is a time consuming process that requires producers to keep neat records and calculations in order to be able to apply the trading strategies. On the other hand, transactions costs reduced most of the profits that was obtained from the trading strategies.

In general, trading the cattle crush spread during the pre-placement period and then hedging the cattle that are placed in feedlots proved to be a strategy that reduces profit volatility, even though it reduces the profit obtained by producers. This is consistent with the theory of hedging because producers, to be able to reduce exposure to the risk of variable prices, have to forgo part of the profit. When pre-placement and post-placement strategies were applied on the mar/mar/oct crush combination, 2003 finished up being the best year while 2001 and 2002 were the worst. For the sep/sep/oct, 2003 also showed the better behavior across strategies because the net returns from the strategies were much larger than the non-crush cost. In contrast, in 2005 and 2006 net returns from the tactics analyzed were lower than the non-crush cost. This means that producers incurred in a loss in those years.

Recommendations

Future research on the use of the cattle crush spread as a pre-placement and post-placement hedging strategy should extend the number of years analyzed in order to refine the trading rules and incorporate information when rare events on the underlying components of the cattle crush occur. Finally, new research on the cattle crush strategy should evaluate those combinations of futures contracts that suppose larger (or shorter) feeding period and different marketing months from April and October.

APPENDIX A. ADDITIONAL FIGURES

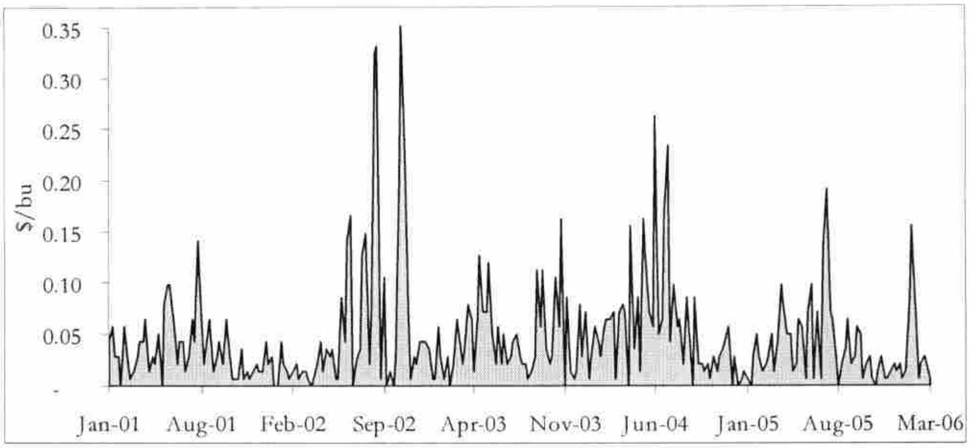

Figure A.1. Central Iowa corn, weekly price volatility (2001-2006)

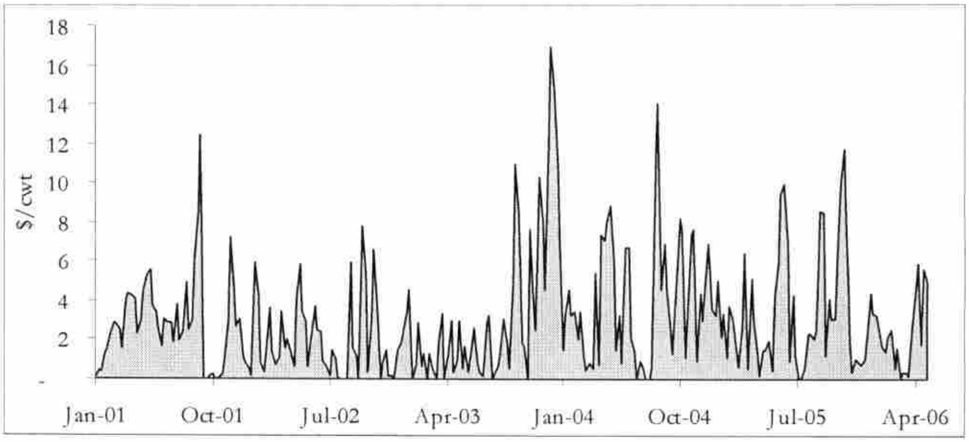

Figure A.2. St. Joseph (Missouri) feeder cattle, weekly price volatility (2001-2006)

