

AN EVALUATION OF CHANGING PROFIT RISKS IN KANSAS CATTLE FEEDING  
OPERATIONS

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## **Abstract**

Cattle feeders face significant profit risk when placing cattle on feed. Risks arise from both financial and biological sources. To date, few standardized measures exist to measure current risks against historic levels, or to obtain forward looking risk estimates. Those that do exist could benefit from updates and inclusion of additional risk elements.

This study measures the risk of expected profits when cattle are placed on feed. This study creates a forward-looking estimate of expected feedlot profits using futures and options market data as price forecasts. Joint probability distributions are created for prices and cattle performance variables affecting feedlot profit margins. Monte Carlo simulation techniques are then employed to generate probability distributions of expected feedlot profits.

Results show cattle feeding is a risky business and cattle feeders have been placing cattle on feed facing significantly negative expected returns since June, 2010. This assessment of negative expected profits is consistent with other findings. Over the study's 2002 to 2013 time frame, the relative risk to cattle feeding profits accounted for by feed costs has been increasing, while the relative risk levels from feeder cattle and fed cattle prices remain steady. Additionally, the probability of realized per-head profits greater than \$100 has been decreasing since 2009 and the probability of realized per-head profits less than \$-100 has been increasing rapidly.

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# **Chapter 1 - Introduction**

Cattle feeding has historically been a risky venture, with returns often swinging from profit to loss in a matter of weeks. Recent, dramatic swings in commodity price volatilities may have further increased the cattle feeding return risk above historic levels. Currently, few standardized measures exist to measure and compare current risks to historic levels, or to obtain forward looking risk estimates. Those that do exist could benefit from updates and inclusion of additional risk elements.

The risks faced by feedlot managers stem from several sources, both financial and biological (Belasco et al. 2009). Financial risks typically include the prices and price volatilities of output (slaughter cattle) and inputs (feeder cattle, feedstuffs, etc.). Biological risks include cattle mortality, weight gain variability, and the cost of veterinary supplies. These biological risks are further complicated by strong seasonal effects. To date, the focus of modeling risk in cattle feeding has either been on price or production risks and few studies have attempted to incorporate both elements.

Cattle feedlot managers face price risk from three primary sources; fed cattle, feeder cattle, and corn cash prices. Fed cattle prices represent the largest (and often, sole) source of revenues for feedlots while feeder cattle and corn represent the largest variable costs (Mark, Schroeder, and Jones, 2000). Colloquially, the relationship between these three commodities is sometimes called the “cattle crush” as these prices comprise the primary components of the cattle feeding margin. There are known interactions between the prices of each of these commodities which justifies examining financial and profit risk under a multivariate framework (Collins, 1997; Tonsor and Schroeder, 2011). Research has also shown that hedging only one component of the cattle feeding margin may expose feedlot managers to greater risk than simply remaining unhedged (Tonsor and Schroeder, 2011). Thus, risk management analysis and strategy should consider every risk component in cattle feeding.

Production risks also pose a significant source of variability in cattle feeders’ profits. Factors including average daily gain (ADG), mortality, dry matter feed conversion (DMFC), veterinary care costs per head (VCPH), and physiologic differences between steers and heifers can influence costs and revenues. Recent work (Belasco et al, 2009) has parameterized these risks and incorporated them into cattle feeding profit functions. While production risks can vary

greatly across feedlots, animals, and feeding locations, these components can be used to proxy cattle performance in a given area and incorporated into cattle feeding risk analysis.

This study seeks to examine how the expected profit risk of placing cattle on feed has changed over time. It is hypothesized that recent changes in both livestock and grains markets have increased feedlot profit risk beyond historic levels. As livestock and grain markets have undergone structural change (Irwin et al., 2009; Herrington and Tonsor, forthcoming) and increased in volatility it is likely that cattle feeding margins, a function of multiple markets, have also increased in volatility. This study will examine the effects of changing market conditions on cattle feeding profit risk and identify patterns and trends in profit risk.

This thesis will add to existing literature by incorporating both production and price risks in estimations of expected feedlot profits. While there are several published studies and analyses which estimate expected and realized profits, many of the assumptions and equations used in their estimations could benefit from updates and inclusion of additional variables. Additionally, most studies in current existence focus on the analysis of expected profits and do not include risk analysis. The few currently available risk analyses are often limited in the scope of their dataset. Therefore, comparisons of risk levels before and after significant historic events, for example the 2003 BSE event or the 2008-9 financial market crash, are unattainable. This study improves upon existing studies by incorporating additional variables relevant to cattle feeding profit equations and by using a dataset such that long-run changes in risk can be analyzed.

This study models expected cattle feeding profits as a function of weekly price and production variables in a joint, multivariate distribution framework. Monte Carlo simulations will be used to determine, given prices and volatilities forecasted by futures and options markets, weekly probability distributions of cattle feeding profits. This research seeks to develop an industry tool which will measure the profit risk of placing cattle on feed during the upcoming week. The expected profit risk will be calculated by measuring various distributional aspects of simulated expected profit probability distributions.

To place the current expected profit distribution in historic context (often important for the cattle feeding industry due to strong seasonal and cyclical effects), the joint input distribution estimations and profit estimations will be conducted using historic data for futures prices, options implied volatilities, cash prices, basis, interest rates, and estimated cattle performance variables from Belasco et al., 2009. Using these historic data will result in a series of historic expected

feedlot profits. Developing a series of historic expected feedlot profits allows current expected feedlot profits to be placed in historic context and for analysis of changes in feedlot profits across time. Results from the historic and current risk levels will be standardized to allow for clear comparison across time, and so that a single, standardized measure of risk can, potentially, be presented to cattle feeders. Additionally, this work will analyze factors which have contributed to changes in expected profit levels and risks over time. This may provide valuable information on how risk management strategies should be updated to reflect the changing nature of risk in cattle feeding.

## **1.1 - Objective**

The primary objective of this thesis is to determine how the expected profit risk of feeding cattle had changed over time. The expected profit risk will be measured by forecasting the expected profit to be realized if cattle are placed on feed in the coming week and analyzing the expected variance around the expected profit. To accomplish this, several specific steps will be taken:

1. Use futures prices and options implied volatilities to specify the mean and variance, respectively, of weekly probability distribution for future prices. Basis will be incorporated to adjust futures market forecasts to Kansas cash price expectations.
2. Use the results published in Belasco et al. 2009 to specify weekly distributions for cattle performance variables.
3. Develop an equation to generate expected profits for placing a 750 lb. steer in a Kansas feedlot during a specified week of the year. The profit equation will be a function of the specified probability distributions for price and production variables.
4. Use Monte Carlo simulation techniques to take correlated draws from the input variable probability distributions and create a joint probability distribution of expected cattle feeding returns. The resulting profit distributions will reflect the expected profit and profit risk of placing cattle on feed during the coming week.

5. Index distributional aspects of the expected cattle feeding profits. Indexing the distributional information of profit forecasts will allow for easier comparison of current profit risks relative to historic levels.
6. Produce a profit risk assessment tool to be made available to cattle feeders via various forms of media.

Research in this area could incorporate a great number of factors which influence feedlot profits (cattle age at placement, weight, breed mixture, and sex of cattle, feedlot location, etc.). To streamline the research process, this thesis will focus on profits obtained from placing steers on feed in Kansas feedlots at a weight of 750 lbs. (following Tonsor and Schroeder, 2011; and Belasco, Schroeder, and Goodwin, 2010) for a period of 5 months (Tonsor and Schroeder, 2011; and Kastens and Schroeder, 1998). Using these assumptions places greater focus on the risk index, rather than modeling feedlot profits under every possible situation. Later, these assumptions can be relaxed and the model expanded to incorporate additional cattle feeding scenarios.

## **1.2 - Background on the Cattle Feeding Industry**

Over the past decade, there have been several changes in the cattle feeding sector. Market events have caused increased volatility in cattle and feedstuff prices while the cattle feeding industry has undergone technological change at the same time. Other factors influencing feedlot profits include reduced national cow herd inventories and widespread drought in grain and cattle producing states. The remainder of this chapter is dedicated to brief explorations of these issues affecting U.S. cattle feeders.

### ***1.2.1 - Changes to U.S. Grains Markets***

In 2005, the Renewable Fuels Standard (RFS) began the requirement that transportation fuel sold in the U.S. met minimum ethanol content requirements (EPA, 2012). Following the act, a significant amount of the U.S. corn crop has been dedicated to ethanol production. The use of corn in a different production system (rather than for livestock or human consumption) created structural change in grain markets as there was a change in corn demand (Irwin et al., 2009). This change in demand increased both corn and other field crop prices. The impact of increased crop prices on the feedlot sector has been to raise feed costs (Herrington and Tonsor, forthcoming). Herrington and Tonsor, using closeout data from Kansas feedlots found significant

structural breaks in total feed costs for Kansas feedlots occurring after the implementation of the RFS.

### ***1.2.2 - Drought and Feed Prices***

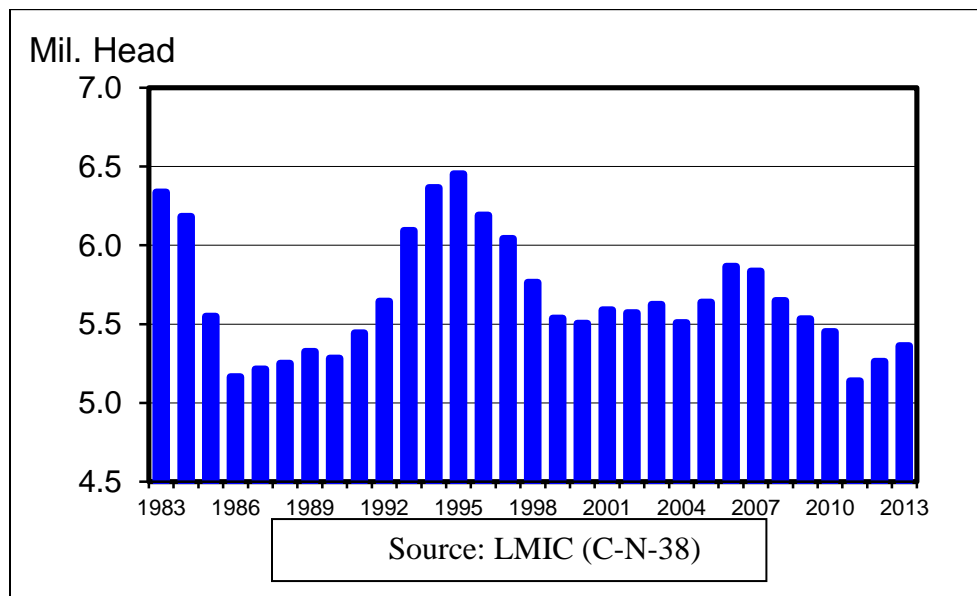
Beyond the effects of the RFS, recent Midwest droughts have further increased feed prices. The summer droughts in 2011 and 2012 had a significant negative impact on crop yields across the U.S. The corn yield for the 2012 crop was estimated at 122 bushels per acre, the lowest yield since 1995 (U.S. Grains Council, 2013). Concerns over the drought's impact on yield drove nearby corn futures prices from \$6.43 on January 6, 2012 to over \$8.02 by August 31, 2012. The drought not only raised corn prices as the price of soybean meal and hay also increased. The U.S. average price of alfalfa hay in January, 2011 was \$121/ton and the two-year drought pushed prices to \$218 by February, 2013. Soybean meal prices followed a similar trend and jumped from \$312.40/ton on January 6, 2012 to \$435.20 on March 8, 2013 (based on nearby futures contract quotes).

The structural changes in the industry and higher feed ingredient costs created large profit losses for feedlots. Based on survey data from Kansas feedlots, Tonsor and Dhuyvetter (2013) estimated January 2013 close-out returns to feeding steers and heifers at -\$138.44/hd and -\$107.98/hd, respectively. These are some of the largest closeout losses in their record and their current projections of future profits remain strongly negative.

### ***1.2.3 - Drought and Feedlot Capacity***

The recent, severe drought in many of the key cattle producing and feeding states (Texas, Oklahoma, and Kansas, among others) has impacted livestock production as well. The drought forced the liquidation of many cow herds across the U.S. and as further tightened cattle supplies (Peel, 2013). Increased feeder cattle prices appear to be signaling producers to initiate slight expansion of the national cow herd (Figure 1-1) as January 1 heifer retention rates (the number of heifer kept for breeding purposes) increased 1.9% in 2013 (LMIC, 2013). The effect of increased heifer retention rates will initially likely place additional strain on feedlots through decreased feeder cattle availability.

**Figure 1-1: Heifers Held as Beef Cow Replacements, January 1, U.S.**



Reduced cattle supplies are impacting both feedlots and beef packers. Feedlots are operating at less-than-full capacity (Oklahoma State University, 2012; Dunkel, 2013) with some analysts estimating the percentage of empty pens at 25% (Hegeman, 2013). This reduced supply of feeder cattle translates to fewer fed cattle, beef packing plants to operate below their optimal capacity (Hegeman, 2013). Operating at less-than-optimal capacity increases marginal costs for feedlots and packers and placed downward pressure on profits. Reduced industry profits are likely to exist until the excess capacity is sufficiently reduced (i.e., firms exit the industry) and feedlots and packers operate closer to optimal capacity levels. Such an exit may have already begun as Cargill announced in early 2013 that it was closing its Plainview, TX packing (Daily Livestock Report, 2013a) and Pratt [cattle] Feeders closed its Hay, KS feedlot (Dunkel, 2013).

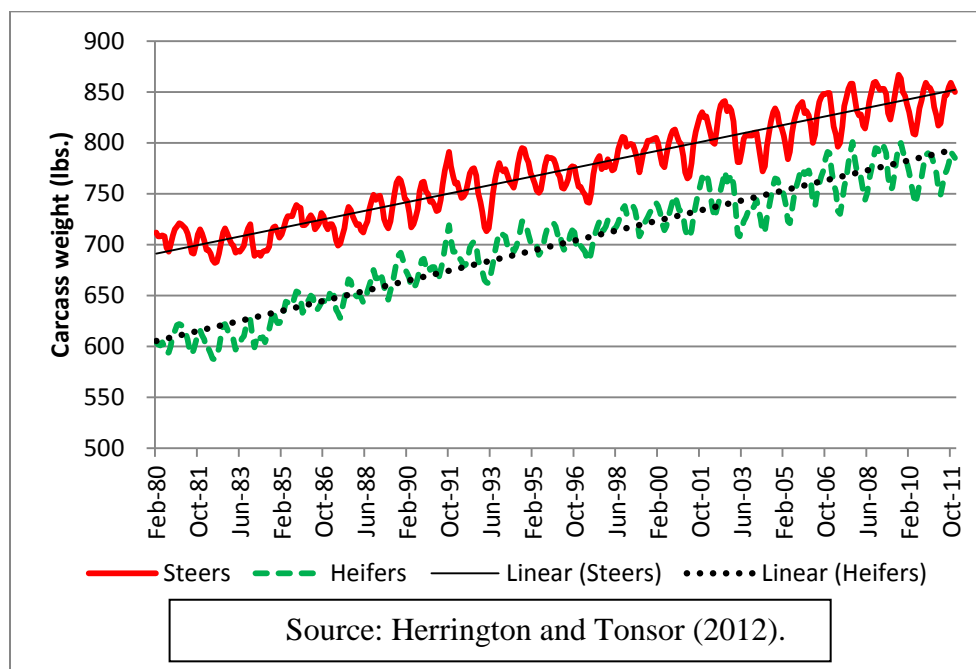
#### ***1.2.4 - Beef Production***

Another significant change in the U.S. cattle feeding sector has been increased productivity of feedlot cattle. Langemeier et al. (2001) and Herrington and Tonsor (2013) both provide evidence that the cattle feeding sector has undergone significant technological change (defined, in economic theory, as an increase in output per unit of input) over the 1990-2012 time period, the result of which has been increased cattle productivity. Herrington and Tonsor (2013) showed statistically significant increases in body weight gain (sale weight less placement

weight), ADG, and gain: feed ratios of feedlot steers and heifers from 1990-2012. Much of this improved feedlot performance is attributed to enhanced cattle genetics and cattle feeding technologies such as  $\beta$ -agonists.

One effect of this elevated productivity has been increased carcass weights as shown in Figure 1-2 (taken from Herrington and Tonsor, 2012). Using data from USDA-AMS sources, Herrington and Tonsor (2012) showed that steer carcass weights increased from near 750 lbs. in 1990 to near 850 lbs. in 2011. Their results suggested an average increase in carcass weights for steers and heifers of 4.9 and 5.8 pounds per year, respectively. The increased carcass weights have created more saleable beef which has helped to offset the effects of tightened cattle supplies.

**Figure 1-2: National Average U.S. Beef Carcass Weights 1980-2011**



### 1.3 - Organization of Remaining Chapters

The remainder of this thesis is organized into the following sections. Chapter 2 contains a review of the literature pertaining to profit simulations, futures markets, risk management in livestock production, and basis research. Chapter 3 describes the data used while Chapter 4

details the methods used in this study. Results are presented in Chapter 5 and Chapter 6 contains a summary of this work, implications for cattle feeders, and ideas for future research.

## **Chapter 2 - Literature Review**

This section provides a review of studies relevant to this work. The literature review is sub-divided into the following research areas: the economic behavior of cattle feeders; profit simulations, an overview of futures market theory and efficiency, risk management in the livestock industry, and research on basis levels and forecasting.

### **2.1 - Economic Behavior of Cattle Feeders**

Kastens and Schroeder (1994) set out to determine why cattle feeders continue to place cattle on feed when negative returns are expected. They note that, if cattle feeders are profit maximizers, this behavior appears irrational unless cattle feeders expect an increase in the live cattle futures price over the feeding period. If this is the case, the authors note, then cattle feeders must believe a downward bias is currently present in the futures market. Kastens and Schroeder (1994) argue that such a belief would explain cattle feeders' infrequent use of short hedges to manage live cattle price risk but that it does not explain why feeders do not simply take a long position in the futures market. One possible explanation provided by Kastens and Schroeder (1994) is that cattle feeders use some other tool to generate cattle price expectations.

Results from Kastens and Schroeder (1994) showed that recent actual profit was a significant and positive variable in explaining feeder cattle placements. However, expected hedgeable profit was not a significant driver of placements. Some monthly dummy variables were significant, reflecting seasonality in cattle production, while a time trend coefficient was negative and significant; congruent with general decreases in cattle numbers. The authors conclude that cattle feeders do not use futures prices to formulate expected profits to guide placement decisions. However, hedgeable profits (profits forecasted by deferred futures contracts) provided useful forecast information for future realized profit.

To explain why cattle feeders appear to ignore the usefulness of expected hedgeable profits as profit forecasts, Kastens and Schroeder (1994) tested for bias in the live cattle futures markets. Analyzing the average price movement of live cattle prices over a 19-week feeding period for each week from January 1977 through May 1993, only five years had price decreases while 12 years had price increases (their data was deflated to real dollars). This supports the

conclusion that cattle feeders believe in downwardly biased futures markets and explains the infrequency of short hedges used to protect against downward price movements.

Perhaps one explanation for this belief of downward bias in live cattle markets comes from improper understanding of market theory and risk management strategy. Risk management information is commonly disseminated to producers through agricultural extension economists (Schroeder et al. 1998). However, Schroeder et al. (1998) noted an apparent discrepancy between agricultural extension economists and published research in the areas of futures market efficiency and timing of risk management strategies. Many extension economists believe extension price forecasts are sufficient to generate returns to trading futures. Furthermore, they believe market timing strategies also exist such that producers could increase their selling prices. The discrepancy is that none of the published research in these areas supports such conclusions.

Results from Schroeder et al.'s survey of agricultural producers and extension economists revealed the perceptions of these two groups were largely indistinguishable from each other. Both felt that forward contracting would not significantly reduce the price received by farmers; a belief that is in direct contrast to published research. The published research (see Elam, 1992 and Ward, Koontz, and Schroeder, 1998) shows that forward contracting for fed cattle does, in fact, reduce the price received for cattle.

Producers and extension economists further believed that market timing strategies exist where producers can increase their prices received. This belief relies on price forecasts to guide market timing and so contradicts the efficient market hypothesis (Fama, 1970) which states that market prices reflect all currently known information. The efficient market hypothesis states that markets represent all known information. As such, futures prices are the most accurate price forecast available and no alternative forecast method can improve upon their forecast accuracy. If futures market forecasts cannot be improved upon, market timing strategies which would increase returns do not exist.

## **2.2 - Profit Simulations**

Due to the lack of observed data for realized feedlot profits, simulation of estimated feedlot profits have become popular methods of estimating returns to feeding cattle. The variance of simulated cattle feeding profits was the subject of Weimar and Hallam's 1990 study of custom finishing contracts in the cattle feeding industry. They first distinguished the risks inherent to

different cattle ownership structures in cattle feeding. They argue that the risks faced by farmer-feeders (where the feedlot facilities and cattle are owned by the same firm) differ from those faced by custom cattle feeders (who own the feedlot facilities but not cattle) as custom feeding contracts transfer the risk of cattle ownership to outside investors.

Weimar and Hallam evaluated the variance in net returns to the feedlot owner and cattle investor under three different custom feeding contracts. Three contracts, yardage plus feed (YF), yardage plus feed costs and a markup on feed (YFMU), and guaranteed cost-of-gain (GCOG) were examined in their study which used Monte Carlo simulations to generate net returns. GCOG contracts did not significantly reduce cattle investor's risk but substantially increased the feedlot operator's risk as compared to the YF contract. The YFMU contract was more variable than the YF contract for feedlot operators in all evaluated feeding periods and in all but one for the cattle investor.

Given the popularity of custom cattle finishing operations, where the price risk is taken by outside investors, it may be useful to examine the risk and return rates of custom cattle feeding with methods used to evaluate different investment opportunities. Hample, Schroeder, and Kastens (1998) developed a return on investment (ROI) framework to determine how perceptions of risk in cattle markets influences expected cattle feeding returns and the usefulness of futures markets as proxies for price expectations. Under the theory that cattle feeders maximize utility that is "increasing in profit and decreasing in risk" (pg. 267), they note that a cattle feeder's utility may be expressed as a function of expected ROI. They authors note that cattle feeder's expectations of a ROI in feeder cattle is derived from expectations about output and input prices. They argue that the feeder cattle purchase decision is endogenous; that is, reflecting all other price expectations. They further argue that, if there is high expected variability in ROI, cattle feeders will bid down the price of feeder cattle until a sufficient risk premium is built into the ROI to justify feeder cattle purchases.