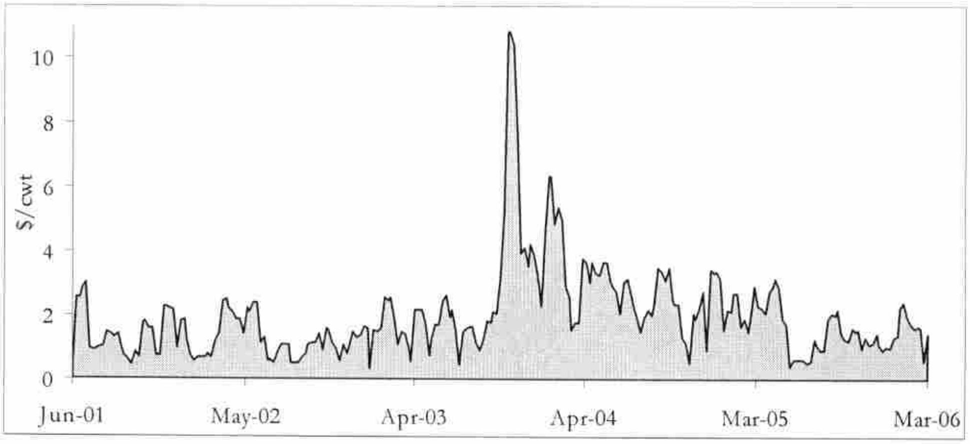

Figure A.3. Iowa-Minnesota fed steers, weekly price volatility (2001-2006)

Figure A.4. Naïve strategy plots, mar/mar/oct cattle crush spread (1995-2006)

Figure A.5. Threshold strategy plots, mar/mar/oct cattle crush spread (1995-2006)

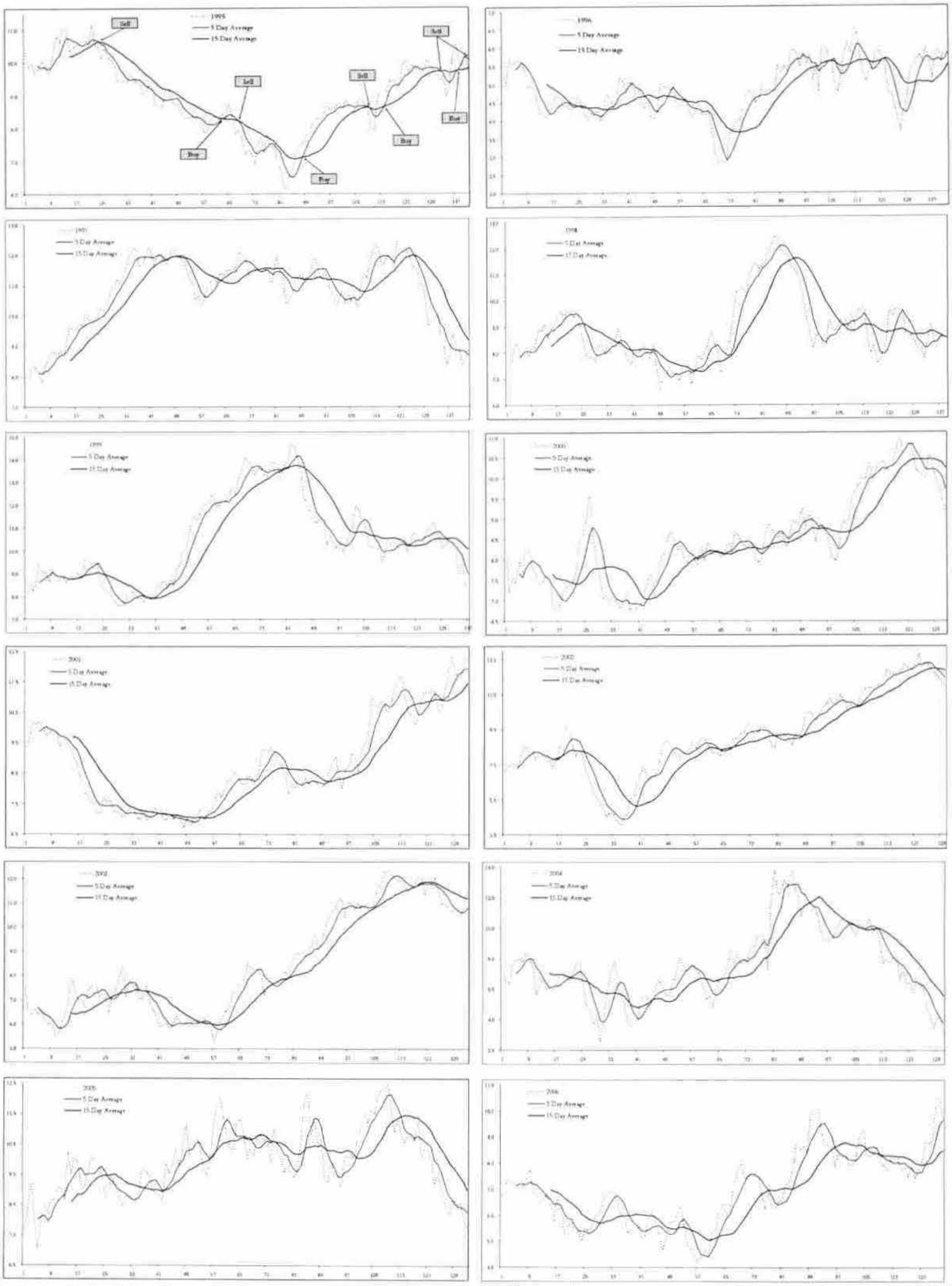

Figure A.6. Moving average strategy plots, mar/mar/oct cattle crush spread (1995-2006)

Figure A.7. Momentum strategy plots, mar/mar/oct cattle crush spread (1995-2006)