The results provided by Hample, Schroeder, and Kastens (1998) revealed that live cattle implied volatilities are a significant variable when cattle feeder are developing ROI expectations. Contrary to other studies, lagged actual profits were not significant in generating ROI expectations. To control for cattle cycle effects where feeders may bid up feeder cattle prices beyond the point of a negative ROI during supply shortages, a variable for the USDA's Cattle on Feed report was included. The negative coefficient for cattle on feed implies, as the authors'

note, that packers may reduce fat cattle bids by a greater proportion during times of increased cattle inventory levels than feedlots increase asking prices during inventory shortages. The authors conclude that, due to a number of insignificant variables in their model and inconsistencies with previously published studies, additional research is needed to identify factors influencing expected returns to cattle feeding.

Belasco (2008) used simulation techniques to identify the origin and extent of risk in cattle feeding. Belasco notes that, like much of agricultural industries, cattle feeders face both price and production risk. Accordingly, producers could, theoretically, obtain 100% price risk management (through the use of futures, options, forward contracts, etc.) and still be exposed to risk from factors inherent to cattle production. Belasco sought to identify the amount of risk cattle feeders face from production factors and the price risk that would remain under four risk management scenarios.

Four production factors were considered by Belasco (2008): average daily gain, dry matter feed conversion, veterinary costs per head, and the pen-level mortality rate. Similarly, four risk management strategies were considered: cattle price protection, corn price protection, full price protection, and no price protection. The simulation results revealed that eliminating corn price variability (i.e. full corn price protection) decreased feedlot profit variability by 14%. Under a 100% cattle price risk management scenario, the profit variance fell by 58%. These findings are consistent with previous studies examining the influence of corn and cattle prices on feedlot profits (Langemeier, Schroeder, and Mintert, 1992; Mark, Schroeder, and Jones, 2000). Finally, Belasco found that eliminating corn and cattle price risks reduced profit variability by 87%, leaving approximately 13% of the variability attributed to cattle production factors. Belasco concluded by noting that insuring livestock production risk remained the largest barrier to obtaining livestock revenue insurance programs.

Tonsor and Schroeder (2011) conducted a study examining the effectiveness of a multivariate approach in forecasting cattle feeding margins in a future time period. The multivariate approach was accomplished by constructing a joint probability distribution of feeder cattle, live cattle, and corn prices using monthly average futures prices and options implied volatilities. Assuming a 750 pound steer would be on feed for five months and sold at 1200 lbs., they derived a 'feeding margin' of:

$$F\hat{M}_{t+h+5} = (12 * \hat{P}_{LC,t+h+5}) - \left( 7.5 * \hat{P}_{FC,t+h} + \sum_{i=t+h}^{t+h+4} 12 * \hat{P}_{c,i} \right)$$

Where the cash price expressions for live cattle, feeder cattle, and corn ( $\hat{P}_{LC,t+h+5t}, \hat{P}_{FC,t+h}, \hat{P}_{c,i}$ ) were obtained from simulated joint price distributions,  $t$  is the time index with  $h$  future periods. Their methodology resulted in  $n$  feeding margin estimates for each forecasted time period under seven different volatility forecasting techniques. The model's point estimate for the feeding margin was represented by the simulated mean feeding margin.

Tonsor and Schroeder (2011) also conducted value at risk (VaR) evaluations for each model and results showed implied volatility, historic volatility, and an average of implied volatility and 1-year lagged historic volatility fit within the expectations of VaR violation frequencies. Their analysis revealed that greater information is held in joint distribution forecasts rather than single point forecasts obtained through futures markets. Furthermore, incorporating historic, realized volatilities along with implied volatilities improved volatility forecasting accuracy.

### ***2.2.1 - Cattle Performance Variables in Profit Models***

Several studies have incorporated cattle feeding performance variables into analysis of feedlot profits. Langemeier, Schroeder, and Mintert (1992) sought to examine which factors most significantly impact feedlot profits stemming from feeding both steers and heifers. The profit model they developed included variables for fed cattle price, feeder cattle price, corn price, interest cost, average daily gain, and feed conversion. Their work utilized regression analysis and coefficients of separate determination to examine the proportionate impact of each independent variable on feedlot profits.

Using proprietary closeout data from a western Kansas feedlot, Langemeier, Schroeder, and Mintert (1992) found that fed cattle price had the largest impact on profits per head. Following that, feeder cattle and corn prices were the next most influential factors, and interest costs, average daily gain, and feed conversion rates “had considerably less influence on profits per head” (pg. 44). They determined that, overall, movement in live cattle prices was responsible for 50 percent of the per head profit variation over time. Feeder cattle and corn prices contributed roughly 25 and 22 percent of profit variability, respectively. They conclude by noting that, given

the significant portion of profit variability explained by output and input prices, feedlot managers should strongly consider cost and revenue risk management strategies.

Using cross sectional data of 1,626 pens of Iowa State University feedlot cattle, Lawrence, Wang and Loy (1999) examined the factors influencing cattle feeding profitability. Following earlier work, their profit model included the prices of feeder cattle, fed cattle, and corn, and feed efficiency, average daily gain, and the interest rate. They also included quarterly, seasonal dummy variables to account for seasonality in cattle performance and per head profits. Ordinary least-squares regression analysis was their principal econometric model and coefficients of separate determination were also used to analyze the proportionate impact of each variable.

The results of Lawrence, Wang, and Loy (1999) agreed with previous studies in which feeder cattle and fed cattle prices explained nearly 70 percent of feedlot profit variability. Their results differed as corn had a lesser impact and individual animal performance was more variable than in Schroeder et al. (1993). Their results also suggested profits decreased with heavier placement weights and feeding steers was, in general, more profitable than feeding heifers.

Similarly, Mark, Schroeder, and Jones (2000) used closeout data from over 14,000 pens of feedlot cattle in two western Kansas feedlots to examine factors influencing feedlot profitability. Using standardized beta coefficients for parameter estimation (they note that OLS coefficients are unit dependent and therefore difficult to interpret), their models included variables for fed cattle, feeder cattle, and corn prices; along with interest rates, average daily gain, and feed conversion variables. Fed cattle and feeder cattle prices had the largest influence on feedlot profit volatility. Profits on lighter weight cattle were more heavily influenced by corn prices (due to greater days on feed) while profits on heavier placements were more influenced by fed cattle prices.

Belasco et al. (2009) sought to quantify yield risks of fed cattle production through estimated *ex ante* profit distributions. These profit distributions were estimated through Monte Carlo simulations and were conditional upon price and performance variables. Critical performance variables in fed cattle production were determined to be dry matter feed conversion (measured by feed:gain), average daily gain, veterinarian and other cattle health costs, and mortality rate. Estimates for these performance variables were found via Harvey's multiplicative heteroskedasticity model. To determine factors influencing the performance variables, the

authors examined the effects of several conditional variables. These conditioning variables were cattle placement weight, dummy variables for spring, fall, summer and winter seasons, pen gender (binary variables for steers, heifers, and mixed pens), and pen location (Kansas or Nebraska). The results found by Belasco et al. (2009) strongly indicated conditioning variables influence cattle performance variables.

In Belasco et al. (2009), the natural logarithm of cattle placement weight had a statistically significant (at the 5% level) impact on the means and variances of all performance variables. Increases in placement weight increased DMFC and ADG rates, and have a negative effect on mortality and veterinary costs. Steers exhibited lower mortality rates, veterinary costs, and DMFC rates than heifers and had increased ADG. Similarly, Kansas feedlots had lower mortality and veterinary costs, higher ADG, and lower DMFC rates.

Following their analysis of feedlot cattle performance variables, Belasco et al. (2009) used the estimated conditional means and variances of their deterministic variables, along with futures prices and options volatilities, to examine the variance of fed cattle returns. Their study used the Black-Scholes implied volatility formula to estimate the variance of futures prices. The volatility of fed cattle returns was estimated using Monte Carlo integration techniques. Their integration of fed cattle returns used six variables (ADG, DMFC, mortality, VCPH, fed cattle price, and corn price) and fixed values for feeder cattle placement weight, number of days on feed, and feeder cattle price. The authors assumed zero correlation between the four cattle performance variables and correlated fed cattle and corn prices based on long-term average daily cash prices. Increases in fed cattle and corn price volatilities significantly increased the distribution of profits and increased variability in ADG significantly increases the variability of returns.

In 2010, Belasco, Schroeder, and Goodwin examined the variability of marketing cattle on grid pricing arrangements and the impact on feedlot profits. They employed a copula approach, enabling the exact specification of the covariance structure without depending on the marginal distribution. The study considered many sources of cattle feeding profit variability, including corn and cattle price risk, production risk, and yield and quality grade risk. Production parameters were estimated through the mean-variance approach while profit distributions were obtained by simulation techniques. The generated profit function incorporated premiums and discounts associated with selling various cattle types on a grid marketing arrangement. Results

identified significant trade-offs between yield and quality grades and noted that grid pricing increases the standard deviation of profits by 20% when risk management strategies were employed.

### **2.3 - Futures and Options Markets**

Broadly, futures markets are markets where participants can buy and sell contracts to deliver, or take delivery of, a specific commodity at a specific point in time. They serve as the primary point of price discovery (Purcell and Koontz, 1999; Tomek and Robinson, 2003), and offer firms opportunities to guarantee profits and transfer price risk. Futures markets also provide price forecasts (as will be discussed in depth later in this chapter) and serve allocative roles in the supply and demand of commodities (Tomek and Gray, 1970; Purcell Koontz, 1999; Tomek and Robinson, 2003).

While price discovery occurs in the futures markets, cash prices and futures market prices are closely linked. This occurs because futures contracts have specified delivery points when physical commodities can be delivered. This physical delivery of commodities is a key element to the link between cash and futures prices because it allows for arbitrage. Arbitrage occurs when market participants see an opportunity to make profits by buying a commodity in one location and selling it in another. For example, if Chicago corn futures are trading at \$6.50/bu while cash corn prices in Des Moines, IA are at \$6.00/bu and transaction costs of moving corn from IA to Chicago are only \$0.40/bu, then arbitrage traders can make a \$0.10/bu profit by selling Chicago corn futures at \$6.50/bu, buying IA cash corn at \$6.00/bu and paying the transaction costs. This act of buying and selling in separate markets will bid up prices on one market and bid down prices in the other, causing cash and futures prices to converge (Tomek and Robinson, 2003). Full convergence may not be observed and the difference is explained by the transaction costs of moving the physical commodity (Tomek and Gray, 1970; Tomek and Robinson, 2003).

Because futures markets serve many important roles (see above discussion) their ability to function efficiently and provide accurate price forecasts is of paramount importance. In one of the seminal works on the efficiency of capital markets, Fama (1970) presented three standards by which market efficiency tests should be conducted. These standards were necessitated by the vacuous (though popular at the time) statement of whether an efficient market “fully reflects” all available information. Fama argued that the ‘reflection’ of information in a market can take one

of three forms: weak form efficiency, semi-strong form efficiency, and strong form efficiency. Fama argues that weak form efficient markets incorporate all information known by past prices, and that models incorporating solely past prices cannot outperform weak-form efficient markets. Semi-strong form markets incorporate all obviously publically available information (stock splits, earnings reports, etc.) while strong-form efficient markets are such that no individual investor or group has monopolistic access to information relevant for price formation.

Fama (1970) noted that previous literature examining market efficiency focused mainly upon tests for weak form efficiency but that tests for strong form efficiency (though difficult to perform) are likely the best benchmark against which to test market efficiency. Fama noted, however, that there were no known instances of deviations from strong-form efficiency permeated down through the capital markets. Fama concluded by saying that “For the purposes of most investors the efficient capital markets model seems a good first (and second) approximation to reality” (pg. 416).

Responding to arguments that commodity futures markets are not efficient price forecasts, Koontz, Hudson, and Hughes (1992) argued that livestock futures markets support the rational price formation theory. In essence, livestock futures markets reflect the average, anticipated cost of feeding until the time of placement occurs. Once animals are placed on feed for delivery in a specific futures contract month, the corresponding futures contract price closely reflects the actual cost of feeding. As the contract nears expiration, the futures prices change to reflect anticipated supply and demand conditions. Noting that futures markets are more complex than a price forecast, incorporating merchandising of the underlying commodity and arbitrage, they argue that “The futures market will not forecast if doing so elicits behavior that will prove the forecast wrong.” (p. 235) Testing the hypothesis by regressing futures prices of fed cattle and live hogs against estimated variable costs of production, their results indicated that deferred livestock futures contracts reflect the average costs of feeding. The live cattle and lean hog futures markets provided poor price forecasts for more distant time horizons but improved as the contract neared expiry.

The forecasting ability of deferred grains contracts was the subject of Zulauf et al. (1996). The authors reevaluated the effectiveness of deferred futures contracts as price forecasts. Original work by Tomek and Gray (1970) found that spring quotes of November and December soybean and corn futures contracts were highly accurate, unbiased forecasts of realized futures

prices. Zulauf et al. updated this work by incorporating corrections for non-stationary data in regression price forecasts. Zulauf et al. used two models to analyze the forecasting ability of spring-time quotes to predict harvest contract prices. The first model was a simple regression of price of a harvest futures contract during its expiration month upon a spring quote for the same contract. The second model analyzed the change in a commodity's cash price from spring to harvest time. The change in cash price is regressed upon an intercept and the basis of the spring quote for the harvest futures contract and the spring cash price.

Zulauf et al. (1996) showed that both corn and soybean prices had become more variable from 1974 to 1995, as evidenced by increased standard deviations of both commodities' price. Results from the first model showed that the  $R^2$  for both corn and soybean meal was lower during the 1975-95 time frame. Spring quotes for November soybeans are biased estimators of harvest-time prices. Conversely, spring quotes of the December corn contract were unbiased estimators of harvest prices. Additionally, results from the second model concluded that spring-time quotes are unbiased estimators of both corn and soybean harvest prices. Their study concludes by noting that farmers and other's in the agricultural industry can use quotes of deferred futures contracts as estimates of future prices.

Tomek (1997) noted that debates (including Zulauf et al., 1996) surrounding the ability of deferred futures contracts to forecast future prices were closely linked to theories of market efficiency. Tomek notes that if a futures market is efficient then econometric models should not be able to improve upon its price forecast. If an econometric model outperforms the futures market (or vice versa) in forecasting, Tomek argued that three explanations are possible:

- 1) That both are correct but reflect sampling error and that if a large enough sample was created, the model's forecasts would be nearly equal.

- 2) The one model is correct and the other is wrong. If the market offers a better forecast, then the econometric model is misspecified. Conversely, if the model outperforms the market, then the market is inefficient.

- 3) The market is weak form efficient (incorporating all information available from past prices, Fama, 1970) but not strong form efficient (where no privately held information or model can outperform a market, Fama, 1970).

Tomek further noted that while econometric models may have superior forecasting ability from a statistical standpoint, if that difference is not great enough to provide profitable trades, the

information does not have economic significance (Tomek, 1997, Rausser and Cater, 1983).

Tomek also noted that accurate price forecasts are difficult to make, as they rely upon a complex array of factors which can change quickly, especially as the forecast horizon increases. In conclusion, Tomek (1997) found insufficient evidence to believe that econometric models can substantially improve upon price forecasts provided by futures markets.

Following this work, Kastens, Jones, and Schroeder (1998) quantified the accuracy of using deferred futures prices and historical average basis to forecast future agricultural commodity cash prices. Deferred futures prices are commonly used as forecasted prices and that this practice depends on futures market efficiency. If a futures market is efficient, they argue “a deferred futures price will, on average, be an unbiased estimate of delivery-time price of the underlying commodity” (pg. 295). Therefore, cash price forecasts can be made based on deferred futures prices and expected basis, along as basis can be accurately forecasted.

Kastens, Jones, and Schroeder (1998) take five approaches to forecast future cash prices. They first use naïve expectations (the previous year’s price will be this year’s price), then a five year average price. The third approach uses futures prices and basis in a fixed level (e.g., cents per bushel) while the fourth approach generates cash price forecasts as a function of futures price and basis where basis is in fixed and proportional components. Finally, the fifth approach used was to regress cash prices on deferred futures prices and use the resulting coefficients to generate predicted cash price values.

Kastens, Jones, and Schroeder (1998) used mean absolute percentage error (MAPE) and maximum absolute percentage error (maxAPE) as the criterion for forecast accuracy. Given this framework, one-year lagged naïve expectations did not significantly diverge from the actual price but the provided forecast was not particularly accurate. Cash price forecasts generated from regressions of cash prices upon futures prices were the poorest forecast method based on maxAPE results. In terms of MAPE, however, forecasts based on five-year average prices were the worst performing (the author’s blame underlying cattle cycles for this phenomenon).

With respect to fed cattle only, Kastens, Jones, and Schroeder (1998) concluded that, based on MAPE and maxAPE measures, futures plus basis (in levels) forecasts were the most accurate. For 7-8 cwt. steers, futures prices plus basis (in level and proportional) had the lowest MAPE while futures plus basis (in levels) had the lowest maxAPE. They note, however, that futures plus basis forecast methods deteriorate as the forecast horizon increases, while naïve

forecasts do not. They conclude by saying that price forecasters would do well to generate localized, historic basis values and simply add those to current futures markets quotes.

### ***2.3.1 - Implied Volatility and Options Pricing Theory***

In option pricing models, the implied volatility is defined as the volatility that, when incorporated into the option pricing model, equates the theoretical option price to the observed option price (Giot, 2003). Thus, it is possible, given traded options prices and other relevant information (length of time until option expiry, the risk-free interest rate, option strike price, and the underlying security price), to discover how much volatility must have been implied by a traded options price.

Implied volatility is often thought of as an estimate of a futures contract's price volatility between the date an option is bought or sold and the expiration of the option. This is because a call or put option will only be exercised if the underlying commodity's price is above or below the strike price (Purcell and Koontz, 1999). Because the option's writer is obligated to pay margin calls on the underlying futures contract, the options premium represents the minimum dollar amount the seller is willing to accept in compensation for the risk of meeting margin calls. If the seller anticipates a highly volatile market (and, therefore, a greater probability that margin calls must be met), the options premium will increase (Purcell and Koontz, 1999). Given the increase in the options premium, *ceteris paribus*, the implied volatility will also increase (Black and Scholes, 1973).

The options market does not only reflect the seller's view of future market movements, however. Option buyers likely have their own beliefs of future market movements which motivate their need for risk management strategies (like buying options contracts). Options buyers will not purchase an option at a premium that is more expensive than the value of risk mitigation it provides. The options premium, then, represents the seller's minimum willingness-to-accept compensation for the risk of meeting margin calls and the buyer's maximum willingness-to-pay for the reduction of risk. Therefore, because implied volatilities are calculated (partially) from traded options prices, they represent the anticipated market volatility inferred by the selling and buying of an option (Purcell and Koontz, 1999).

### ***2.3.2 - Implied Volatilities as Forecasts***

In financial industries, there is a widely held belief that options implied volatilities are the best forecast of realized market volatility. Because options implied volatilities are based off traded options premiums and the underlying futures price, they represent information and forecasts found in two different markets. These market-based forecasts theoretically incorporate all information found in other models or forecasts (Fama, 1970) and are the best forecast of short-term realized volatility. Several papers have researched the reality of this assumption and a brief discussion of their findings follows.

Figlewski (1997) notes that while implied volatility is often treated as “the market’s well-informed prediction of the underlying asset’s futures volatility” (pg. 1) that arbitrage trading needed to align options prices with market volatility expectations may not occur efficiently. Figlewski further notes that, of the five parameters in Black and Scholes 1973 model, implied volatility is the only one which is not directly observable. Because of this, and other factors, Figlewski states that volatility forecasting remains more of an art than a science.

Figlewski (1997) also argues that markets are man-made institutions and security prices are artifacts of human behavior. This, he argues, is very different from classical statistics which is based on a fixed, conceptual framework with predictable changes and reactions. Financial markets, based on human actions, are “no more fixed and immutable than human behavior is (pg. 80).” Because human behavior is ever-changing, Figlewski argues that out-of-sample forecasts of volatility, or any market attribute, will remain a difficult task.

Giot (2003) examined implied volatility as an input into Value-at-Risk (VAR) models (broadly, quantitative measures which assess the probable loss occurring to a portfolio of assets over a specific time frame) and examine the performance of VAR models based on implied volatilities against those based off other volatility estimators. Giot showed that other volatility estimations (e.g., past squared returns to a commodity) only marginally improve the performance of models based on lagged implied volatility. Furthermore, the results of different VAR models suggest that those based exclusively on lagged implied volatility models performed as well as those based on more complicated mathematical models (e.g., GARCH). Giot concluded that implied volatilities have “high information content regarding conditional variance and VAR forecast of the underlying future[s] contracts (pg. 454).”

Simon (2003) examined the power of implied volatility to predict realized volatility in the corn, soybean, and wheat futures markets. This study differed from previous work as Simon examined realized volatility over the 4 week period of an option's life, rather than simple 1-week realized volatility. Simon argued that implied volatilities represent market forecasts of volatility over the life of an option and do not specify where the volatility will occur. Simon hypothesized, then, that implied volatility should be a better predictor of volatility over the life of an option rather than volatility realized over the following week.

Simon noted that the predictive power of implied volatilities may have increased in recent years as grain markets have become more volatile, causing the signal-to-noise ratio of implied volatility also increase. Increases in the signal to noise ratio typically reflect increased ability of a statistic (for example, implied volatility) to predict subsequent significant market movements, rather than merely indicating random market fluctuations ("noise"). For risk managers, increases in implied volatility signal-to-noise ratio would indicate that implied volatility has become a better predictor of realized volatility and, therefore, a more relevant tool for risk management decision making.

Simon (2003) suggested that implied volatility for corn, soybeans, and wheat has significant power to predict realized volatility. Simon found that 50 to 80% of total variation in realized volatility was explained by implied volatility. Corn implied volatilities were biased estimates of realized volatility while soybean and wheat implied volatilities were unbiased. Furthermore, implied volatility had greater out-of-sample predictive power than other statistical models.

Similarly, Manfredo and Sanders (2004) sought to examine the ability of live cattle implied volatilities to forecast subsequent 1-week realized volatility in live cattle futures. They stress the need for accurate volatility forecasts has increased due to increased risk management in agriculture. Some risk management strategies and risk measures (Value-At-Risk, for example) use volatility forecasts as inputs. A correct forecast of volatility, then, is critical for accurate decision making.

Manfredo and Sanders (2004) regressed 1-week realized volatility on the previous week's quote of implied volatility. Implied volatility was systematically biased over their sample period and overstated realized volatility by 4.5% on an annualized basis, compared with a 3.3% overstatement in realized volatility from GARCH models. They note that risk managers can

adjust for this bias by subtracting a constant value (shown in Manfredo and Sanders, 2004) from implied volatility forecasts. Further tests performed by the authors suggested options implied volatilities “pass the condition for weak efficiency” (pg. 225) and do encompass information provided by other models (e.g., GARCH). Finally, Manfredo and Sanders note the ability of implied volatility to forecast realized volatility increased over their sample period.

Responding to commodity markets with marked volatility increases and a belief that options premiums were overpriced, Brittain, Garcia, and Irwin (2011) investigated the efficiency of options pricing and the ability of options implied volatilities to forecast realized volatility. Their study followed Urcola and Irwin (2011) who found efficient option pricing in corn, soybean, hog, and wheat markets and Simon (2003) who found that corn market implied volatilities overstate realized volatility (but not enough to generate returns to short straddle positions). Brittain, Garcia, and Irwin (2011) focus on efficiency of live and feeder cattle futures markets as evaluated by empirical returns simulated by buy-and-hold and straddle positions trading strategies. Implied volatility estimates were compared against GARCH volatility estimates as predictors of realized volatility.

Brittain, Garcia, and Irwin (2011) showed significant inefficiencies in options pricing. Their examination of the forecast errors given by implied volatility and GARCH estimates concluded that both models overstate realized volatility. GARCH forecast errors of live cattle realized volatility were slightly smaller than implied volatility forecast errors but the reverse was true of feeder cattle GARCH forecast errors. Further tests, however, revealed implied volatilities held greater predictive power than GARCH models. That said, those same tests concluded both live and feeder cattle options are biased and inefficient forecasts of one-week realized volatilities.

## **2.4 - Risk Management in Livestock Production**

Research in the area of risk management in livestock production, and more broadly, in all agricultural production, is both wide and deep. Risk management can infer any number of connotations, from futures and options market hedging strategies to insurance contracts, and has many sub-disciplines (price or volatility forecasting, structuring of cash price contracts, different futures market strategies, optimal insurance products, etc.). The following section of this study is

designed to provide an overview of the topics and present some of the most notable and relevant (to this study) research.

### ***2.4.1 - Hedging in the Futures Market***

As noted earlier in this chapter, futures markets and cash markets are closely linked due to arbitrage and physical delivery of commodities. This allows for hedging to occur, that is, for market participants to take positions in futures markets which will minimize their risk exposure. As Purcell and Koontz (1999) note, the basic principle of using futures markets to manage risk (or to 'hedge' profits) is to take a position in the futures market which will offset gains or losses in the cash market. Hedges may range from simple strategies to highly complex techniques involving multiple futures and options contracts and, potentially, cash market risk management tactics as well.

In a review of risk management techniques in agricultural markets, Tomek and Peterson (2001) noted that the use of futures contracts to hedge input and output prices should be sufficient to assure livestock producers of a profit when desirable prices occur in the market. Such a program would involve buying and selling output and input futures contracts at nearly the same time. This process of buying and selling different futures contracts with different expiration dates is commonly referred to as a 'crush' and is most frequently seen in the soybean processing complex and in cattle and hog feeding operations (Tonsor, 2006).

Cook (2009) notes that trading the cattle 'crush' in futures markets models the economics of feedlot operations and offers risk mitigation. The basics of trading the feedlot cattle crush involve buying feeder cattle and corn futures and selling live cattle futures. In the feedlot crush example, feeder cattle futures contracts are purchased so that any subsequent increase in cash prices (which would increase feedlot costs) are nearly equally offset by gains from the long futures position (remember, cash and futures prices are closely linked and price changes in one market are usually quickly reflected in the other). Conversely, short positions are taken in the live cattle market (contracts are sold) so that any drop in cash live cattle prices (which will decrease feedlot revenues) are counteracted by gains from the short futures position. Cook (2009) also states that similar risk management benefits can be obtained through various options positions.

Harri et al. (2009) noted that risk management tactics depend on the marketing arrangement under which cattle are sold. They argue that, under cash negotiated marketing arrangements where cattle were price on the average quality of the pen (typical of cattle marketing prior to the early 2000's, according to Harri et al., 2009) futures market positions are sufficient to manage risk. Under increasingly popular grid pricing systems (where cattle are assigned premiums and discounts based on individual characteristics), the optimal risk management structure may have changed. Their research finds grid pricing systems where the base price (the price from which premiums (discounts) are added (subtracted)) is closely linked to the live cattle market can be effectively hedged using futures markets. However, grid pricing systems using base prices more closely linked to wholesale beef values have more limited hedging potential.

#### ***2.4.2 - Additional Risk Management Tactics***

Beyond simple futures market hedges, other risk management contracts have been considered in the literature. Elam (1992) notes that cash forward contracting had become increasingly popular as packer concentration increased. Forward contracting involves an agreement by which fed cattle are promised for delivery at a specific packing plant at a future time for an agreed upon price. Elam noted forward contracting has advantages over hedging in the futures market, namely that the exact cash price is known, cash is not needed for margin calls (money the holder of a futures contract must provide if the market moves against the futures position), and a specific number of cattle can be contracted (rather than a generic 40,000 pound live cattle futures contract). In exchange for these advantages, Elam reports that it appears cattle feeders are offered lower cash prices from forward contracts than could have obtained through futures hedging.

Elam's results that forward contracting lowers cash cattle prices were later corroborated by Ward, Koontz, and Schroeder (1998). Their results show decreased transaction prices as the percentage of cattle classified as under 'captive supply' (cattle owned by, or committed to, a specific packer two weeks or more before slaughter) increased. Additional results showed cattle feeders have incentives to use forward basis contracts (where cattle are sold for an agreed upon basis, rather than price) as such contracts offer significant reduction in fed cattle return variability.

In another alternative to futures hedging, Shao and Roe (2003) evaluated the usefulness and practicality of window contracts in the hog finishing industry. Window contracts specify a price ceiling and floor (e.g., a 'window') for the duration of the contract. If the reference market price falls within the window, the producer receives the price. If the reference price falls outside the window, the packer pays the ceiling or floor price, or some combination of the reference price plus the ceiling or floor price.

Shao and Roe used futures prices as the expected market price at the time of slaughter. Monte Carlo simulations (based off implied volatilities) were then employed to estimate the ceiling and floor prices where the window contract has a zero value. Tonsor and Schroeder (2006) found this approach allowed for easy incorporation of basis risk and inclusion of covariance relationships between input and output prices.

Following Shao and Roe (2003), Tonsor and Schroeder (2006) explored the viability of window contracts in the beef sector. Assuming that cash prices followed a lognormal distribution and incorporating a random walk drift component into price series, they estimated cash prices as a function of Monte Carlo simulated volatility estimates. The volatility estimates were constructed from an average of implied volatility and 1-year lagged historic volatilities. Two window contracts were evaluated, one with a \$0/head floor and another with a \$50/head floor. Their results showed that as risk aversion increased, the producers' preference shifted toward use of the window contracts. Under a risk-neutral producer scenario, the authors found preference for cash marketing strategies because window contracts reduced producer revenue. Risk-neutral producers would be indifferent between hedging in the futures market and entering window contracts.

## **2.5 - Basis**

Basis is the difference between the local cash price and the nearby futures contract. Basis reflects transaction costs of arbitrage from the cash location to the futures exchange-specified delivery point (Tomek and Robinson, 2003). Additionally, because the price discovery process for agricultural commodities occurs in the futures markets (Purcell and Koontz, 1999), basis may serve to 'adjust' futures prices for local supply and demand.

Basis plays an important role in the creation of cash price forecasts. If futures prices are used to forecast prices, then basis forecasts can be incorporated to generate an expected cash

price. Narrowly, the expected cash price is equal to the expected futures price plus the expected basis. Under this forecasting regime, an accurate basis forecast is paramount to the success of cash price forecasts or any hedging strategy (Tonsor, Dhuyvetter, and Mintert, 2004).

Tomek and Peterson (2001) also note that basis relationships are fundamental to the success of hedging effectiveness. Some basis forecasts are based on naïve expectations (this year's basis will be the same as last year's basis) while some econometric models have been developed. However, Tomek and Peterson argue that econometric models providing accurate basis forecasts are difficult to develop as it is complicated to develop *ex ante* estimates of the explanatory variables.

Parcell, Schroeder, and Dhuyvetter (2000) modeled live cattle basis as a function of lagged basis, cattle weight, percentage of cattle sold under forward contract agreements, nearby corn futures price, the choice-select spread (a proxy for measuring the quality of cattle produced in different areas), and the portion of cattle on feed in a specified location relative to the seven-state cattle on feed number. Their model also included cold storage stocks (a measure of packer's need to purchase live animals versus sell beef from storage), changes in the live cattle futures contract, and the month of the year (to reflect seasonal basis changes).

Parcell, Schroeder, and Dhuyvetter found basis shocks lasted longer in Colorado basis than in Texas or Kansas locations. Increases in corn futures prices led to decreases in fed cattle basis levels for all locations as cattle feeders moved cattle off feed (thereby increasing slaughter cattle supply and lowering local prices) to avoid higher feeding costs. Similarly, increases in the choice-select spread increased basis in each of the states (indicating that demand for higher quality beef is reflected in offered cash prices). Kansas basis levels decreased as the portion of cattle on feed in Kansas increased. Finally, their study confirmed seasonal patterns found in other basis studies.

Tonsor, Dhuyvetter, and Mintert (2004) argue basis expectations are typically generated using historic basis values corresponding to the week of the year for which a basis expectation is desired. Their study determined the optimal number of lagged historic years to use in the generation of basis expectations and the optimal amount of current information to incorporate. Following the change from delivered feeder cattle futures contracts to cash settled contracts (which occurred in September, 1986); 4-year average basis had the lowest forecast error for feeder cattle. Similarly, live cattle basis from 1998 to 2002 had the lowest mean absolute error

when 2-year average basis was used but the difference was not statistically different from other forecasts using lagged averages. Including the current basis deviation from the average in ‘optimal’ levels (32% and 45%, respectively) for 4-week forecasts of feeder cattle and live cattle increased basis forecast accuracy over forecasts with no current information.

Taylor, Dhuyvetter, and Kastens (2006) find strict use of historic averages to generate basis expectations ignores relevant current information. Their research examined nine basis forecasting methods to predict realized basis at harvest and 24 weeks post-harvest. The first seven forecast methods were 1-7 year lagged average historic basis, while the remaining methods were the previous week’s basis level and a historical average which incorporated current deviation from the average. They found 1 year lagged basis forecasts performed best for corn and soybeans. Post-harvest basis forecasts which incorporated current information had increased forecasting power but this did not hold true for harvest time forecasts.

Two recent works, Hatchett, Brorson, and Anderson (2010) and Sanders and Baker (2012) have examined the forecast power of historical basis levels in light of recent structural changes in the grains complex. These structural changes caused increased volatility in grain basis across the Midwest and changed the nature of basis forecasts (Irwin et al., 2009). Hatchett, Boroson, and Anderson found 1 year lagged basis had the greatest explanatory power in predicting storage-contract corn and soybean basis. Forecasts of pre-harvest corn and soybean basis were only slightly improved using 1 year lagged basis rather than 5 year historic average basis. Sanders and Baker (2012) updated past research which compared simple corn basis forecasting methods (e.g., historic basis) to complex, time-series econometric methods. Time series models performed better (had lower mean absolute errors) than moving averages in the short run but for longer forecast periods (or during times of highly volatile markets), simple moving averages performed better.

## **Chapter 3 - Data**

Friday settlement futures prices and options implied volatilities for feeder cattle, live cattle, corn, and soybean meal were gathered from Bloomberg data terminals for the time period January 2, 1998 to March 15, 2013. Weekly reported cash prices for the specified commodities in locations detailed in the ensuing discussion were obtained from the Livestock Marketing Information Center (LMIC) in Denver, Colorado for the same time period. Gathering data for four years prior to the intended start date of the simulations (January 1, 2002) allows for a four-year average historical basis to be used for selected variables through the entire study.

### **3.1 - Futures Prices and Options Data**

Friday settlement prices and options implied volatilities were used for this study to avoid the ‘smoothing’ effects of averaging weekly prices and because there were fewer missing values compared to closing data on other weekdays. The put and call options implied volatilities<sup>1</sup> were calculated by Bloomberg using the Trinomial model for American options and using the two nearest-to-money puts and calls, respectively, and the Friday settlement price. The put and call implied volatility estimates were averaged in this study to reflect the average risk of upward and downward price movements. A summary of the futures data used in this study are presented in Table 3-1.

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<sup>1</sup> Graphs of implied volatilities used in this study are provided in Appendix A.

**Table 3-1: Summary Statistics for Futures Prices and Implied Volatilities, 1/2/2002 to 3/15/2013**

Variable	Commodity	Units	Report Frequency	Mean	Standard Deviation	Min	Max
Futures Price	Feeder Cattle	(\$/cwt)	Weekly	108.97	20.54	73.05	161.33
	Live Cattle	(\$/cwt)	Weekly	94.00	18.21	64.40	136.45
	Corn	(¢/bu.)	Weekly	395.61	181.03	189.75	824.50
	Soybean Meal	(\$/ton)	Weekly	267.52	90.80	143.60	547.10
Put Implied Volatility	Feeder Cattle	%	Weekly	14.34	5.76	6.54	124.59
	Live Cattle	%	Weekly	15.25	3.32	9.23	45.01
	Corn	%	Weekly	30.94	9.86	1.07	78.68
	Soybean Meal	%	Weekly	27.93	8.85	1.82	77.94
Call Implied Volatility	Feeder Cattle	%	Weekly	14.11	3.53	6.54	32.84
	Live Cattle	%	Weekly	15.17	3.22	9.23	34.31
	Corn	%	Weekly	31.08	9.81	0.76	78.23
	Soybean Meal	%	Weekly	27.90	8.78	1.00	77.37

Because this study provides a forward looking estimate of profits occurring from placing cattle on feed, the selection of the appropriate deferred futures contract is important. Deferred futures contract selection rules follow the pattern in Table 3-2. The table can be further illustrated by using the example of placing cattle on feed during the first week of January. The expected profit simulations assume a 150 day feeding period, resulting in fed cattle being marketed in early June. Accordingly, the June live cattle contract (the nearby contract at the time of marketing) is used (along with basis adjustments discussed below) to derive the expected sale price of fed cattle<sup>2</sup>. The March corn and soybean meal contracts are used to reflect expected prices mid-way through the feeding period. Finally, the nearby March feeder cattle contract is used as the expected price of purchasing feeder cattle.

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<sup>2</sup> Futures prices are often viewed as forecasts of a commodity's price for a specific location and future time period. Basis (the difference between cash and futures prices) 'localizes' these forecasts based on local supply and demand. Basis has shown to be relatively stable over historic time periods and historic, moving-average basis forecasts are often highly accurate predictors of realized future basis. Because basis is equal to cash minus futures prices, that equation can be rearranged such that cash prices are equal to futures prices plus basis. Therefore, an expected futures price plus and expected basis level, can be, and often are, used as predictors of cash prices.

**Table 3-2: Futures Contracts used for Simulations**

<b>Placement Month</b>	<b>Finish Month (150 DOF)</b>	<b>LC Contract</b>	<b>FC Contract</b>	<b>Corn Contract</b>	<b>Soybean Meal Contract</b>
Jan	Jun	Jun	Mar	Mar	Mar
Feb	Jul	Aug	Mar	May	May
Mar	Aug	Aug	Apr	May	May
Apr	Sep	Oct	May	Jul	Jul
May	Oct	Oct	Aug	Jul	Jul
Jun	Nov	Dec	Aug	Sep	Aug
Jul	Dec	Dec	Aug	Sep	Sep
Aug	Jan	Feb	Sep	Sep	Sep
Sep	Feb	Feb	Oct	Dec	Oct
Oct	Mar	Apr	Nov	Dec	Dec
Nov	Apr	Apr	Jan	Dec	Jan
Dec	May	Jun	Jan	Mar	Jan

The decision of which futures contract to use for corn and soybean meal is dependent on assumptions about cattle feeding practices. This study assumes that feedlots are not 100% hedged in feedstuffs prices and that feedlots will procure grain throughout the feeding period. This assumption is supported by Davies and Widawsky (1995) who documented that commercial feedlots typically purchase corn several times during the feeding period, rather than making one purchase at the time of cattle placement. Additionally, the volume of feed consumed by cattle will increase during the feeding period, making expectation of grain prices near the middle to end of the feeding period more relevant. Accordingly, the first deferred futures contract is used, whenever practical, as the expected price for corn and soybean meal.

Though this study attempts to use the first deferred futures contract to estimate expected grain prices, some instances require the use of the nearby futures contract to generate price expectations. Nearby futures contracts are used to avoid “old crop/new crop” price differences inherent to deferred grains contracts. Such price differences occur because different contracts may represent incentives to store grain post-harvest or the expected supply and demand at harvest (Koontz, Hudson, and Hughes, 1992; Tomek and Robinson, 2003). Using a futures contract which reflects “new crop” information to predict prices at a time when feedlots would purchase “old crop” grain would inherently lead to poor price forecasting. Accordingly, nearby and first deferred futures contracts are used to best reflect seasonal grain pricing patterns.

Expected feeder cattle prices were generated using the futures contract nearest to expiration not in its expiration month. The decision to use futures contracts not in their expiration month is justified because trading volume significantly decreases upon entering a contract's expiration month. Upon entering the expiration month, many traders roll to the next contract to avoid risks associated with physical delivery (or financial settlement, as in the case of feeder cattle) of contracts (Tomek and Robinson, 2003). As liquidity drops, markets often exhibit erratic behavior and the forecasts they provide are presumed to be less accurate. The decrease in perceived accuracy stems from the efficient market hypothesis (Fama, 1970) which states that actively traded markets represent all known information regarding a given commodity and, therefore, futures prices reflect a forecast based on all available information. The reverse stands true as well. If a market is thinly traded by only a few participants, it reflects limited information and the futures forecasted prices, based on less information, are less accurate. To avoid such complications, this study uses prices from futures contracts not in the expiration month.

### ***3.1.1 - Missing Data Corrections***

Over the 1998 to 2013 time span, there were 24 missing observations for live cattle implied volatilities which accounted for 3% of the 794 total observations. Specifically, the missing implied volatilities occurred at 10/4/2002 and from 8/6/2004 through 12/31/2005, which corresponded, according to the contract rollover rules specified above, to the February, April, and June 2005 live cattle contracts. The missing implied volatility estimates for the above dates and contracts were estimated by using Black and Scholes' (1973) model to calculate implied volatilities from options premium data provided by the Chicago Mercantile Exchange (CME) Group (Cook, 2013).

The Black-Scholes calculation of an options implied volatility requires five specific variables; the options strike price, the price of the underlying commodity, the risk-free rate of return, the days remaining until the option's expiration, and the option premium. For this study, the options premium and strike price were provided by the CME Group (Cook, 2013) and the futures prices and days to option expiration were obtained as described above. The risk-free rate of return was estimated by using weekly yield on a 6-month Treasury-bill, from data available from the Kansas City Federal Reserve (Federal Reserve Bank of Kansas City, 2004). It is important to note, that the yield on the 6-month T-bill was near historic lows from August, 2004

through December, 2004. This may have the effect of creating higher implied volatility estimates than would be obtained from data using a higher risk-free interest rate. Using these data, implied volatilities were calculated by manually changing the volatility level until the Black-Scholes calculated options premium matched the market traded option premium to the hundredths decimal.

Feeder Cattle implied volatility quotes were also missing for the 11/5/2004 through 12/31/2004 quotes of the January 2005 contract (the missing values accounted for 9 of 794 total observations, or 1.1%). Estimates of these values were constructed by taking the 1998-2013 average ratio of November and December implied volatility quotes for the January feeder cattle and June live cattle contracts. This ratio was calculated for both put and call implied volatilities. The average ratio for put implied volatilities was 0.93 and 0.96 for call implied volatilities. These ratios were then multiplied by the live cattle implied volatility for the corresponding dates to obtain estimated feeder cattle implied volatilities.

### **3.2 - Cash Prices**

The cash prices for feeder cattle, live cattle, and corn were gathered from select weekly USDA reports of Kansas prices. The cash feeder cattle price was taken from USDA AMS Data Source: DC\_LC750 (Winter Livestock Feeder Auction, Dodge City, KS, Weighted Average Prices) and were for Medium and Large Frame #1 steers weighing between 700 to 800 pounds (LMIC, 2013). Nearly 8% of cash Kansas Feeder Cattle price quotes were missing and these values were filled using an average price of the two weeks before and after the missing value. Cash live cattle prices were Weekly Weighted Average - Kansas (USDA AMS report: LM\_CT164) prices and there were no missing values.

Because cattle feeding operations are spread across much of Western Kansas, the cash corn price was estimated using an average of several reporting locations. A simple average of reported prices for Dodge City, Colby, and Garden City, Kansas was used to formulate the cash corn price. Prior to June 17, 1999, Colby and Garden City prices were not available. Cash prices before this date are solely based on Dodge City reported prices. Approximately 5% of reported prices were missing from both Colby and Garden City datasets. These missing values were filled in using the average price of the two weeks prior to and following the missing value.

Cash soybean meal quotes were from the *Central Illinois Soybean Processor SB-Crude Oil, Meal-R, and Reg. (not hulls)* report (USDA AMS report number GX\_GR117) (LMIC, 2013). While this study is intended to reflect the market risk of feeding cattle in Kansas (and thus procuring feedstuffs for delivery to Kansas locations), Kansas cash prices were not available for soybean meal. Therefore, the central Illinois soybean meal prices are used as a proxy for Kansas prices.