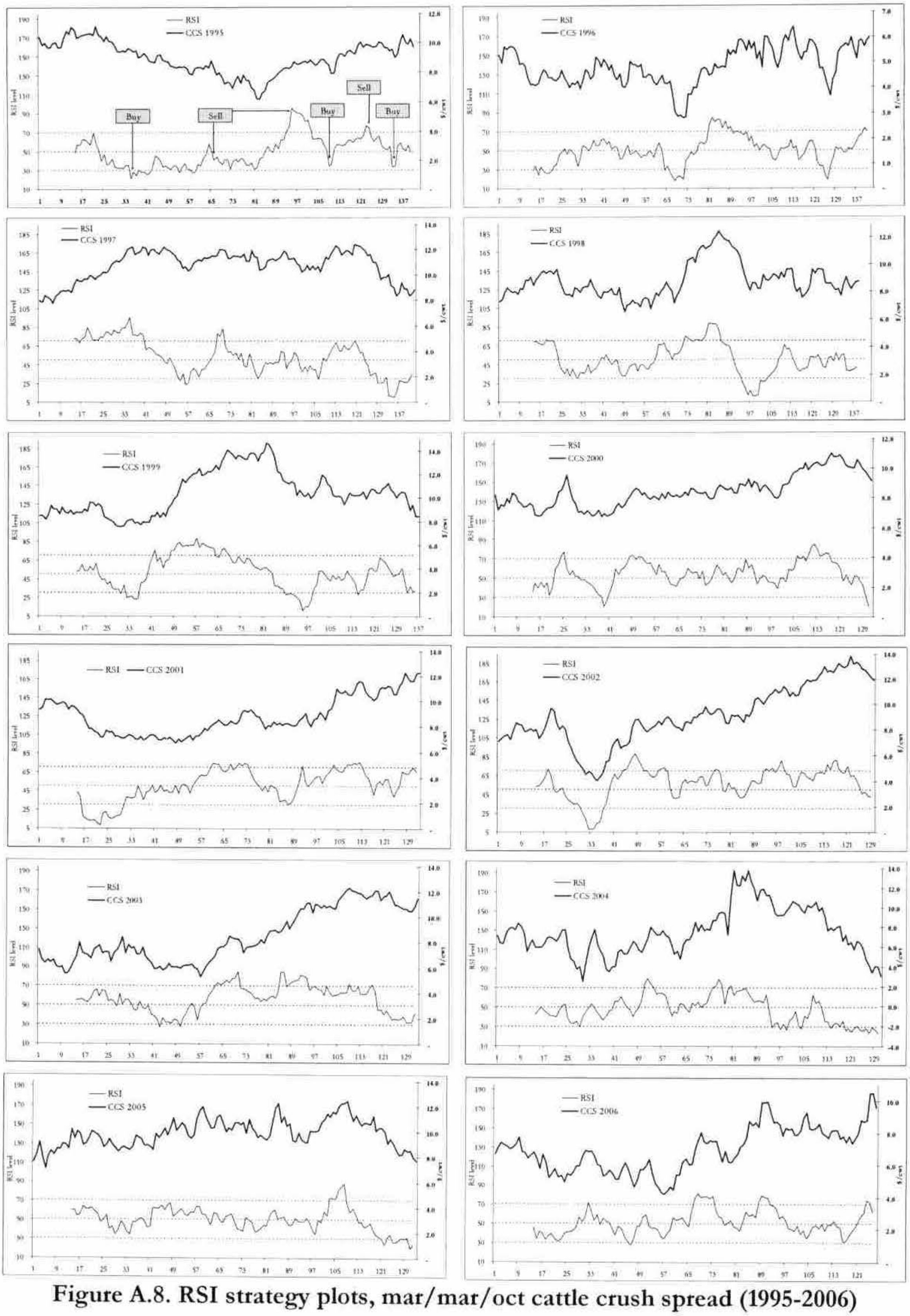

Figure A.8. RSI strategy plots, mar/mar/oct cattle crush spread (1995-2006)