The final cash prices (i.e., non-futures market data) used in this study are for hay and interest rates. Monthly alfalfa hay prices were obtained from national average *Prices Received by Farmers* reports from USDA-NASS (courtesy of LMIC, 2013). Because hay prices were reported as a monthly series, hay prices are repeated each week during the forecasted month.

Interest rate data was gathered from the Federal Reserve Bank of Kansas City's Quarterly Agricultural Credit Survey which measures the interest rates of loans issued to agricultural operations by banks in the Kansas City Federal Reserve's region. This analysis used data for Operating Loans issued by Kansas banks. Forecasts of the interest rate during the feeding period were again generated using naive expectations. Specifically, the lending rate of the previously reported quarter was forecasted to be the lending rate for cattle placed in the current quarter. Due to the difference in the number of observations between the quarterly interest rates and weekly simulations, the expected interest rate value was repeated for each week during the forecasted quarter. Summary statistics for all cash prices and basis calculations are presented in Table 3-3.

**Table 3-3: Summary Statistics of Cash Prices and Basis 1/1/1998 – 3/15/2013**

Variable	Units	Data Frequency	Standard			
			Mean	Deviation	Min	Max
Feeder Cattle	(\$/cwt)	Weekly	101.92	21.98	64.23	159.75
Live Cattle	(\$/cwt)	Weekly	85.87	17.75	56.36	129.89
Avg. Kansas Corn	(\$/bu.)	Weekly	3.35	1.76	1.63	8.49
Soybean Meal	(\$/ton)	Weekly	243.73	96.20	123.00	579.10
Hay	(\$/ton)	Monthly	129.79	38.39	84.80	218.00
Interest Rate	%	Quarterly	7.49	0.95	5.94	9.22
Feeder Cattle Basis	(\$/cwt)	Weekly	0.94	2.90	-7.66	11.61
Live Cattle Basis	(\$/cwt)	Weekly	-0.40	3.17	-10.38	10.32
Corn Basis	(\$/bu.)	Weekly	-0.13	0.22	-0.99	0.53
Soybean Meal Basis	(\$/ton)	Weekly	4.54	14.94	-30.40	123.50

### 3.4 - Feedlot Cattle Production Data

The data for feedlot cattle performance variables was estimated using empirical distributions estimated by Belasco et al. (2009). Their study estimated quarterly (Spring, Summer, Fall, and Winter) conditional means and variances of average daily gain (ADG), dry matter feed conversion (DMFC), veterinary costs per head (VCPH), and mortality rates for steers and heifers in Kansas and Nebraska feedlots. This study used their results to estimate the distributions from which simulations would draw values for each of the four variables. The conditional means and variances from these estimated distributions (assuming a 750 lb. steer placed in a Kansas feedlot) are shown in Table 3-4. According to Belasco et al. (2009), the conditional distributions for ADG, DMFC, and VCPH each follow a normal distribution. Belasco et al., (2009) point out that mortality follows a censored normal distribution as there cannot be a realized negative death loss. Therefore, they utilize a Tobit model to estimate the conditional mean and variance of the mortality distribution.

**Table 3-4: Cattle Performance Variable Conditional Means and Variances<sup>3</sup>**

Variable	Season	Conditional Mean	Conditional Standard Deviation
Average Daily Gain (lbs./head/day)	Winter	3.48	0.3933
	Fall	3.43	0.2198
	Spring	3.61	0.1365
	Summer	3.66	0.1746
Dry Matter Feed Conversion (lbs. feed/lb. gain)	Winter	5.80	0.0841
	Fall	6.11	0.0988
	Spring	5.71	0.0699
	Summer	5.80	0.0833
Veterinary Costs per Head (\$)	Winter	9.52	0.3891
	Fall	10.36	0.4084
	Spring	9.55	0.3555
	Summer	10.27	0.3465
Mortality Rate (%)	Winter	1.13	1.2899
	Fall	1.30	1.5702
	Spring	0.99	1.1924
	Summer	1.15	1.4023

While defining distributions for ADG, DMFC, and VCPH was easily accomplished, defining the censored normal distribution of MORT was more intricate. The software used for this study (@Risk, by Palisade Decision Tools) could not specify a censored normal distribution. In place of specifying a distribution, an empirical distribution was built by generating 10,000 random mortality rates using spreadsheet commands. These generated values followed the means and variances specified by Belasco et al. (2009) and were such that the probability of incurring a negative mortality rate was applied to the probability of having a zero mortality rate. In so doing, the generated values are a mix of discrete and continuous values, following the characteristics of

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<sup>3</sup> Estimated from results in Belasco et al. 2009.

a censored normal distribution (Greene, 2008). During the profit simulations, these generated values of seasonal mortality rates were randomly drawn and used as the expected mortality rate for the coming feeding period.

### ***3.5 - Supplemental Definitions***

Basis: Basis is the difference between the futures contract price and the cash price for a given commodity at a point in time. Because there are often several deferred futures contracts trading at any one point, it is possible to have basis quotes for several futures contracts Basis can be mathematically represented as:

$$\mathbf{Basis}_{i,t} = \mathbf{Cash}_{i,t} - \mathbf{Futures}_{i,t}$$

Where Cash is the cash price of commodity “*i*” in time “*t*”, Futures is the price of the nearby futures contract of commodity “*i*” in time “*t*”, and Basis is the basis of commodity “*i*” in time “*t*”.

Commonly used abbreviation's: Several terms are used frequently in this analysis and are abbreviated to add simplicity. The following table (Table 3-5) provides a list of the most commonly abbreviated terms.

**Table 3-5: Table of Abbreviated Terms**

<b>Abbreviation</b>	<b>Term</b>	<b>Units</b>	<b>Description</b>
DOF	Days on feed	Days	The length of the feeding period
ADG	Average daily gain	Lbs./head/day	The average daily weight gain of a steer of pen of cattle
DMFC	Dry Matter Feed Conversion	Lbs. of feed/lb. of gain	The ratio of feed consumed to produce one pound of weight gain
VCPH	Veterinary Costs per Head	\$/head	The total veterinary costs per animal
C	Corn	\$/bu. (unless otherwise noted)	The price of corn
LC	Live Cattle	\$/cwt. (unless otherwise noted)	Cattle which have finished the feeding period and are to be marketed for slaughter
FC	Feeder Cattle	\$/cwt. (unless otherwise noted)	Cattle which are purchased for placement into a feedlot
SMB	Soybean Meal	\$/ton	A high-protein feedstuff, usually 48% protein, that is often incorporated into cattle feed rations
Fut. IV	Futures Price Implied Volatility	%	The annualized expected volatility of the natural logarithm of a commodity's price.
Distn.	Distribution	Same as variable	Denotes a probability distribution is associated with a variable, rather than a single estimate.
COV	Coefficient of Variation	Unit-less	A measure of the variance of a variable around the mean. Calculated by dividing the variable's standard deviation by the mean.

## **Chapter 4 - Estimation of Cattle Feeding Returns**

This section discusses the equations and other methods used to estimate returns to cattle feeding. This section will discuss how specific data were used to create probability distributions, the correlations used in the model, the building of needed empirical distributions, and the exact equations used to estimate returns to feeding cattle. The software used for this analysis was Palisade Decision Tools' @Risk program (Version 6); a Microsoft Excel add-in specializing in Monte Carlo simulations (Palisade Decision Tools, 2012a).

### **4.1 - Price Distribution Specification**

As discussed in Chapter 2, futures prices are often used as market-level forecasts of a commodity's future price. Several past studies have used futures prices as expected or forecasted prices (Shonkwiler, 1986; Kastens, Jones, and Schroeder, 1998; Tonsor and Schroeder, 2011) and this approach is applied to this study.

As with any forecast, however, deferred futures prices are not perfect forecasts and the quote for a deferred futures contract, say, three months earlier, will likely not be the price when that same futures contract expires. Therefore, there is a level of forecast error present in any futures price forecast and this forecast error will likely increase during volatile market conditions. In compensation for this potential forecast error, writers of options contracts (where an option will be exercised if the futures price falls above or below the options "strike price") ask for higher options premiums during times of increased market volatility. As the options premium increases, according to Black and Scholes (1973), so does the implied volatility. Options implied volatilities, then, can be viewed as market-level forecasts of the volatility of the underlying security.

Options implied volatiles are commonly used to estimate the market-expected variance of a futures price (Simon, 2002; Manfredo and Sanders, 2004; Belasco et al., 2009; Brittain, Garcia, and Irwin, 2011; Tonsor and Schroeder, 2011). Tonsor and Schroeder (2011) note that because implied volatilities are derived from forward-looking futures markets, they contain information not found in forecasts based on historical volatility. This study follows this method and employs options implied volatilities as the expected variance of a market's price forecast.

Since options  $IV$  are the annualized standard deviation of the log of price changes, the following formula was used to convert implied volatility into the expected standard deviation of a price series over the forecast period:

$$(1) \quad SD_i = \frac{IV_i}{100} * \sqrt{\frac{DTR}{365}} * Px_i$$

Where “ $i$ ” is the specified commodity,  $IV$  is implied volatility in percentage,  $Px$  is the futures price,  $DTR$  is the days to realization of a market transaction (i.e., a position is taken in the futures market), and  $SD$  is the expected standard deviation (Hale, 2010). Equation (1) uses 365 days per year (as opposed to the occasionally used 256 trading days in a year) for consistency with Bloomberg’s methods used to calculate implied volatilities. Under this formula, no transformations are needed for the futures prices (i.e., the natural log of futures prices was not taken)<sup>4</sup>.

The days until a cash transaction is realized ( $DTR$ ) was 7 days for feeder cattle (assuming feedlots will place cattle within the coming week), 150 days for live cattle, and 75 days for corn, and soybean meal prices. Corn and soybean meal prices used 75 days to cash price realization to reflect the average length of time until feedstuffs are purchased. Davies and Widawski (1995) found that feedlots purchase corn at several intervals through the feeding period. Therefore, the length of time until feedstuffs are purchased in the cash market will vary across the feeding period. Because some feedstuffs will be purchased near the placement date (say, 14 days after placement) while other will be purchased near the end of the feeding period (perhaps 130 days from placement) this study averages the length of time until feedstuffs are purchased in the cash market to 75 days, the mid-point in the feeding period.

The weekly values for futures prices and calculated standard deviations of futures prices were used to specify futures-implied price distributions for feeder cattle, live cattle, corn, and soybean meal prices. Following several previous studies (Black and Scholes, 1972; Purcell and Koontz, 1999; Belasco et al. 2009; Tonsor and Schroeder, 2011), the lognormal distribution is assumed for all commodity prices. Expected price distributions were created using the futures price of a commodity as the distribution’s mean and the transformed options implied volatility as

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<sup>4</sup> This is because the calculation of implied volatility involves taking the exponential of the change between the log of two prices.

the standard deviation. These forecasted distributions are subsequently used as inputs in the estimation of cattle feeding returns probability distributions.

#### ***4.1.1 - Incorporation of Basis***

Basis is a significant factor in determining the realized returns for feedlots in a specific location. This study attempts to model expected returns for feedlots in Kansas and, accordingly, adjusts futures-implied distributions for basis. For this analysis, zero basis risk is assumed and, therefore, the expected basis variance for a given week is assumed to be zero. While this ignores actual basis risk faced by livestock producers, incorporating basis variability as a factor of profit risk is beyond the scope of this study. Incorporation of basis variability is, perhaps, an excellent starting point for future research.

Because zero basis risk is assumed, basis merely ‘shifts’ the expected price distribution along the horizontal axis by a fixed amount (rather than changing the shape of the distribution). This study first captures the future-implied distribution of prices and adds basis as later calculations are performed. Basis is incorporated as a distribution shifter because implied volatility is a measure of futures price volatility only, not the volatility of an underlying cash commodity price. Therefore, the variance of a commodity’s cash price (i.e., futures + basis) cannot be estimated using implied volatilities directly. Since there is no known method to transform the implied volatility into a cash price variance estimate, implied volatilities can only be used as variance estimates of futures price distributions. Therefore, futures prices and options implied volatilities are used to create the expected distribution of futures prices. Once this futures price distribution has been created, basis is added to shift the distribution so that cash price interpretations can be drawn.

#### ***4.1.2 - Corn Price Units***

The futures prices for corn were reported in cents per bushel. while cash prices were reported in dollars per bushel. Basis calculations were also made in \$/bu. units. Because options implied volatilities represent an expected variance for a unit-specific commodity, expected corn price distributions were calculated in ¢/bu. and transformed into \$/bu. when calculations involving basis occurred. It is well known that such monotonic transformations do not change

the shape of a distribution and only serve to change the scale. Therefore, this transformation served only to scale the distribution to the correct units for basis adjustment<sup>5</sup>.

#### ***4.1.3 - Hay Price Distribution Specification***

There is no futures contract for hay, so expected hay prices for the feeding period were generated by assuming naïve expectations. Specifically, the hay price in the month prior to the placement on feed date was assumed to be the expected hay price during the feeding period. To illustrate, the December, 2011 hay price was used as the expected hay price for the feeding period beginning January, 2012 and ending June, 2012. This follows research by Dhuyvetter, Taylor, and Tonsor (2012) which showed that short-term (less than 5 month) hay price forecasts generated using one-month lagged naïve expectations had the lowest mean absolute error among several alternative forecasting methods. The variance of expected hay prices was assumed to be the standard deviation of the previous year's monthly hay prices.

It is important to note that forecasted price distributions are based on forward looking data (e.g., futures prices) for all commodities except hay. Hay price distributions are formulated using only historic data and this information asymmetry may not reflect the true risk present in hay markets. This approach will likely overstate and understate the actual risk at different times. If hay prices have remained steady but are entering a volatile period or a significant price trend (perhaps driven by drought), the one-year lagged standard deviation will likely understate the realized volatility. Conversely, if hay prices have recently been volatile but are entering a period of low volatility, this approach will overstate the realized volatility.

While using the approach may understate or overstate price risk of purchasing hay, it is not expected to have substantial impacts on the results. Hay (as will be discussed later in this chapter) constitutes only 12% of cattle feed rations and thus has a minority share of any total feed cost calculation. Therefore, the effect of any error in hay price variance estimation is expected to be minimal.

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<sup>5</sup> The reverse could have been done, where basis was scaled up to units of ¢/bu. However, subsequent calculations were more easily performed with corn prices in \$/bu. units.

## 4.2 - Basis Calculations

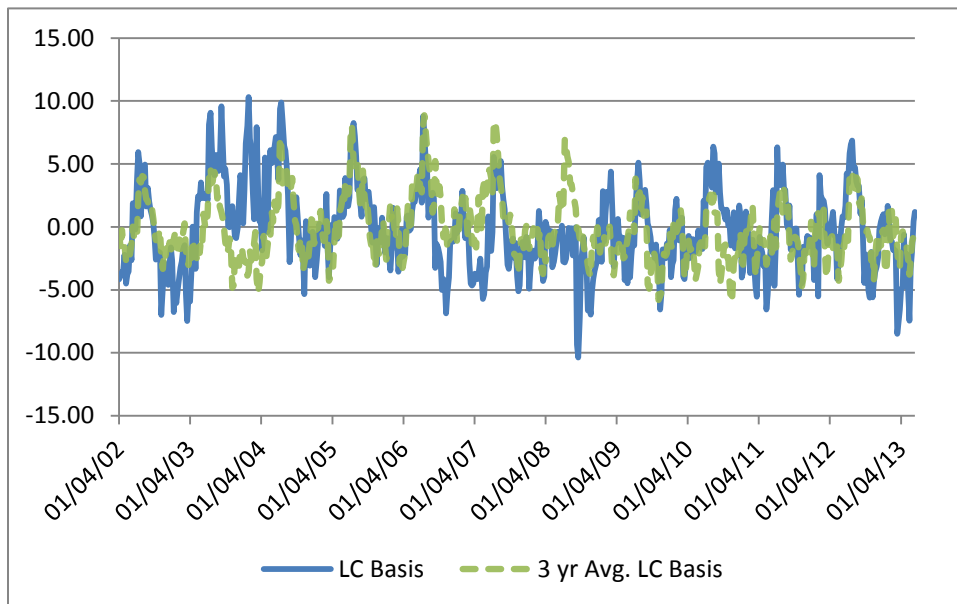
Basis was calculated for feeder cattle, live cattle, corn, and soybean meal for each week from 1999 through 2013. Basis expectations at the time of cattle placement were based on average historical basis for all commodities. The formula for calculating the specific basis forecast is as follows:

$$(2) \quad E[Basis_{i,t}] = \frac{1}{K} \sum_{k=1}^K Basis_{i,t-k}$$

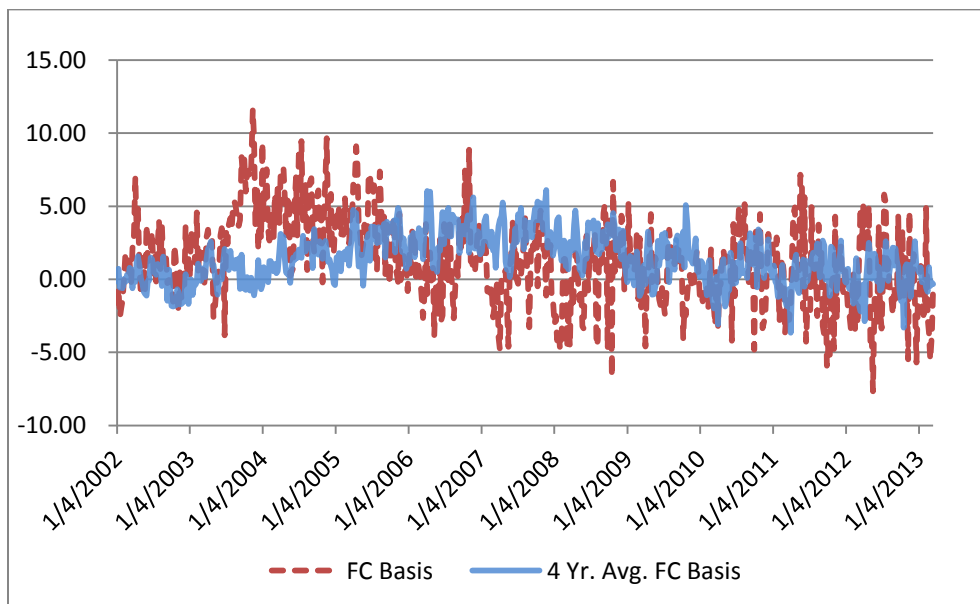
Where “ $i$ ” is an index corresponding to specific commodities, “ $t$ ” denotes a specific calendar week, and  $K$  denotes the number of years included in the average.

The number of years included in the average basis varied by commodity. Following Tonsor and Schroeder (2011), a four year average basis was calculated for feeder cattle prices and a three year average basis was calculated for fed cattle. Soybean meal basis was calculated from a three year average basis and corn basis used a two year average basis. A two year average corn basis was chosen as recent studies have shown that shorter time periods may be more effective in corn basis forecasting (Taylor, Dhuyvetter, and Kastens, 2006; Hatchett, Brorsen, and Anderson, 2010; and Sanders and Baker, 2012) due to structural changes in the grains industry (Irwin et al. 2009). Graphs of historic average basis calculations for each commodity are shown in Figure 4-1, Figure 4-2, Figure 4-3, and Figure 4-4.

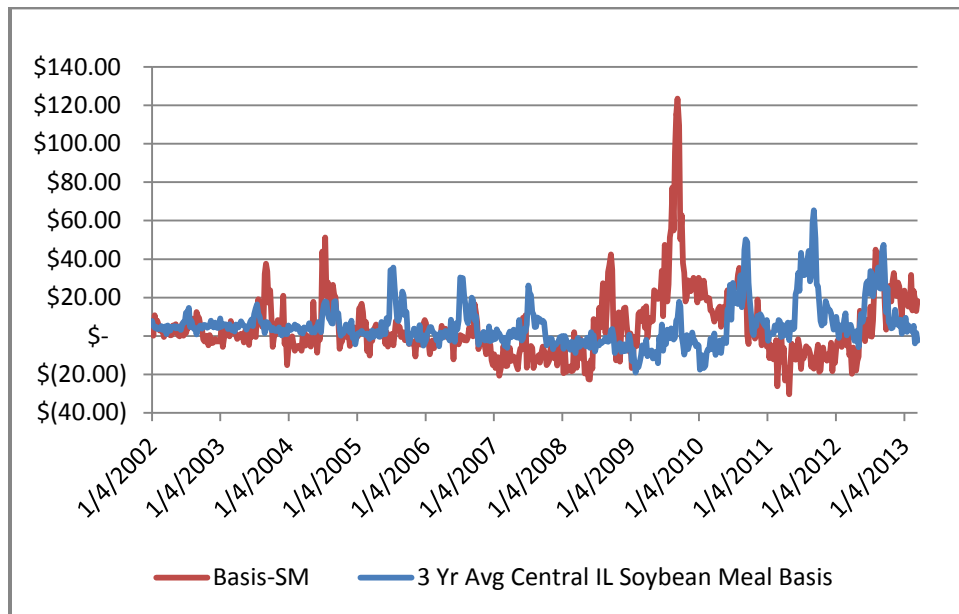
**Figure 4-1: Weekly Kansas Average Live Cattle Basis, Actual and 3 year Historical Average Basis, 1/2/2002 through 3/15/2013**



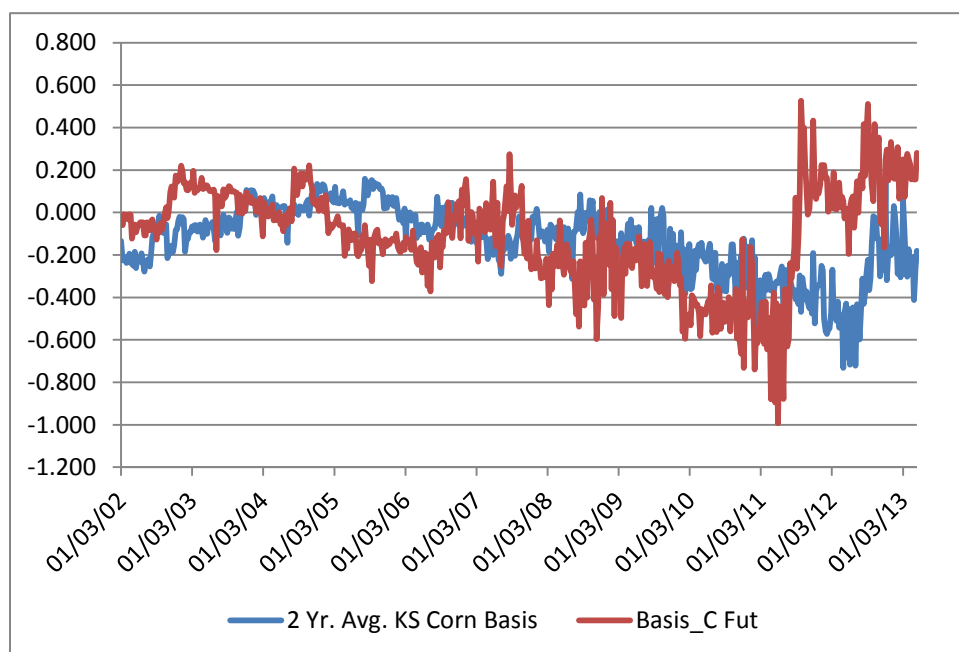
**Figure 4-2: Dodge City, Kansas Feeder Cattle Basis, Actual and 4 year Historical Average Basis, 1/2/2002 through 3/15/2013**



**Figure 4-3: Central IL Soybean Meal Basis, Actual and 3 year Historical Average Basis, 1/2/2002 through 3/15/2013**



**Figure 4-4: Kansas Corn Basis (average of Dodge City, Colby, and Garden City, Kansas prices), Actual and 2 year Historical Average Basis, 1/2/2002 through 3/15/2013**



### 4.3 - Correlation of Variables

To estimate the risks faced by cattle feeders when generating expectations of returns, the variables used in profit simulations must reflect correlation structures found in the industry. The correlation of futures prices was based on weekly returns to feeder cattle, live cattle, corn, and soybean meal prices. Following Tonsor and Schroeder (2011) and Manfredo and Sanders (2004), returns to a commodity were specified as:

$$(3) \quad R_{i,t} = \ln(P_{i,t}) - \ln(P_{i,t-1})$$

where  $R$  is the return to commodity “ $i$ ” in time “ $t$ ” (where “ $t$ ” refers to week) and  $P$  is the price of the  $i^{th}$  commodity. The correlations were based on weekly data from 1/2/1998 to 3/15/2013. The estimated correlation matrix is presented in Table 4-1.

**Table 4-1: Correlation of Weekly Returns**

	<i>Feeder Cattle</i>	<i>Live Cattle</i>	<i>Corn</i>	<i>SBM</i>
Feeder Cattle	1	0.612	-0.1617	-0.013
Live Cattle	0.612	1	0.167	0.116
Corn	-0.162	0.167	1	0.555
SBM	-0.013	0.116	0.555	1

The correlation of hay prices to grain prices was estimated through a similar process. Because hay prices were available only on a monthly basis, the average monthly price of corn and soybean meal was calculated. The log of monthly returns was calculated for each price series, respectively. These monthly returns to feedstuffs were then correlated with each other and the correlation coefficients are presented in Table 4-2. There was zero correlation assumed between hay prices and feeder cattle and live cattle prices as there was no known previous literature examining such correlations and as there is little economic theory to justify such correlations.

**Table 4-2: Correlation of Monthly Returns**

	<i>Alfalfa Hay</i>	<i>Corn</i>	<i>Soybean Meal</i>
Alfalfa Hay	1	0.084	-0.023
Corn	0.084	1	0.659
Soybean Meal	-0.023	0.659	1

Regarding the cattle performance variables (ADG, VCPH, DMFC, and mortality), no explicit correlation was created. This is consistent with the methods used by Belasco et al. (2009) who note that “rank correlation is preserved by any monotonic transformation of random variables” (pg. 102). They further note that, given the estimated distributions of their performance variables (which are conditioned on factors including, cattle sex, feedlot location, and season, among others), “draws from a multivariate normal distribution can be used to generate correlated values with means and variances specified by the modeling framework.” (pg. 102). Their methods (which follow those of Fackler, 1991) calculate an estimated profit for each realization of the performance variables. In so doing, they note that such simulations preserve the correlations inherent to the data. Because this analysis follows their methods and uses their conditional means and variances estimates, the performance variable draws in this study will also maintain the correlations found in the original data.

One key assumption made in this study is that the correlations between price variables do not change over time. As discussed earlier, many of the commodities in this study have seen structural changes in their respective industries, which may now cause prices to respond to different information than in the past. Such changes in market responses may change the correlation structures between variables. This paper does not examine changes in variable correlation and such research is left to future efforts.

#### 4.4 - Cattle Performance Variables

As mentioned in Chapter 3, the cattle performance variable distributions were taken from results published in Belasco et al. (2009). Their results presented the coefficients and standard error for Harvey’s multiplicative heteroskedasticity model which was used to estimate the conditional means and variances of ADG, DFMC, VCPH, and mortality. This study estimated the means and variances with the following equations:

$$(4) \quad \hat{\mu} = X_j' \beta$$

and

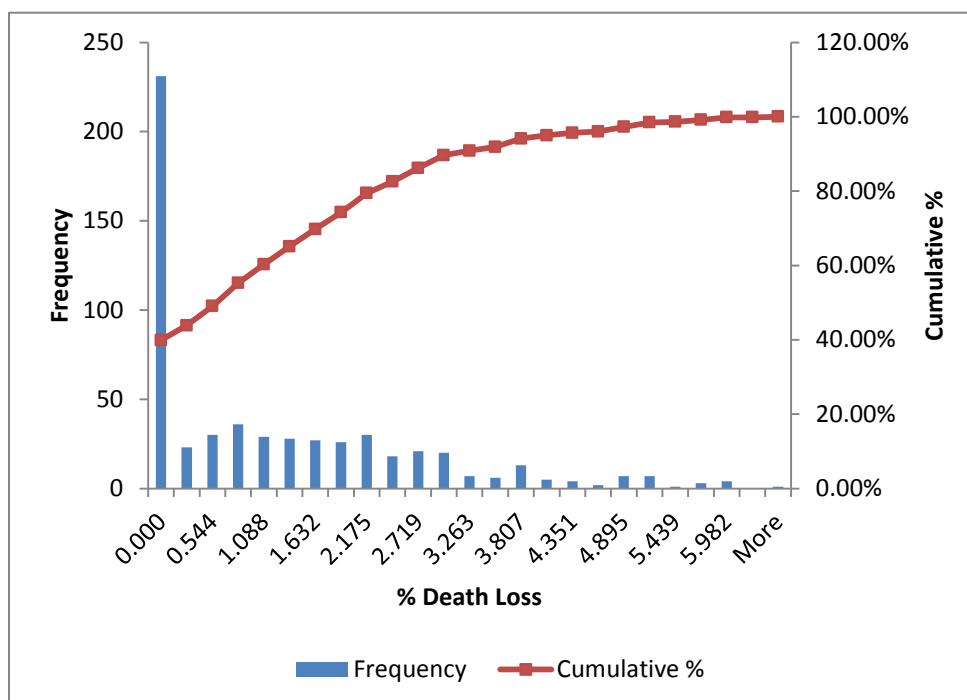
$$(5) \quad \widehat{\sigma}_t^2 = \sigma^2 \exp(Z_j' \alpha),$$

Where  $\hat{\mu}$  and  $\widehat{\sigma}_t^2$  are the estimated conditional mean and variance of variable “j”,  $X_j$  is a vector of conditioning variables including an intercept,  $Z_j$  is also a vector of conditioning variables (without an intercept, which is captured in  $\sigma^2$ ). For this study, the conditioning variables were

specified to be steers placed in Kansas feedlots in each of the four seasons, and the natural log of placement weight (assumed to be 750 lbs). ADG, DMFC, and VCPH each follow  $\sim N(\hat{\mu}, \hat{\sigma}_i^2)$ .

Mortality rates are assumed to follow a censored normal (where the probability of a negative value, given the specified mean and variance, is added to the probability of a zero value) and were estimated using an empirical distribution as outlined in Chapter 3. The results from this empirical distribution are shown in Figure 4-5. From this distribution, cattle feeders can expect to realize zero death loss from placing 750 lb. steers in Kansas feedlots approximately 39.9% of the time. The mortality rate distribution is significantly right-skewed and some mortality rates over 6% are realized. However, the probability of a Kansas cattle feeder observing a mortality rate greater than 3.2% is less than 10%.

**Figure 4-5: Realized Mortality Draws Histogram**

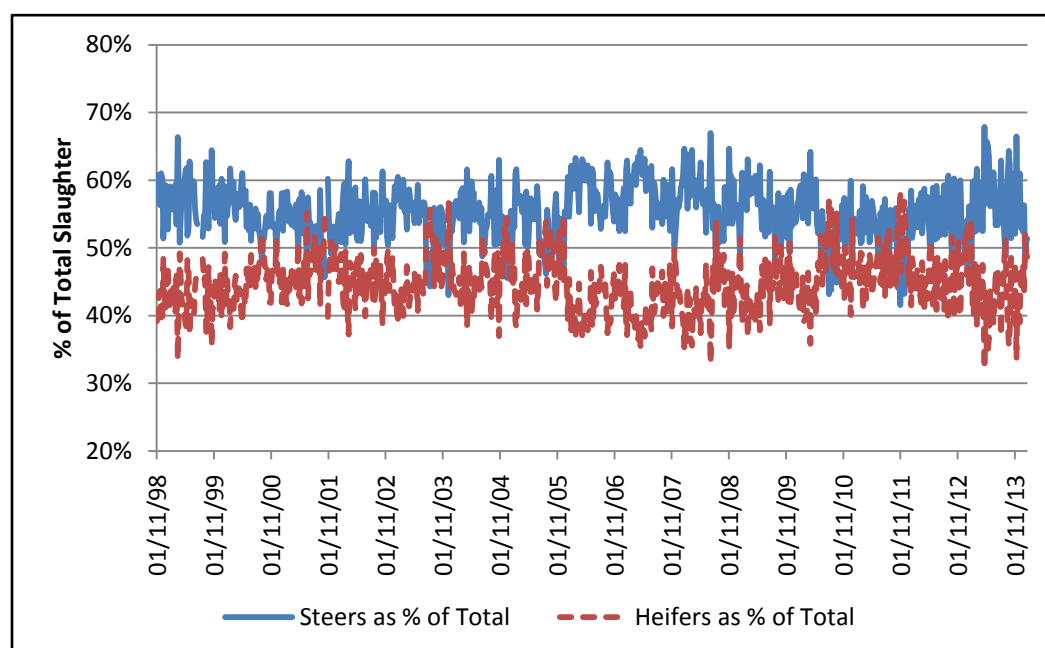


## 4.5 - Profit Function Specification

Several needed assumptions were made when designing equations to estimate expected returns of placing cattle on feed. The first was to assume a uniform sex and weight of placed cattle. This study chose to estimate only the returns to feeding steers with 750 lb. placement

weight. Steers are the most commonly fed cattle sex (Figure 4-6, data source: LMIC, 2013) and are widely thought to have less variability than heifers in feedlot performance. The assumption of 750 lb. placement weight is consistent with CME Feeder Cattle Delivery Specifications, fits within industry standards for placement weights, and avoids complications associated with the use different price series for differing feeder cattle weights.

**Figure 4-6: U.S. Steer and Heifer Slaughter as Percent of Total, 1998 – 2013**



A second critical assumption was to hold the feeding period to a specified length, 150 days. While arguments can be made for holding ADG, days on feed (DOF), or sale weight of cattle constant and leaving the remaining variables stochastic, this study chose to hold DOF constant for several reasons. These reasons are briefly discussed in the following paragraphs.

If the number of days on feed is left stochastic, then an assumption regarding the ‘optimal’ sale weight of cattle has to be made. The ‘optimal’ sale weight may vary according to season, cattle type, and market conditions (if packing plants are offering higher premiums for leaner cattle, feedlots may ship cattle at a lower weight). Additionally, slaughter weights of cattle have been trending upward (Herrington and Tonsor, 2012) so the ‘optimal’ slaughter weight appears to be changing over time. Herrington and Tonsor (forthcoming) note DOF for Kansas

feedlot steers has increased over the past decade, but the rate of increase has been significantly slower than increases in slaughter weights.

Furthermore, Belasco et al. (2009) note that for cattle with placement weights ranging between 500 and 1,000 lbs. the days on feed usually vary by less than 14 days. Herrington and Tonsor (forthcoming) estimated that for steers placed at an average weight of 772 lbs., the average days on feed was 149 days with a standard deviation of 12 days.

Precedence has also been set for holding DOF constant in feedlot profit simulations. In the profit simulations conducted by Belasco et al., DOF were held constant at 150 days as a conditioning variable. Finally, assuming a fixed-time feeding period negated the need for correlating DOF with other production variables.

One final assumption is that cattle performance variable means and variances have remained constant over time. While this is likely to poorly reflect the reality of an industry experiencing technological change (Langemeier, Jones and Kuhl, 2001; Herrington and Tonsor, forthcoming), this assumption is made because no reliable, published estimates of cattle performance variable changes over time were available. Estimation of such performance changes is beyond the scope of this study.

Many studies have examined the price and production risks faced by cattle feed yards. Price risks have been estimated as joint probability distributions of corn, feeder cattle, and fed cattle prices (Tonsor and Schroeder, 2011), which comprise the most significant sources of costs and revenues for cattle feeders (Langemier, Schroeder, and Mintert, 1992; Lawrence, Wang, and Zoy, 1999). Production risks are found in dry matter feed conversion, average daily gain, death loss, and animal health care costs. Drawing from Tonsor and Schroeder (2011) and Belasco et al., (2009), these risks are parameterized and incorporated into a profit function consistent with placing a steer on feed in time  $t$ , feeding corn, soybean meal, and hay in each of the 21 feeding weeks (the closest integer for a weekly approximation of 150 days on feed) starting with time  $t + 0$  and selling a finished steer in time  $t + 21$ . The general form of expected *ex ante* profits is:

$$(6) \quad E[\pi_{t+21}] = E[TR_{t+21}] - E[TC_{t+21}]$$

Where TR is total revenue, TC is total costs of feeding cattle, and  $E[\cdot]$  is the expectations operator. TR and TC can each be further defined as:

$$(7) \quad E[TR_{t+21}] = (E[LCPx_t] + E[LCBasis_t]) \times E[SaleWt_{t+21}] \times (1 - E[MORT_{t+21}]) \times 0.96$$

and

$$(8) \quad E[TC_{t+21}] = E[TVC_{t+21}] + YC$$

Where

$$(9) \quad SaleWt_{t+21} = 750 + E[ADG_{t+21}] * DOF,$$

$$(10) \quad E[TVC_{t+21}] = E[FCC_t] + E[TFC_{t+21}] + E[VCPH_{t+21}] + E[IC_{t+21}],$$

and

$$(11) \quad YC = \$0.40 * DOF.$$

*SaleWt* is the finished weight of fed cattle, *LCP<sub>x</sub>* is the price forecasted in week “*t*” which will be realized in time “*t+21*” (i.e., a draw from the live cattle price distribution), *LCBasis* is the predicted basis at marketing time, and MORT is the expected cumulative mortality rate at the end of the feeding period (randomly drawn from the empirical distribution). TR also includes a fixed “shrinkage” value (0.96) to adjust for weight lost when shipping cattle. In Equation (8), TVC is the total variable cost per head of feeding cattle, YC is the per-head fixed cost (yardage cost) of feeding cattle, based on a \$0.40/head/day charge (typical of Kansas feedlots, Belasco et al., 2009), and DOF is a fixed value for a 150 day feeding period. ADG and VCPH are random draws from their respective distributions, FCC is feeder cattle purchase costs, TFC is the total feed cost (also per head), and IC is the interest cost of feeding cattle. These variables are further explained in the following equations.

$$(12) \quad E[FCC_t] = 750 \times (E[FCPx_t] + E[FCBasis_t]),$$

$$(13) \quad E[TFC_{t+21}] = E[DMFP_{t+21}] \times E[DMFC_{t+21}] \times E[ADG_{t+21}] \times DOF,$$

$$(14) \quad E[DMFP_t] = \left( \frac{E[CPx_t] + E[CBasis_t]}{56} \times \left( \frac{1}{0.88} \right) \right) \times 0.85 + \left( \left( \frac{E[HayPx_t]}{2000} \right) \times \left( \frac{1}{0.90} \right) \right) \times 0.12 + \left( \left( \frac{E[SBMPx_t] + E[SMBasis_t]}{2000} \right) \times \left( \frac{1}{0.91} \right) \right) \times 0.03,$$

and

$$(15) \quad E[IC] = \left( \frac{1}{2} (YC + E[FC] + E[VC]) + E[FCC] \right) \times DOF \times \frac{IR}{365}.$$

*FCPx*, *CPx*, *HayPx*, and *SBMPx*, are expected prices drawn from feeder cattle, corn, hay, and soybean meal price distributions, respectively. *FCBasis*, *C\_Basis*, and *SM\_Basis* are the forecasted basis levels for feeder cattle, corn, and soybean meal, respectively. These draws from price distributions and expected basis levels are the forecast in time “*t*” of a price and basis to be

realized in time “ $t+21$ ”. DMFC is a draw from the estimated dry matter feed conversion distribution. Equation (12) states that the cost of purchasing feeder cattle is equal to the draw of feeder cattle price times 750 pounds (the assumed placement weight). Equation (13) notes that total feed costs are a function of DOF, ADG, DMFC, and the feed price on a dry matter basis (DMFP). DMFP is the expectation in time “ $t$ ” of the feed price to be realized during the feeding period. DMFP is measured assuming corn, hay and soybean meal constitute 85%, 12%, and 3% of feed rations, respectively. The equation further assumes moisture content of 12%, 10%, and 9% for corn, hay, and soybean meal, respectively. Finally, the interest cost shown in Equation (15) is applied to half the yardage cost, feed costs, and veterinary costs under the assumption that such costs are evenly distributed across the feeding period. The interest rate is fully applied to the cost of feeder cattle for the full duration of the feeding time.

## 4.6 - Monte Carlo Methods

This study estimates the distributional characteristics of the dependent variables described above. To accomplish this, statistical sampling methods are used. While statistical sampling can be accomplished via a variety of methods, techniques, and algorithms, two of the most popular methods, Monte Carlo and Latin hypercube, are discussed here.

### 4.6.1 - Monte Carlo sampling

Monte Carlo sampling has been widely used in the analysis of risk in agriculture (Weimar and Hallam, 1990; Hardaker et al., 2003; Shao and Roe, 2003; Tonsor and Schroeder, 2011) and is a staple approach for stochastic simulations. As Hardaker et al. (2003) note, the cumulative density function (CDF) is the critical element in statistical simulations. The CDF provides the probability that a value of  $X$  will be less than or equal to itself. In mathematical terms, this can be represented as:

$$(16) \quad F(x) = P(X \leq x), \text{ where } F(x) > 0 \text{ and } < 1.$$

Monte Carlo (or random) sampling utilizes the inverse function of the CDF, the value of  $X$  that corresponds to a given probability, represented as:

$$(17) \quad x = G(F\{x\})$$

This inverse function is used to generate random values of  $X$ . These values are (typically) created by generating uniformly distributed probabilities,  $\mu$  (where  $\mu$  is  $> 0$  and  $< 1$ ). These random probabilities are placed in the inverse CDF function and the specified  $G(\cdot)$  calculates the

corresponding values of  $X$ . Thus, Hardaker et al. (2003) note that the inverse function specifies that  $X$  is a function of  $\mu$ , or:

$$(18) \quad x = G(\mu)$$

Using the Law of Large Numbers (LLN), the generated values of  $X$ , for a sufficiently large sample, will converge to closely represent the original distribution. Furthermore, the central limit theorem dictates that the standard error of an estimate approaches zero as  $1/\sqrt{n}$  (Boyle, Broadie, and Glasserman, 1997).

A frequent use of Monte Carlo simulations is to estimate unobservable distributions of dependent variables. If  $Y$  is a monotonic transformation of  $X$ , and  $X$  has an observable distribution, random sampling of  $X$  can be used to generate sample values of  $Y$ . This method depends on two factors: the correct specification of the  $X$  distribution and the transformation of  $X$  into  $Y$ . Errors in either of these two steps will, of course, lead to significant errors in the estimation of  $Y$ . One source of potential error comes through how completely the chosen sampling technique will recreate the original distribution of  $X$ . One potential weakness of Monte Carlo sampling, and one correction method, is discussed in the following section.

#### ***4.6.2 - Latin hypercube sampling***

As Hardaker et al. (2003) note, Monte Carlo simulations can leave the tails of highly skewed or long-tailed distributions underrepresented. This occurs because the values of  $\mu$  are chosen randomly from all points across the distribution and certain probability values may or may not be drawn. This undersampling of certain portions of the distribution can be corrected by using stratified or Latin hypercube sampling (McKay, Beckman, and Conover, 1979). Latin hypercube sampling divides the CDF of a variable,  $X$ , into intervals ('strata') of equal probability so that the variable  $X$  has all portions of its distribution represented (McKay, Beckman, and Conover, 1979; Hardaker et al. 2003). Hardaker et al. (2003) note that Latin hypercube sampling is often called "sampling without replacement" as each interval of the  $X$  distribution is sampled only once.

This stratified sampling leads to increased estimation efficiency as the sampled distribution converges to the specified distribution in fewer iterations (Hardaker et al., 2003). McKay, Beckman, and Conover (1979) further note that this approach has benefits when the output distribution ( $Y_t$ ) is dominated by only a few components of  $X$ . Latin Hypercube sampling

“ensures that each of those components is represented in a fully stratified manner, no matter which components might turn out to be important.” (McKay, Beckman, and Conover, 1979, pg. 240).