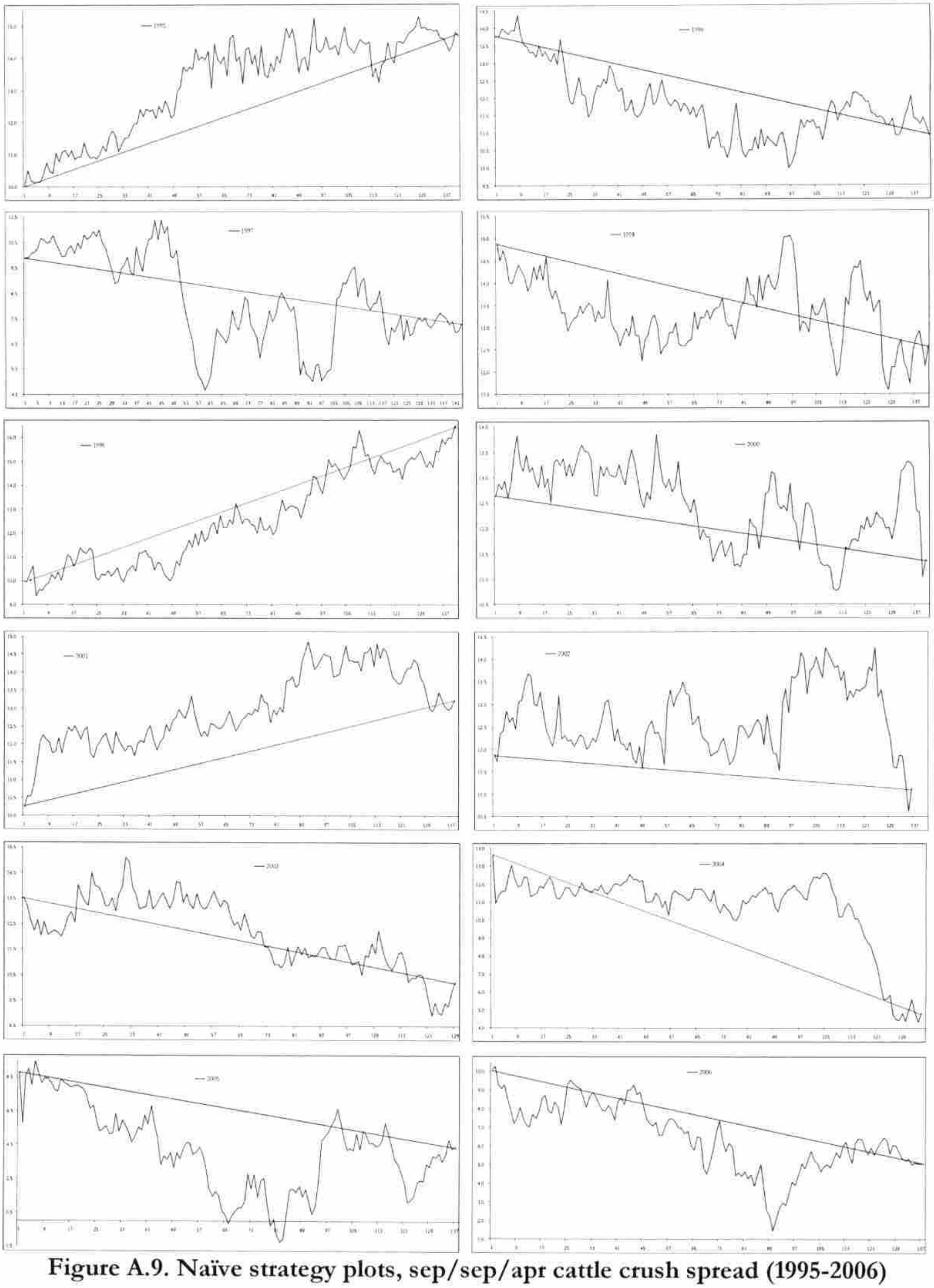

Figure A.9. Naïve strategy plots, sep/sep/apr cattle crush spread (1995-2006)

Figure A.10. Threshold strategy plots, sep/sep/apr cattle crush spread (1995-2006)

Figure A.11. Moving average strategy plots, sep/sep/apr cattle crush spread (1995-2006)