Because of the advantages outlined in the Latin hypercube section, this study employs Latin hypercube methods for all simulations. Under the hypothesis that risk in cattle feeding returns has increased in recent years, it is possible that cattle feeding returns may have highly skewed tails. The increased sampling efficiency provide by Latin hypercube methods for estimated long-tailed distributions will likely yield more realistic and robust results than traditional Monte Carlo simulation.

## Chapter 5 - Results

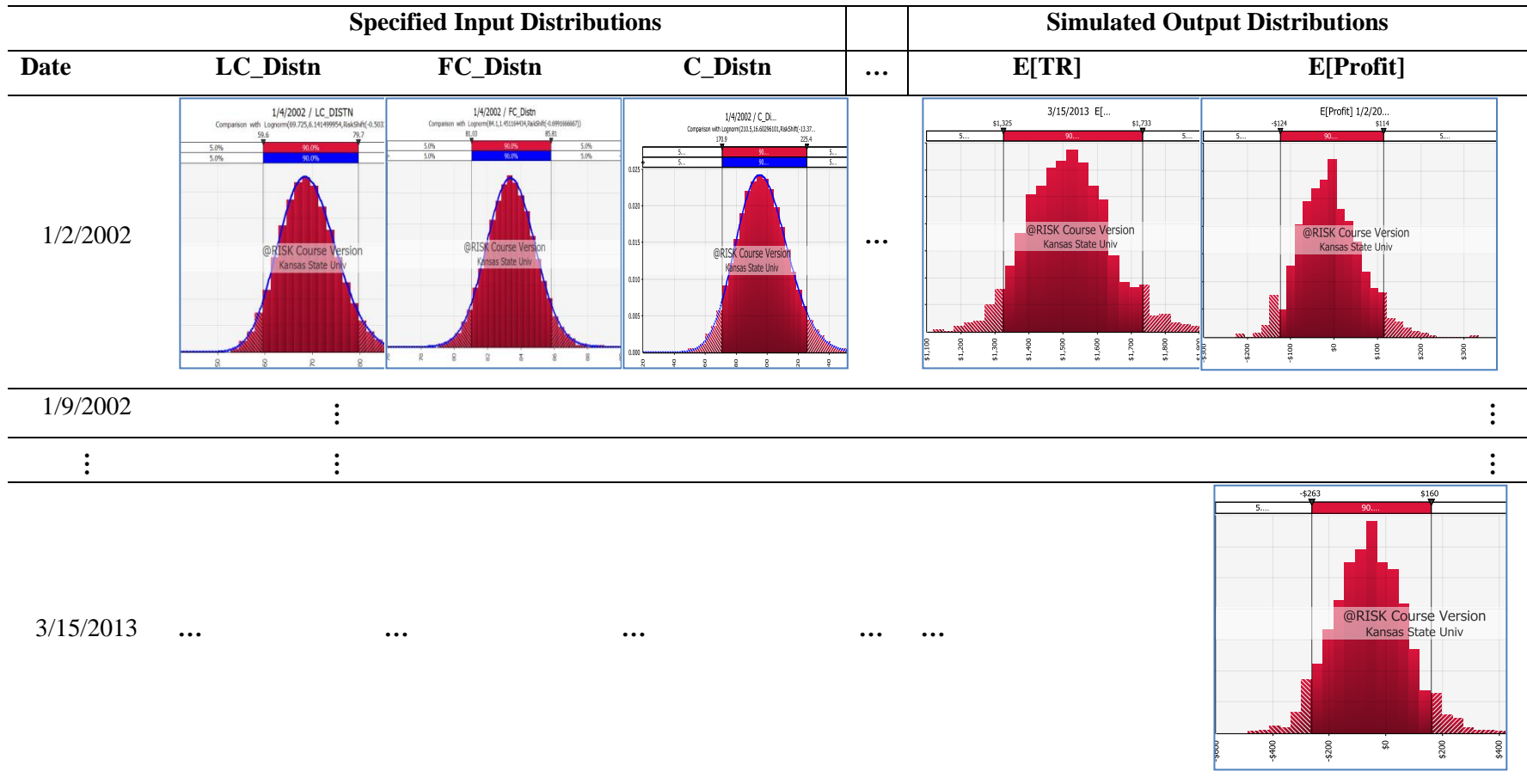
The results from the models and method discussed in the previous chapter are presented here. This chapter is organized into the following discussions: a brief overview of simulation results, assessing the accuracy of simulated feedlot returns, a more thorough analysis of cattle feeding profits, examining the ‘riskiness’ of placing cattle on feed, and the development of methods to summarize risk for industry audiences.

The discussion in this section will refer both to output and input distributions. To provide clarification on the specific distributions incorporated under these broad categories, Table 5-1 is provided. Each of these input and output distributions were created for each of the 585 weeks in the dataset. This process is simplified and shown in Figure 5-1 which shows that for each week in the dataset, simulated values were drawn from specified input distributions and were used to simulate the distributions of output variables (such as expected profits). Distributional characteristics of these output distributions were analyzed to gather information on how probabilistic risks have changed for Kansas cattle feeding operations.

**Table 5-1: List of Simulated Input and Output Distributions**

Input Distributions	Input Distribution Abbreviation	Output Distributions	Output Distribution Abbreviation
<i>Live Cattle futures price (\$/cwt)</i>	<i>LC</i>	<i>Expected Profit (\$/hd.)</i>	<i>E[Profit]</i>
<i>Feeder Cattle futures price (\$/cwt)</i>	<i>FC</i>	<i>Expected Total Costs (\$/hd.)</i>	<i>E[TC]</i>
<i>Corn futures price (\$/bu.)</i>	<i>C</i>	<i>Expected Variable Costs (\$/hd.)</i>	<i>E[VC]</i>
<i>Soybean Meal futures price (\$/ton)</i>	<i>SBM</i>	<i>Expected Total Revenue (\$/hd.)</i>	<i>E[TR]</i>
<i>Hay price (\$/ton)</i>	<i>Hay</i>	<i>Expected Dry Matter Feed Price (\$/lb)</i>	<i>E[DMFP]</i>
<i>Average Daily Gain (lbs./day)</i>	<i>ADG</i>	<i>Expected Total Feed Cost (\$/hd.)</i>	<i>E[TFC]</i>
<i>Dry Matter Feed Conversion</i>	<i>DMFC</i>	<i>Expected Feeder Cattle Costs (\$/hd)</i>	<i>E[FCC]</i>
<i>Veterinary Costs per Head (\$/hd)</i>	<i>VCPH</i>	<i>Expected Interest Costs (\$/hd)</i>	<i>E[IC]</i>
<i>Cattle Mortality Rate</i>	<i>Mort.</i>	<i>Expected Fed Cattle Sale Weight (lbs.)</i>	<i>E[SaleWt.]</i>

**Figure 5-1: Diagram of Selected Input and Output Distribution Simulations for each week in the dataset**



## 5.1 - Cattle Feeding Profits

For each week in the dataset, an expected profit was calculated based on 1,000 draws from correlated input distributions. This resulted in 585 simulated profit distributions across the 1/2/2002 to 3/15/2013 time period. Summary statistics for the mean of each simulated distribution over the eleven year analyzed time frame are presented in Table 5-2. The average expected profit per-head is \$-31.56 over the study's time period with a standard deviation of \$47.90 per head. Profits ranged from a maximum expected value of \$102.08/head to a low of \$-172.55. This study, then, reflects results from others (Langemeier, Schroeder, and Mintert, 1992; Belasco et al. 2009; Tonsor and Dhuyvetter, 2013; NAIBER, 2013) who have also estimated significant fluctuations in feedlot profits.

It is important to remember that this model does not project the expected profits of any single cattle feedlot. Rather, it is a barometer of the general profitability of cattle feeding operations across Kansas. Some Kansas feedlots will be more economically efficient than assumed in this model and will likely have higher expected profits. These higher returns could come from value-added marketing programs or from cost efficiencies not reflected in this model. Conversely, there are likely to be Kansas feedlots which are less efficient than this model assumes.

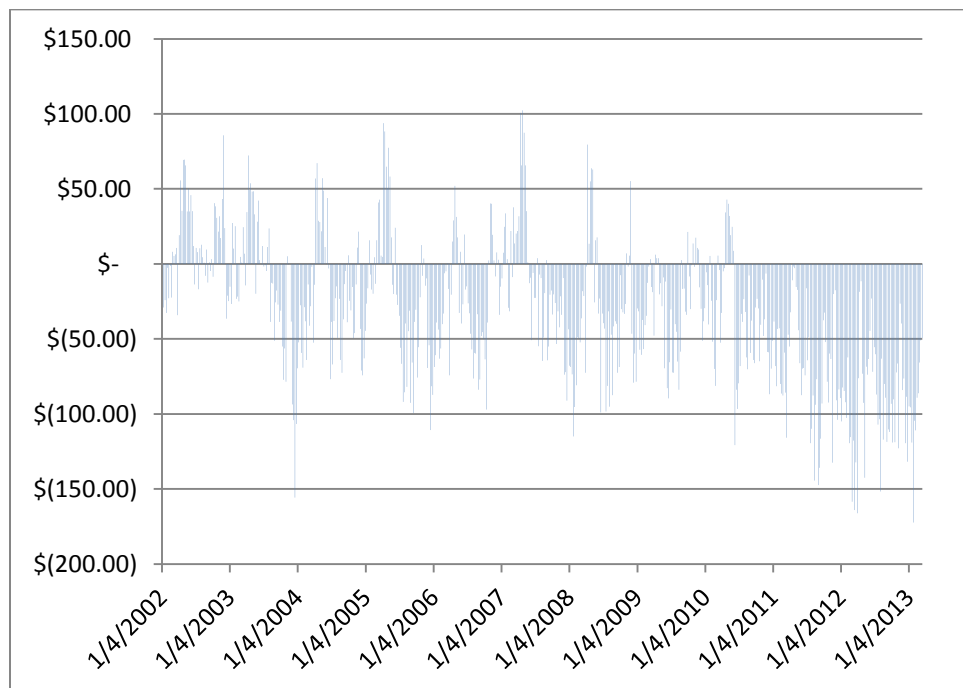
**Table 5-2: Summary Statistics of Mean Simulation Results from 1/2/2001 to 3/15/2013**

	E[Profit] (\$/hd)	E[TR] (\$/hd)	E[TC] (\$/hd)	E[VC] (\$/hd)	E[FCC] (\$/hd)	E[TFC] (\$/hd)	E[DMFP] (\$/lb)	E[IC] (\$/hd)	E[SaleWt.]
Mean	-31.56	1141.32	1172.89	1112.89	827.17	245.93	0.0790	29.87	1281.79
SD	47.90	221.10	245.76	245.76	154.57	103.44	0.0331	5.02	13.62
COV	-1.52	0.19	0.21	0.22	0.19	0.42	0.4194	0.17	0.01
Min	-172.55	773.81	768.25	708.25	549.14	121.87	0.0394	20.06	1265.04
Max	102.08	1640.46	1713.29	1653.29	1208.39	514.16	0.1615	42.33	1298.54

The results of the simulations show that expected returns to cattle feeding have been highly variable over the past 11 years. Expected profits fluctuate between positive and negative returns frequently, with an extended period of expected negative profits beginning mid-2010 (Figure 5-2). This period of expected negative profits has been the subject of many analyses and news briefs in recent times (see Daily Livestock Report, 2013a). Many of these sources (Belasco et al. 2009, Tonsor and Dhuyvetter, 2013) have found similarly expected negative returns and

have questioned why feedlot managers, owners, or investors continue to place cattle on feed when negative returns are expected. Given the results below, it would appear that placing cattle on feed in the past two years would be a poor investment. Before analyzing the rationale for placing cattle on feed during negative profits, a brief comparison between this model's results and the results of other profit simulations is made.

**Figure 5-2: Simulated Mean Expected per Head Profits, Kansas Feedlots 1/2/2002 – 3/15/2013**



## 5.2 - Assessments of Model Accuracy

In classical econometrics, the accuracy of a model or forecast can be analyzed by generating predicted values and comparing the predictions to the realized values. Such procedures are common among analyses of agricultural commodities (Tonsor, Dhuyvetter, and Mintert, 2004; Manfredo and Sanders, 2004; Brittain, Garcia, and Irwin, 2004; Tonsor and Schroeder, 2011). Unfortunately, no realized profits for Kansas feedlots were available for comparison against this model. To provide some comparison of this model's performance, the results presented here are compared against similar models which also evaluate expected feedlot profits and profit risk.

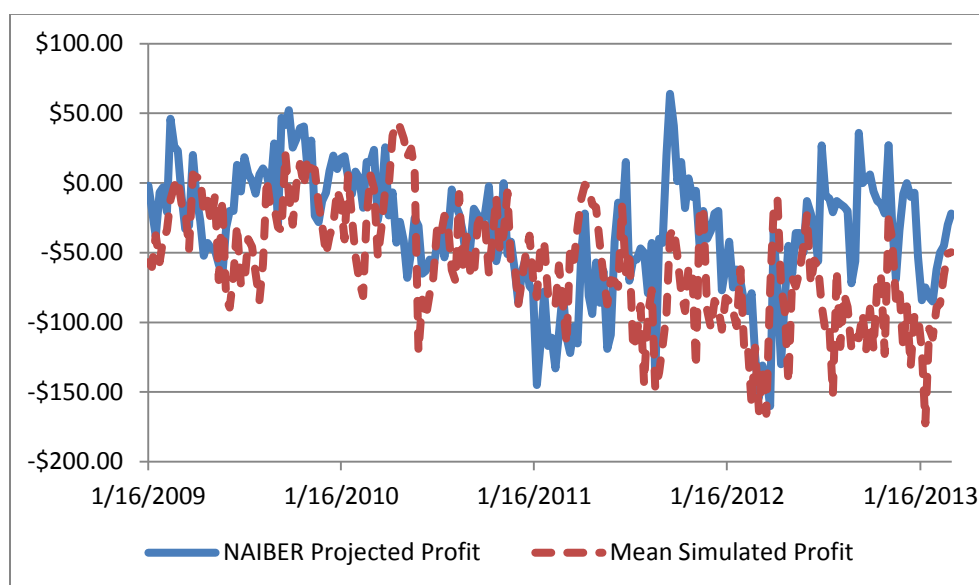
### ***5.2.1 - Comparisons against NAIBER Fed Cattle Profit Calculator***

The North American Institute for Beef Economic Research (NAIBER) provides a weekly evaluation of expected returns to Kansas cattle feeding operations. The simulation tool's data starts in 1/12/2009 and is available for the current week (at least, the week during which this analysis was written). The model used by NAIBER utilizes the same cattle performance variable specification (drawn from Belasco et al. 2009) as this study and uses deferred live cattle and corn futures prices as price expectations. The deferred live cattle futures contract used by NAIBER is the contract expiring nearest to, but not before, the expected marketing date of live cattle. Similarly, the corn futures contract used by NAIBER is the contract expiring nearest to, but not before, the middle month of the feeding period. This specification of deferred live cattle and corn futures contracts is the same as is used in this study. NAIBER also uses implied volatilities to calculate the expected variance of live cattle and corn prices. Feeder cattle prices are based off Oklahoma City Medium No. 1 steers and feeder cattle placement weights (and therefore, the cost of purchasing feeder cattle) vary across the 2009-2013 time period.

Key differences between the NAIBER model and this model are 1) feeder cattle price risk is assumed to be zero in the NAIBER calculator since price is considered to be known at placement, 2) finish weights are held constant while DOF are varied in NAIBER's calculations, 3) live cattle and corn implied volatilities are calculated using the Black-Scholes formula in NAIBER's results (the Trinomial model for American options was used for this study), 4) the NAIBER calculator uses a three-year average corn basis calculation while this study uses a 2-year average basis, 5) NAIBER does not include soybean meal or hay prices in calculating feed costs, 6) NAIBER correlates only live cattle and corn prices (because feeder cattle prices are inputs selected by the user) based on cash prices from 1980 to 2005 (this study correlates live cattle, feeder cattle, corn, and soybean meal prices based on 1998 to 2013 futures prices), and 7) NAIBER uses historic lagged standard deviations of basis levels as forecasts of the standard deviation of future basis. NAIBER thus incorporates basis risk into calculations, a factor which this study holds constant. The cumulative effect of these differences is that this model, by incorporating feeder cattle price risk and using a different model for implied volatility calculation, may provide different risk estimates than the NAIBER model. Additionally, by incorporating hay and soybean meal prices into feed costs calculations this study adds variables which should more accurately represent cattle feeding costs.

Figure 5-3 shows a graphic comparison of the two expected fed cattle profit calculations<sup>6</sup>. From 2009 through late 2011, the two methods appear to track closely with one another, but begin to diverge in early 2012. Narrowly, the NAIBER estimated expected profits become more positive and indicate a brief recovery from the negative feedlot profits. By contrast, the results from this study suggest staunchly negative expected profits and, indeed, expected the lowest expected profit per head seen in the study. It is unknown what exactly caused this divergence between the two estimates, but given the above discussion of difference between the two models some possible explanations may exist.

**Figure 5-3: Comparison of NAIBER Expected Fed Cattle Profit Calculator expected profits against Mean Simulated Expected Profits, 1/16/2009-3/15/2013.**



First, because the NAIBER calculator uses cash prices for feeder cattle prices (whereas this study uses futures prices adjusted for basis) decreases in cash feeder cattle prices could have increased NAIBER's estimated profits. Indeed, the Oklahoma City feeder steer basis was weaker than normal during this time period (see Figure A-5 in Appendix A).

A second explanation, also related to basis, is that during the latter part of 2012 and into 2013, corn basis followed an unusually strong pattern (Figure 4-4). Because the NAIBER

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<sup>6</sup> The correlation coefficient between the two expected profits calculations, over the time period 1/16/2009 to 3/15/2013, was 0.378

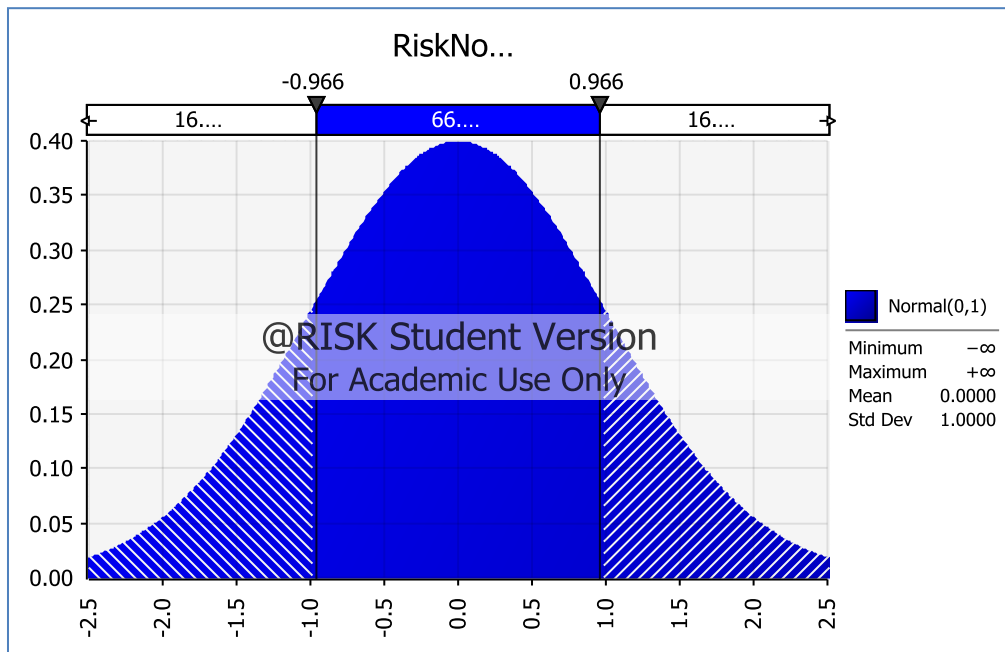
approach uses a 3-year average basis, rather than a 2-year average basis as used in this study, the NAIBER estimates could understate the price of corn as lagged basis values will not adjust as quickly to new information. Thus, it appears that basis calculations play a significant role in formulating fed cattle profit expectations.

Finally, and perhaps more likely, differences in feed cost calculations may explain these differences in expected profits. NAIBER, as noted previously, does not include hay or soybean meal prices and corn is the only commodity in the feed ration. This study includes the prices (and price risks) of all three commodities. In late summer, 2012, corn prices began to recede from record highs. This corresponds with an increased in expected profits as calculated by NAIBER. However, during this same time period, alfalfa hay prices remained extremely high. Therefore, by incorporating hay prices this model adds additional costs which may account for more negative expected profits compared to NAIBER estimates.

The variance of NAIBER's expected feedlot profits was also compared against this study's estimated variance. NAIBER calculates a 2/3 probability range for expected feedlot profits by dropping the lowest 1/6 and highest 1/6 of simulated expected profit values. The remaining values, having dropped in total 1/3 of the distribution, constitute 2/3 of the distribution of simulated expected profits.

An example of this 2/3 probability range for a Normal(0,1) distribution is shown in Figure 5-4. Dropping the lowest 1/3 (16.7%) and the highest 1/3 (16.7%) of the values (the blue and white portions of the distribution) in the distribution leaves 2/3 (66.6%) of the distribution remaining, shown in solid blue. The values bounding the upper and lower 2/3 of the Normal(0,1) distribution are -0.966 and 0.966, respectively. This same approach is applied to the NAIBER calculator and the expected profit values at the lower and upper end of the simulated expected profit distribution are reported as the 2/3 probability range of expected feedlot profits.