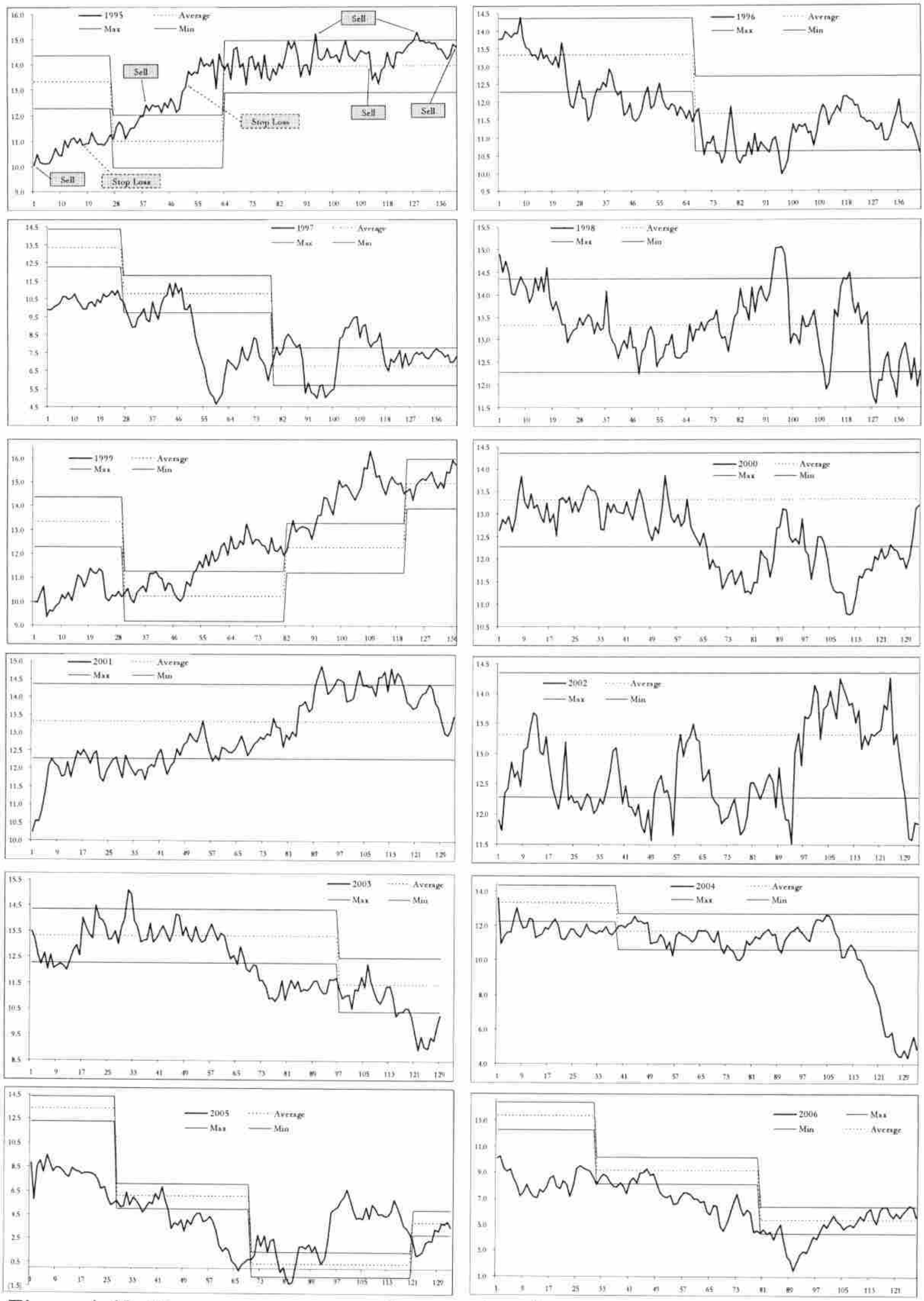

Figure A.12. Momentum strategy plots, sep/sep/apr cattle crush spread (1995-2006)

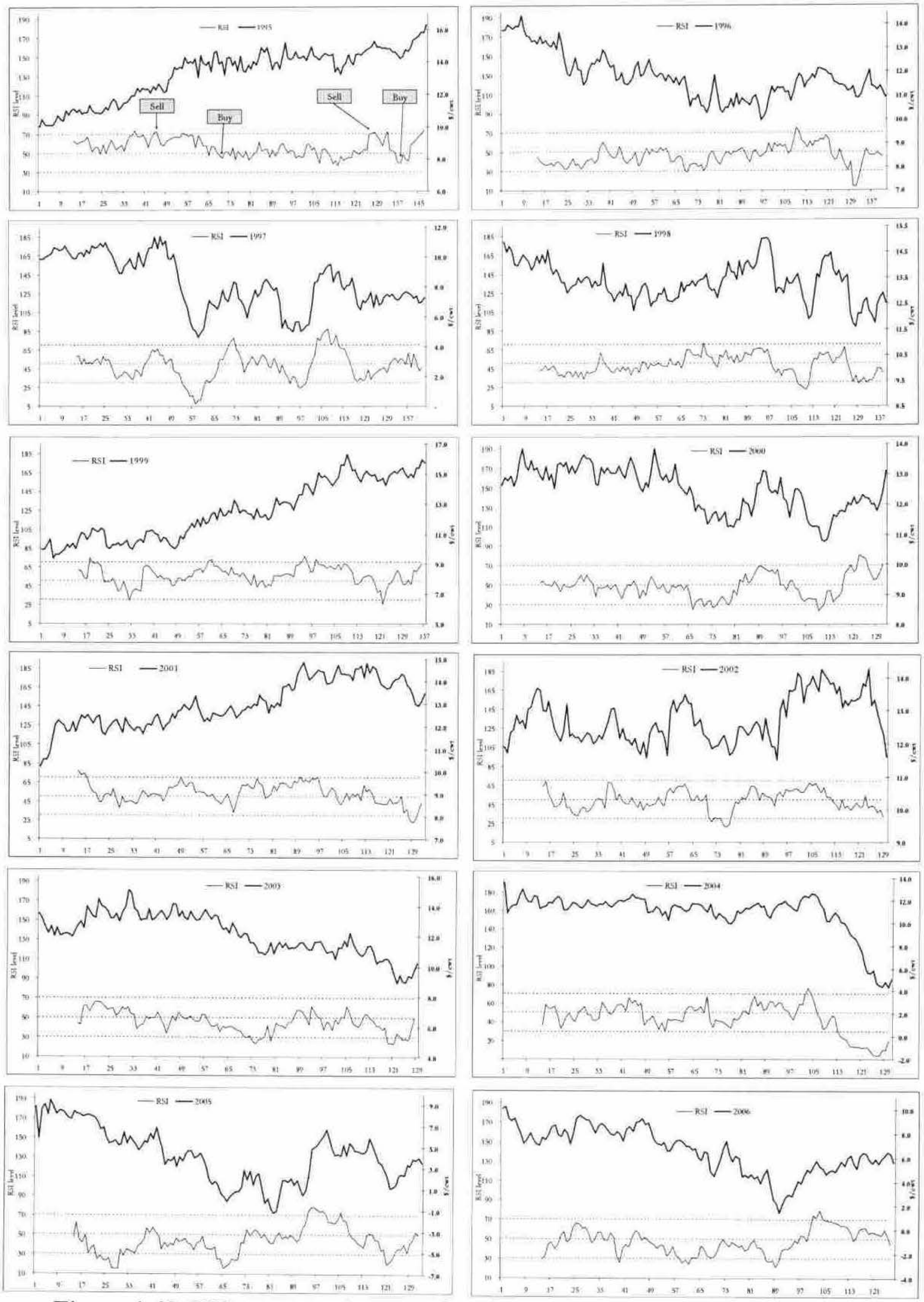

Figure A.13. RSI strategy plots, sep/sep/apr cattle crush spread (1995-2006)

APPENDIX B. ADDITIONAL TABLES

Table B.1. Correlation coefficient between CCS value and live cattle futures contracts

Year	mar/mar/oct	sep/sep/apr
1995	0.38	-0.90
1996	0.09	0.68
1997	-0.33	-0.66
1998	-0.18	-0.15
1999	0.21	-0.94
2000	0.81	0.09
2001	0.20	-0.64
2002	0.35	0.51
2003	0.11	-0.45
2004	0.05	-0.63
2005	-0.54	-0.65
2006	0.08	0.05

Table B.2. Starting dates of the selected trading strategies (mar/mar/oct)

Year	Naïve	Threshold	Moving Averages	Momentum	RSI
1995	31-Aug-94	30-Sep-94	4-Oct-94	31-Aug-94	20-Oct-94
1996	30-Aug-95	30-Aug-95	21-Mar-96	30-Aug-95	27-Sep-95
1997	26-Aug-96	3-Sep-96	19-Mar-97	26-Aug-96	19-Sep-96
1998	2-Sep-97	2-Sep-97	20-Mar-98	2-Sep-97	23-Dec-97
1999	3-Sep-98	13-Oct-98	11-Mar-99	3-Sep-98	21-Oct-98
2000	7-Sep-99	8-Sep-99	2-Mar-00	7-Sep-99	11-Oct-99
2001	1-Sep-00	29-Sep-00	20-Feb-01	1-Sep-00	26-Sep-00
2002	5-Sep-01	11-Oct-01	14-Mar-02	5-Sep-01	22-Oct-01
2003	3-Sep-02	3-Sep-02	14-Mar-03	3-Sep-02	3-Dec-02
2004	5-Sep-03	5-Sep-03	13-Feb-04	5-Sep-03	17-Nov-03
2005	1-Sep-04	1-Sep-04	14-Mar-05	1-Sep-04	1-Feb-05
2006	12-Sep-05	12-Sep-05	15-Feb-06	12-Sep-05	15-Dec-05

Table B.3. Starting dates of the selected trading strategies (sep/sep/apr)

Year	Naïve	Threshold	Moving Averages	Momentum	RSI
1995	22-Feb-94	22-Feb-94	28-Mar-94	22-Feb-94	25-Apr-94
1996	22-Feb-95	22-Feb-95	12-Apr-95	22-Feb-95	31-Jul-95
1997	23-Feb-96	23-Feb-96	21-Mar-96	23-Feb-96	10-May-96
1998	24-Feb-97	24-Feb-97	18-Mar-97	24-Feb-97	28-Jul-97
1999	2-Mar-98	2-Mar-98	3-Apr-98	2-Mar-98	27-May-98
2000	4-Mar-99	15-Mar-99	25-Mar-99	4-Mar-99	17-Jun-99
2001	1-Mar-00	1-Mar-00	30-Mar-00	1-Mar-00	22-Mar-00
2002	1-Mar-01	9-May-01	26-Mar-01	1-Mar-01	18-Jun-01
2003	13-Mar-02	5-Apr-02	3-Apr-02	13-Mar-02	26-Jun-02
2004	3-Mar-03	3-Mar-03	15-Apr-03	3-Mar-03	29-Jul-03
2005	1-Mar-04	1-Mar-04	26-Apr-04	1-Mar-04	31-Mar-04
2006	1-Mar-05	1-Mar-05	23-Mar-05	1-Mar-05	24-May-05

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