**Figure 5-4: 2/3 Probability range for a Normal (0, 1) distribution**

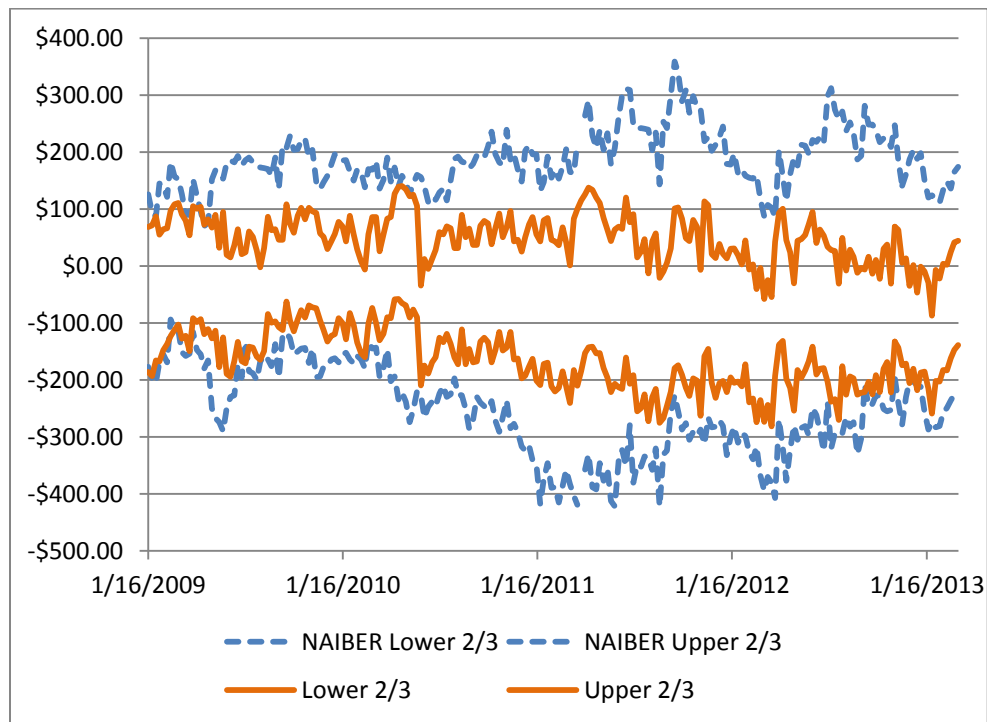


The 2/3 probability approach was applied to this study. Using @Risk functions which report the value of a distribution corresponding to a specified probability, the values corresponding to the 16.7<sup>th</sup> and 83.3<sup>rd</sup> percentiles were calculated.

The 2/3 probability range of expected profits from NAIBER and this study's calculation are presented in (Figure 5-5)<sup>7</sup>. The two measures of risk initially have similar estimates, with NAIBER estimating a \$300 2/3 probability range on 1/16/2009 while this study estimated a \$250 2/3 range. In subsequent results the two measures to diverge, with NAIBER providing significantly wider estimates of expected profits. In early July, 2011, NAIBER estimated over a \$600 range between the lower and upper two-thirds values of the expected profit distribution while this study calculated a \$310 range. Again, this may indicate that the variability of expected feedlot profits in this study is less than other similar simulations, even if the mean expected returns of this study are lower.

<sup>7</sup> The correlation coefficients between the upper and lower 2/3 of NAIBER's estimates and this study's estimates were 0.668 and 0.108, respectively.

**Figure 5-5: Simulated 2/3 probability range of Expected Profit Distribution for Kansas Feedlots compared against simulated 2/3 probability range NAIBER Kansas Feedlot profit estimates, 1/16/2009 to 3/15/2009**



There are several possible reasons why the 2/3 probability range of expected feedlot profits differs so greatly between the two models. The first is that different correlation structures are imposed in each model (with this model imposing a greater number of historical relationships between the input distributions); NAIBER correlates only corn and live cattle prices while this study correlates all input prices (except for the zero correlation assumed between live cattle, feeder cattle, and hay). This inclusion of additional correlations may serve to ‘restrict’ the values which can be drawn from each input distribution, thereby reducing risk estimates.

Secondly, NAIBER incorporates basis risk as a function of feedlot profit risk. This is done by using the standard deviation of historic basis level. This study holds basis constant to simply the model. By eliminating basis risk, this model may underestimate the amount of risk present in feedlot profits. A brief test was conducted to determine how much risk might be added to this model by including a measure of basis risk. Basis risk, calculated from the standard deviation of previous year’s basis levels, was included for live cattle and corn prices. The results from the test simulations which included basis risk showed some increases in the standard

deviation of expected profits. However, the risk levels were increased by only 25% and did not significantly converge with risks estimated by NAIBER. Therefore, further inclusion of basis risk was suspended to focus efforts on the analysis of changing price risk on expected feedlot profits.

The third difference between the NAIBER 2/3 probability range and this study's estimate may lie in implied volatility calculation. NAIBER used implied volatilities generated using the Black-Scholes (1973) model while implied volatilities in this model were gathered using the Trinomial model for American options. Differences in the calculation steps of implied volatilities may change risk estimates. Furthermore, the exact equations NAIBER uses to convert implied volatilities to market-expected standard deviation of futures prices may differ from Equation (1) in this study. Differences in this calculation will lead to different estimations of expected standard deviations of futures prices, thereby creating differences in estimated risk levels.

Finally, the software and Monte Carlo algorithms used between NAIBER and this study differ. NAIBER uses R software for simulations where this study uses the Mersenne Twister algorithm in @Risk. Differences in sampling techniques between these two software packages may significantly influence estimations of expected profits, especially for skewed or long-tailed distributions. Additionally, NAIBER uses 10,000 iteration simulations to build expected profit distributions while this study used 1,000 iteration simulations. Higher sampling iterations may lead to better sampling of distribution tails and provide wider risk estimates. This study tested the impact of simulating expected profits using 100, 1,000, 5,000, and 10,000 iteration samples. The results did not show significantly greater risk estimates between 1,000, 5,000, and 10,000 iteration samples. Therefore, this study continued to use 1,000 iteration samples to lessen the computational burden placed on computer software by the 10,000 iteration samples.

### ***5.2.2 - Comparisons against Focus on Feedlots Calculated Profits***

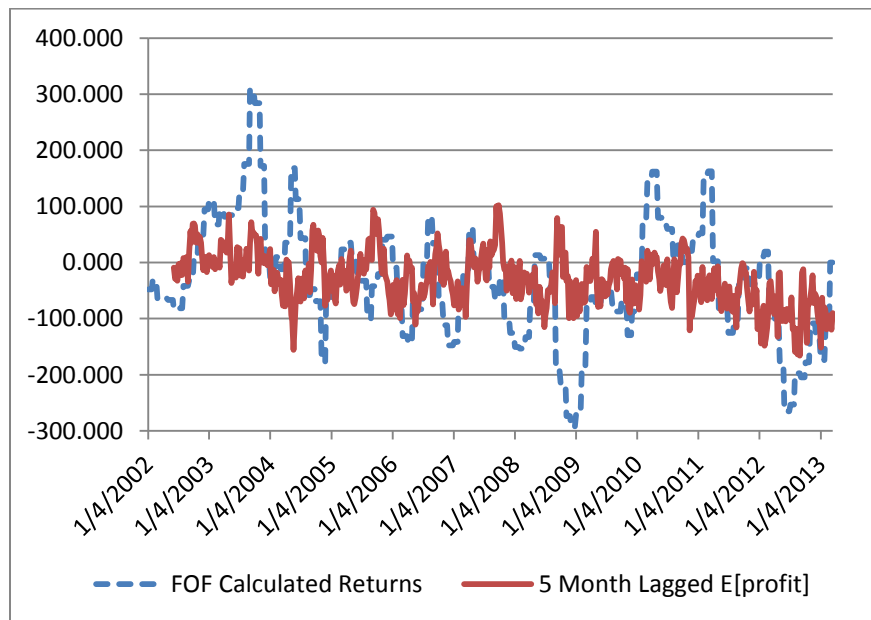
The second comparison of these expected feedlot profits is against the monthly report Historical and Projected Kansas Feedlot Net Returns, by Tonsor and Dhuyvetter (2013). These estimated closeout profits (compiled by Tonsor and Dhuyvetter, 2013) are calculations based off reported values from 6 to 8 (on average) feedlots who participate in the monthly *Focus on Feedlots (FOF)* survey (data available from LMIC, 2013). The survey data contains reports for average placement and finish weight, days on feed, average daily gain (ADG), feed-to-gain ratio

(on a dry matter basis), mortality rates, and average realized and projected cost of gain (COG). In their estimation of historic returns, Tonsor and Dhuyvetter use reported USDA reported prices for Kansas Direct Slaughter Cattle report to estimate the selling price of fed cattle and the Winter Livestock Feeder Auction report for Dodge City, KS to estimate the purchase price of feeder cattle (Tonsor and Dhuyvetter, 2012). The data for this comparison was provided by Tonsor (2013).

Temporal differences arise between the *FOF* calculated profits and this study's expected profits. The *FOF* estimates are of profits realized in time  $t$  while this study estimates profits to be realized in time  $t+5$ . Accordingly, when comparing profit estimates between these two calculation methods, this study's expected profits are lagged 5 months. Incorporating this lag allows comparisons to be made on the basis of expected profits for cattle sold in time  $t$  (provided by this study) versus actual profits of cattle sold in time  $t$  (from the *FOF* data).

The comparison between the two approaches is shown in Figure 5-6. The two series' diverge from one another greatly at different intervals and are correlated at the 0.295 level. Results from the *FOF* data appear more volatile, swinging from \$300/hd profits to -\$300/hd losses while the simulated results from this study appear (relatively) more stable. By and large, the two series' follow the same general trends and both reflect significantly negative profits starting in 2011. Tonsor and Dhuyvetter do not calculate the variance of the calculated historic feedlot profits or a confidence interval around the mean, thereby prohibiting variance comparisons.

**Figure 5-6: Expected Returns to Kansas Feedlots as Estimated from Focus on Feedlots Survey Data and Five Month Lagged Mean Simulated Expected Profits, 1/2/2002 - 3/15/2013**



One potentially significant driver of differences between the *FOF* calculated results and the results from this analysis comes from mortality rates. The *FOF* data reports mean mortality rates of 1.31% and a maximum reported mortality rate of 2.78%. The empirical distribution used in this study has a similar mean of 1.09% but a significantly higher maximum of 6.91% (this distribution was created from models published by Belasco et al. 2009. Their data included at least one observation of 25% mortality rate which could significantly skew the estimated distribution). The equations in this model are structured in a highly conservative manner so that any mortality is realized at the end of the feeding period. Feedlot operators are assumed to have incurred all costs at this point and only revenue is adjusted for the expected mortality. Therefore, if the empirical distribution constructed in this model overstates mortality, it will certainly understate revenues and profits.

Further consideration of cattle mortality rates suggests this model does not reflect the true timing of cattle mortality. Belasco et al. 2009 found a negative relationship between placement weights and mortality rates. If this relationship continues across the feeding period, cattle ready for sale (at their heaviest weight) will have the lowest expected mortality rate. Therefore,

applying mortality rates which are based on data reflective of the entire feeding period to the sale of finished cattle clearly overstates the probable mortality at this point in the production process.

A more realistic approach to modeling feedlot cattle mortality would be to estimate expected mortality rates at different periods in the feeding process (i.e., expected mortality in the first feeding month, second feeding month, etc.) and apply those rates to costs and revenues accordingly. Alas, there does not appear to be such a dataset or model available at this time and incorporating such an approach into this study could present significant difficulty.

One final difference between the *FOF* calculated historic profits and the expected profits modeled in this study is in cattle finish weights and the number of days on feed (DOF). *FOF* data shows actual finish weights and DOF, both of which vary across the dataset. The assumptions in this model are such that the cattle finish weight is a function of quarterly changing ADG distributions, a constant placement weight (750 lbs.), and a constant DOF number (150). The seasonal ADG rates were estimated using Belasco et al.'s (2009) models which aggregated data from 1995 to 2004. Due to their estimation procedures, no analysis of how ADG has changed across time was available. Thus, the finish weight of cattle in this model does not reflect broader industry changes which may have increased ADG or feed conversion rates and, consequently, the sale weight of fed cattle.

### ***5.2.3 - Conclusions from Model Comparisons***

The bottom line from comparing the results of this study against the NAIBER Fed Cattle Profit Calculator and the *Focus on Feedlots* estimated returns to cattle feeding is that this study appears to agree with other work. Broadly speaking, the three methods seem to follow many of the same trends, and therefore appear to capture the major market movements. While divergences occur between all three models, such differences are expected.

Differences occur between these models results due to differences in assumptions and calculation methods. Small differences in methodology (for example, 2-year or 3-year lagged basis) can have significant impact on results, especially during 'abnormal' market behavior. "Abnormal" markets, meaning those which diverge significantly from previous trends or cycles, are difficult to forecast and can have extreme impacts on a model's predictions or results. The U.S. grains complex has experienced increased volatility in recent years (Irwin et al. 2009) which, given the above discussion of the difficulty of price forecasting under volatility, may

explain how seemingly subtle differences between the three models compared here have large impacts.

Given that the results of this study follow patterns observed by others and that small changes in modeling techniques have significant impacts on results, it appears reasonable to conclude that this model reflects (at least partially) the reality of risk in feedlot profits. While some of the assumptions made in the development of this model may not reflect all of the current changes in cattle feeding (for example, cattle performance variables are estimated from a time period before the approval of  $\beta$ -agonists for cattle rations), it does capture major trends in the risks and returns to feeding cattle. The trends implied by this model are more closely analyzed in the following discussions.

### **5.3 - Analysis of Cattle Feeding Returns**

As mentioned earlier in this chapter, the negative expected profits estimated by this model would indicate that placing cattle on feed in the last two years would have been a poor investment decision. For individuals (or firms) seeking to custom finish cattle or diversify investment portfolios by taking ownership of cattle through the finishing process, investing during times of negative expected returns would appear irrational. However, for non-custom finishing feedlots (farmer-fed operations), a different perspective can be taken. Economic theory suggests that a firm can still remain in operation if revenues are expected to exceed variable costs (even if revenues will not cover total costs) when production is realized and pay fixed costs at a late time. Therefore, the economic conditions for exiting the industry in the short run occur when a firm can no longer expect revenues to exceed variable costs. Under this economic theory, if cattle feeders expect to cover variable costs their continued operation may be justified in the short run. To this end, the probability that expected total revenues will exceed expected variable costs for Kansas cattle feeding operations from 2002 to 2013 was analyzed.

#### ***5.3.1 – Analysis of Returns above Variable Costs***

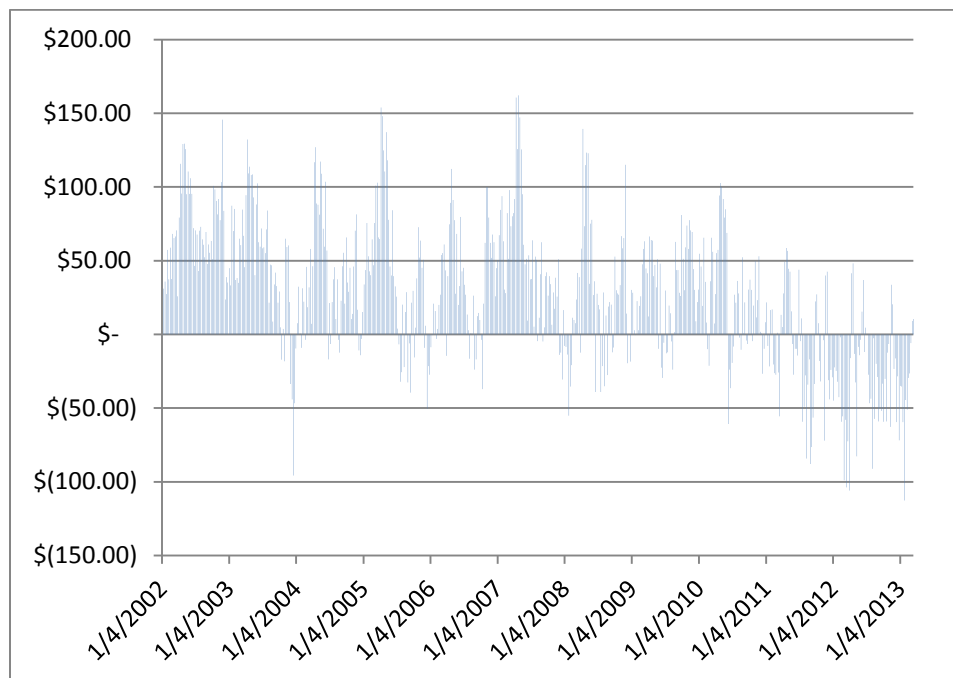
Table 5-3 provides the summary statistics of returns above variable costs over the January 2, 2002 through March 15, 2013 time period and Figure 5-7 shows the average returns over variable costs expected at the time of placement. For the time period beginning in 2002 and lasting until 2010, given futures market implied prices, cattle feeders could often expect to cover variable costs. Over the eleven years analyzed in this study, the average probability that cattle

feeders would cover variable costs was 0.6. Table 5-4 shows the average probability that cattle feeders would cover variable costs by year. From 2002 to 2010, cattle feeders could most often expect to cover their variable costs, indicating that economic ‘shut down’ conditions (where total revenue is less than variable costs) did not exist for most producers. Starting in 2011, this model suggests cattle feeders can no longer expect to cover variable costs for the majority of placements. If feeders can no longer cover variable costs, then the economically rational response is to not feed cattle. Why, then, are cattle still being placed on feed in Kansas feedlots?

**Table 5-3: Summary Statistics for weekly simulations of Expected Total Revenue - Expected Variable Costs for Kansas Feedlots (\$/hd.), 1/2/2002 - 3/15/2013**

Mean	28.44
SD	47.90
COV	1.68
Min	-112.55
Max	162.08

**Figure 5-7: Mean Expected Returns (\$/hd) above Variable Costs for Kansas Feedlots, 1/2/2002 – 3/15/2013.**



**Table 5-4: Probability that Kansas Feedlots Total Revenue will Exceed Variable Costs by Year**

<b>Year</b>	<b>Prob.(TR&gt;VC)</b>
2002	0.8172
2003	0.6994
2004	0.5920
2005	0.6402
2006	0.6147
2007	0.6672
2008	0.5477
2009	0.6067
2010	0.5833
2011	0.4576
2012	0.3852
2013	0.3585

### ***5.3.2 – Analysis of Cattle Feeder Behavior***

There are several possible explanations for why cattle are still placed on feed in the face of expected negative returns above variable costs. The first is that cattle feeders may be using some other metric to develop expectations about returns to cattle feeding. The model presented in this study, like all economic models, is a simplification of reality which may or may not fully reflect all factors present in cattle feeding operations. Accordingly, these results could be biased if, in reality, cattle feeders use some additional variable not present in this model. Conversely, bias could also arise if this model includes too many variables when cattle feeders make placement decisions based on a few, simple variables. The bottom line is that there are many methods to develop expectations of future profits and changing one or two variables can have a significant impact on the results.

Similarly, cattle may have become more efficient than this model assumes. An increase in cattle efficiency would lower feeding costs, making expected (and realized) costs lower than what is estimated in this model. Cattle performance variables used in this model were based on distributions estimated by Belasco et al. (2009). The distributions estimated by Belasco et al. (2009) were created using data from 1995 to 2004. Recent changes in cattle performance (Herrington and Tonsor, forthcoming) and additional technologies like  $\beta$ -agonists make it likely that these distributions underestimate true cattle efficiency.

A third possible reason for placing cattle on feed during expected negative profits is that cattle feeders believe live cattle futures markets (and, therefore, the results of this study) are biased downward. Kastens and Schroeder (1998) found such a bias to be present in the minds of cattle feeders. The result of perceptions of a downward bias is that cattle feeders expect live cattle prices to rise, generating positive returns. While such expectations are not rational under the efficient market hypothesis, they would explain why cattle placements do not decrease when negative returns are expected.

Additionally, cattle feeders may persist in feeding cattle under negative expected returns if they do not develop *a priori* profit expectation and rather rely on past profits to guide placement decision. Kastens and Schroeder (1998) found past profit to influence placement decisions but this still does not explain why, after two years of negative expected returns, cattle feeders have not used this metric to make placement decisions and subsequently decreased cattle placements.

Furthermore, the above mentioned economic theory suggesting firms should shut down when variable costs cannot be covered assumes free entry and exit into and from a market. That is, firms do not face significant financial, legal, or physical obstacles when starting business or exiting the industry. It can be argued cattle feeders do face significant barriers to entry and exit from the industry. Cattle feeding requires large amounts of land and physical facilities (pens, feed bunks, feed mills, etc.). If a cattle feeder decides to exit the industry, these physical facilities represent significant capital investments that may be recouped by selling the feedlot or simply abandoned. Finding a buyer for a cattle feedlot during a period of extended negative feedlot profits is likely to be difficult, and simply abandoning the feedlot implies the owner will likely not recoup a significant portion of the capital investment. Additionally, abandoning the feedlot may also leave the feedlot owner with few to no options for paying off outstanding debt. Thus, cattle feeders do face significant barriers to exiting the industry.

Similarly, if cattle feeders face barriers to exiting the industry, they also face significant costs upon the decision to enter or re-enter the industry. Land must be purchased and facilities built, or sufficient financial capital must be raised to purchase an existing feedlot. Therefore, given the barriers to both entry and exit of the industry, cattle feeders may opt to continue feeding cattle through times of negative profits rather than incur shut-down costs or re-entry costs.

Aside from fully exiting the industry, cattle feeders could temporarily exit the industry or temporarily reduce fed cattle supplies. However, there may be costs associated with such strategies as well. If feedlots have agreements with beef packers to supply a certain number of animals per month or year, they may place cattle on feed during negative expected profits to meet agreements. Even if no formal agreement exists between the feedlot and the packer, feedlots may fear a temporary supply reduction in live cattle would cause the packer to purchase cattle from other sources and packers may ‘give away’ slaughter capacity to other sources. This may encourage feedlots to place cattle on feed to provide continual ‘reservation’ of slaughter capacity at packing plants.

A final explanation for placing cattle on feed when negative profits are expected may lie in the relationship between the expected live cattle price at marketing and the expected breakeven price. The breakeven price is the price where zero profit (but no loss) is realized, or where total revenue equals total costs. Cattle feeders may use comparisons of the expected breakeven price to the expected live cattle cash price to guide placement decisions. If the expected cash live cattle price is close to the expected breakeven price, cattle feeders may take the risk of placing cattle on feed in hopes that subsequent market fluctuations will increase the cash live cattle price above the breakeven price. To analyze the merits of this theory, an analysis of the expected breakeven price faced by Kansas cattle feeders at placement time was conducted.

### ***5.3.3 – Live Cattle Breakeven Price vs. Expected Price***

The expected breakeven price was calculated by plugging Equation (7) (the total revenue equation) into the  $E[TR_{t+21}]$  term in Equation (6) (the general profit function). The left-hand side of Equation (6) was made equal to zero (the breakeven price is where profits equal zero) and the remaining equation was solved to isolate the live cattle price. Solving for price in this manner yields the price at which total revenues and total costs are equal and no profit (and no loss) is realized. Thus, the resulting price is the expected breakeven price for Kansas cattle feedlots.

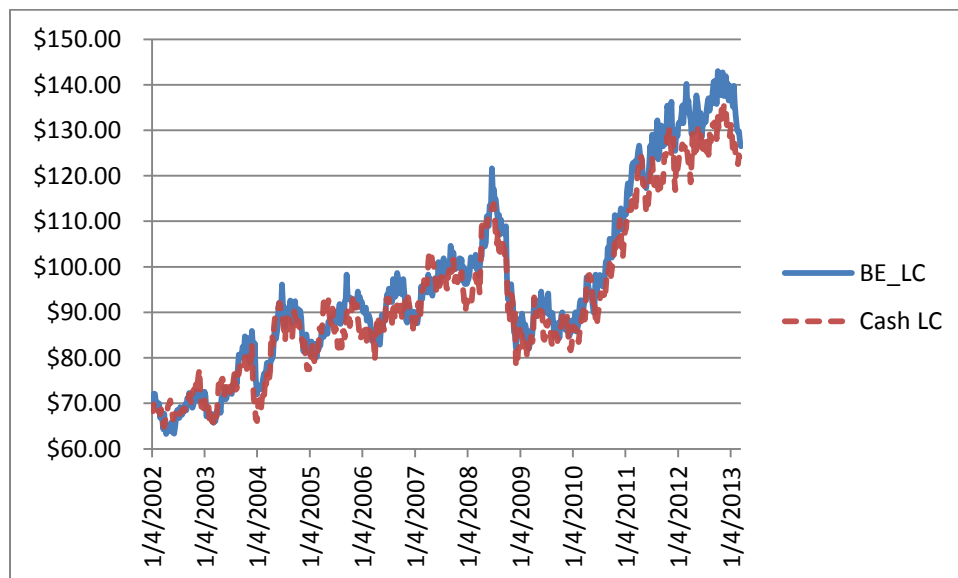
The total cost breakeven live cattle cash price was calculated for each week in the dataset with the following equation:

$$(19) \quad BE_{LC} = E[TC_{t+21}] * \frac{1}{E[SaleWT_{t+21}](1-MORT_{t+21})^{0.96}}$$

Where  $BE_{LC}$  is the breakeven live cattle cash price and all other variables maintain previous definitions. Over the 2002 to 2013 dataset, the average breakeven live cattle cash price

was \$90.39/cwt. with a standard deviation of \$20.24/cwt. The minimum breakeven price was \$63.26 while the maximum calculated breakeven cash live cattle price was \$143.02. Figure 5-8 shows the relationship between the expected breakeven price and the expected price for cash Kansas live cattle. The graph shows the expected cash price to be below the breakeven price for the majority of the weeks in the dataset. The two prices appear to track closely through 2011 but recent expected cash prices have fallen well below the expected breakeven price, congruent with the severely negative expected profits estimated in this study.

**Figure 5-8: Breakeven Cash Live Cattle Price vs. Expected Cash Live Cattle Price for Kansas Feedlots, 1/2/2002 - 3/15/2013**



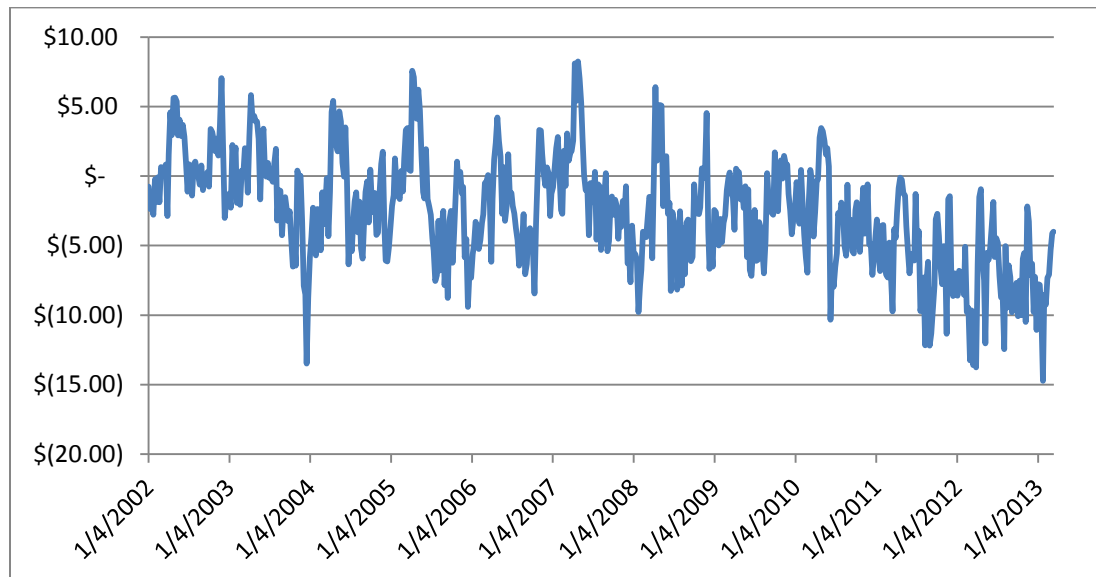
If the theory that cattle feeders use the difference between expected cash live cattle prices and expected breakeven prices to gauge the probability of making a profit and guide placement decisions is correct, then small differences between the two expected prices would justify (perhaps) placing cattle on feed. Placements would be justified because a small difference between the expected breakeven price and expected cash price would imply small market movements could allow for the hedging of profits. For example, if the expected breakeven price is \$1/cwt. higher than the expected cash price, an increase in live cattle futures prices (holding basis constant) of \$1.50/cwt. would (holding all other prices constant) allow feedlots to profitably hedge the live cattle prices. Therefore, if the difference between the expected breakeven price and the expected cash live cattle price is sufficiently small, it would appear

reasonable to cattle feeders to place cattle on feed when profits are negative and expect future market movements to provide opportunities to hedge profits.

From January, 2002 to March, 2013, the average difference between expected Kansas cash live cattle prices and the expected cash breakeven Kansas live cattle price was -\$2.62, indicating, on average, that the expected cash price is below the cash price needed to breakeven. The standard deviation of this difference is \$3.96 and the dataset indicated a minimum and maximum difference of -\$14.73 and \$8.23, respectively. Given the CME's daily trading range of \$3/cwt. up or down from the previous day's closing price, it would appear that price movements of \$2.62 (the change in futures prices (holding basis constant) needed, on average according to this study, for expected Kansas cash live cattle prices to equal the expected breakeven price) are reasonable and cattle feeders may have rational justification for placing cattle on feed when expected profits are negative and hoping futures prices will move such that profits (or breakeven prices) can be hedged.

Figure 5-9 shows the difference between the expected cash price and expected breakeven price for Kansas live cattle. The graph shows that, prior to 2011, the difference between the two expected prices was largely mean-reverting and followed some seasonal patterns. The mean of the difference, pre-2011, was -\$1.61/cwt. (standard deviation \$3.44/cwt.) while the post-2011 mean is -\$6.74/cwt. (standard deviation \$3.17/cwt.). The relatively small difference, on average, between the two expected prices before 2011 offers support for the rationality of cattle feeders placing cattle on feed during negative profits and expecting slight changes in prices to allow for profit hedging. However, such tactics now appear irrational following 2011 as the average difference has widened significantly. Under this post-2011 price regime, fluctuate nearly four times the magnitude of pre-2011 prices to allow cattle feeders to hedge breakeven live cattle prices.

**Figure 5-9: Expected Kansas Cash Live Cattle Price minus Expected Kansas Cash Live Cattle Breakeven Price**



The above analysis focused on the relationship between the expected live cattle price and the price needed for producers to have exactly zero returns above total costs, or the total cost breakeven price. Because economic theory suggests in the short run continued production is rational if producers can cover variable costs, the above analysis is repeated but with respect to the live cattle price needed to exactly cover variable costs. If the price needed to exactly cover variable costs, the variable cost breakeven price, is close to the expected cash live cattle price, then placing cattle on feed may be rational even if the probability of covering variable costs is less than 0.5. The approach is rational because market fluctuations even smaller than those needed to move prices above the total cost breakeven price could allow producers to hedge prices and thus expect to cover variable costs. If such an approach were taken, the economic shut down conditions could be avoided.

The average variable cost breakeven price from 2002 to 2013 was \$91.46/cwt. (standard deviation \$20.23/cwt.), less than the average total cost breakeven price of \$96.39/cwt. and the average expected Kansas cash live cattle price of \$93.77/cwt. (standard deviation \$18.08/cwt.). Therefore, over this time period, Kansas cattle feeders could most often expect to cover variable costs at the time of placement. Figure 5-10 shows the relationship between the expected cash price and the variable cost breakeven price from 2002 to 2013. In 2002, the expected cash price

was significantly higher than the variable costs breakeven price, however, that relationship appears to have changed, with the variable cost breakeven price rising above the expected cash price consistently since 2011. Before 2011, the average difference between the expected cash price and the variable cost breakeven price was \$3.32/cwt. (standard deviation: \$3.41/cwt.), indicating that expected cash prices were greater than the variable cost breakeven price.

Following 2011, the average difference has been -\$1.81/cwt. (standard deviation: \$3.13/cwt.), indicating that cattle feeders should not expect to cover variable costs at the time of placement. However, this difference may be covered by subsequent price changes which occur in the price discovery process in futures markets. If future volatility in the futures markets is expected to cause prices to fluctuate \$4/cwt. (from \$2 higher than the current expected price to \$2 lower) then placing cattle on feed and expecting to hedge returns above variable costs may be rational. Given the persistence of feeder cattle placements into feedlots during recent times of negative expected returns above variable costs, it appears cattle feeders may be employing such market timing strategies.

**Figure 5-10: Expected Kansas Cash Live Cattle Price and Variable Cost Breakeven Price for Kansas Cattle Feeders, 1/2/2002 - 3/15/2013**

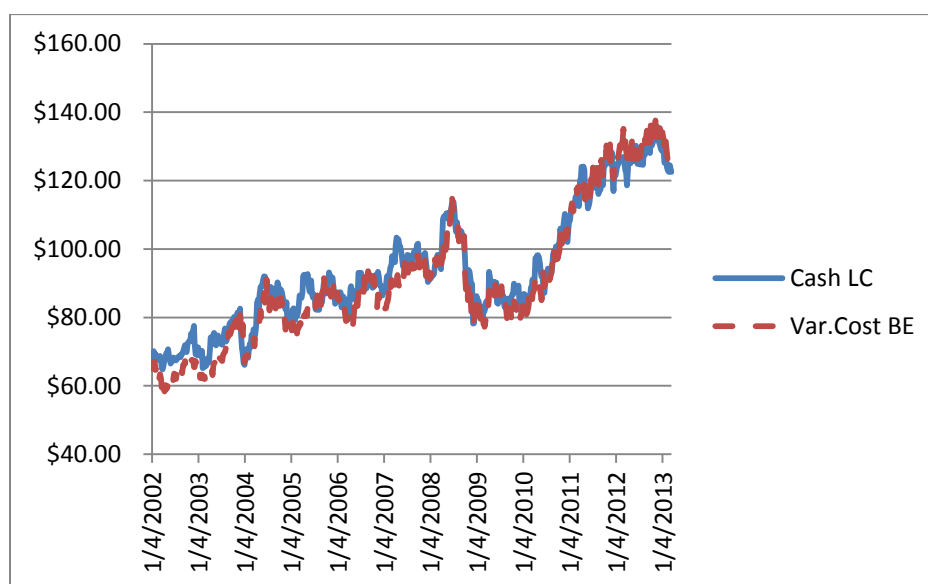
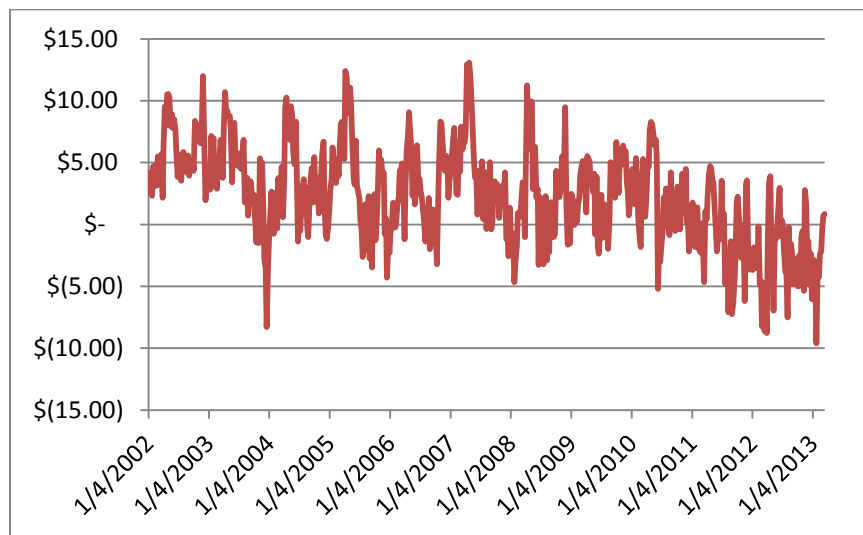


Figure 5-11 shows the difference between the expected Kansas cash live cattle price minus the variable costs breakeven price. Prior to 2011, the difference was greater than \$5/cwt. only two times, indicating that for the vast majority of placement, market movements following

placement of less than \$5/cwt. would allow cattle feeder to hedge returns above variable costs. Following 2011, however, there have been several weeks where the expected price was nearly \$10 under the variable cost breakeven price. This indicates that cattle feeders who are placing cattle on feed during these times must be expecting major upward market movements to occur before variable costs can be covered.

**Figure 5-11: Expected Kansas Cash Live Cattle Price minus Variable Cost Breakeven Price for Kansas Cattle Feeders, 1/2/2002 - 3/15/2013**



When the difference between the expected price and the variable cost breakeven price is small, it can be argued that the price discovery process in futures market will move prices sufficiently over the feeding period to allow cattle feeders to hedge returns. Under such conditions, market timing strategies for hedging may be rational. However, as the expected price falls further below the variable cost breakeven price, cattle feeders who place cattle on feed during such times must be expecting either dramatic, volatile swings in prices or upwardly biased markets. Since markets are unbiased (under the Efficient Market Hypothesis), this approach of placing cattle on feed and ‘timing the market’ later to hedge returns above variable costs appears to be irrational. It is possible that live cattle futures markets have increased in volatility such that \$10/cwt. price swings (the most extreme difference between expected and variable costs breakeven prices) can be expected to occur. However, testing of this theory is left to future research.

One significant problem with the theory of using small market fluctuations to provide hedging opportunities is that futures markets are equally likely to move up or down. Thus, placing cattle on feed with a negative expected cash price-expected breakeven price difference again ties into beliefs of market bias and the efficiency of markets. If markets are completely efficient and market biases do not exist, then placing cattle on feed and hoping for a subsequent increase in price (no matter how large or small the magnitude) is irrational. However, if short-term inefficiencies and biases are observed, or if markets are mean reverting in the long run but experience significant divergences from the mean in the short-run, then such cattle placement tactics may be justified. The analysis of such questions is left to future research, however, and the bottom line of this analysis is that while it may have once been justifiable for cattle feeders to expect to take advantage of small price fluctuations to hedge breakeven prices, current cash live cattle price levels make such strategies appear irrational.

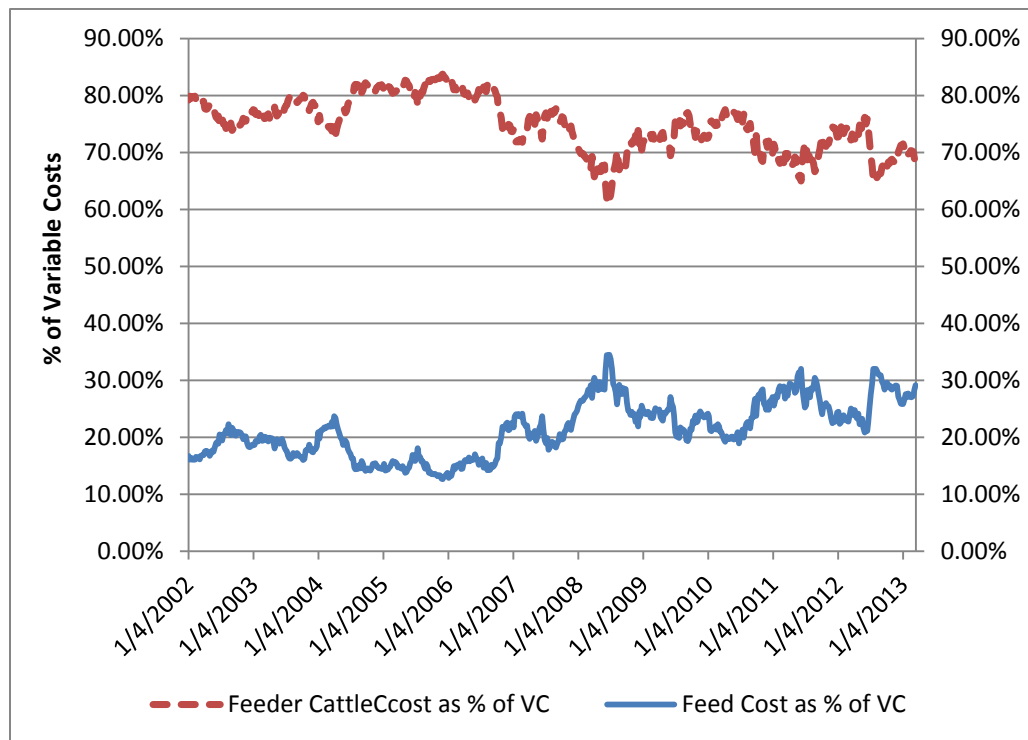
#### ***5.3.4 - Drivers of Cattle Feeding Profit: Costs***

The two largest components of cattle feeding costs are the purchase cost of feeder cattle and the cost of feed. Examination of how these two cost components have changed over the last eleven years may offer insight into the factors influencing cattle feeding profits. Figure 5-12 shows the percentage of expected variable costs that are attributed to expected feeder cattle costs and expected feed costs since 2002. The most notable trend is the increase in variable costs attributed to feed costs. On 1/2/2002, expected feed costs accounted for 16.7% of variable costs and by 1/4/2013, this figure had risen to 25.83%. The percentage of variable costs explained by feeder cattle costs fell during this same period from nearly 80% in 2002 to just under 70% by 2013.

Because feed costs now constitute a more significant portion of cattle feeding costs than in historic times, if the expected price risk of feedstuffs has also increased then feedstuffs price risk is becoming a more significant portion of a feedlot's expected risk profile. To measure the increase of risk of feedstuff prices, the coefficient of variation (COV) was calculated for each week in the study based on the weekly simulated mean and simulated standard deviation of relevant dependent variables (those with distributions estimated by Monte Carlo simulations). The coefficient of variation is a unit-less measure of the amount of variation that is explained by

the mean. The COV is calculated by dividing the standard deviation by the mean, and thus eliminates any effects of trending variables<sup>8</sup>.

**Figure 5-12: Percentage of Simulated Expected Variable Costs attributed to Expected Feeder Cattle Costs and Expected Feed Costs for Kansas Feedlots, 1/2/2002 - 3/15/2013<sup>9</sup>**



The COV for expected feed costs over the study's time period is shown in Figure 5-13. A general uptrend is observed in the COV<sup>10</sup> which offers support for the hypothesis that the expected risk of feed prices when cattle are placed on feed has increased. This would initially suggest feedlot managers, owners, and investors should adjust or increase risk management

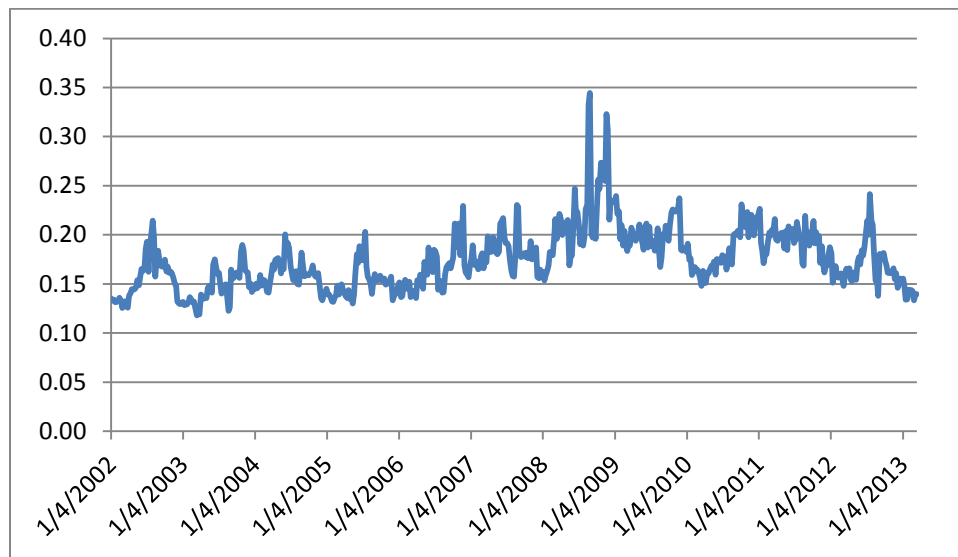
<sup>8</sup> For example, if the mean of a price series is trending upward, the value of its standard deviation will also trend upward, even if the variation around the mean has not changed

<sup>9</sup> Variable costs include feeder cattle costs, feed costs, interest costs, and veterinary costs.

<sup>10</sup> A linear regression of the expected feed costs COV on a time trend variable yielded a coefficient of 0.000077 (significant at the 1% level), see in Table A-1 in Appendix A.

strategies for dealing with feedstuffs prices. However, assumptions made in the development of this model may negate this result.

**Figure 5-13: Coefficient of Variation of Simulated Expected Feed Costs for Kansas Feedlots, 1/2/2002 - 3/15/2013**

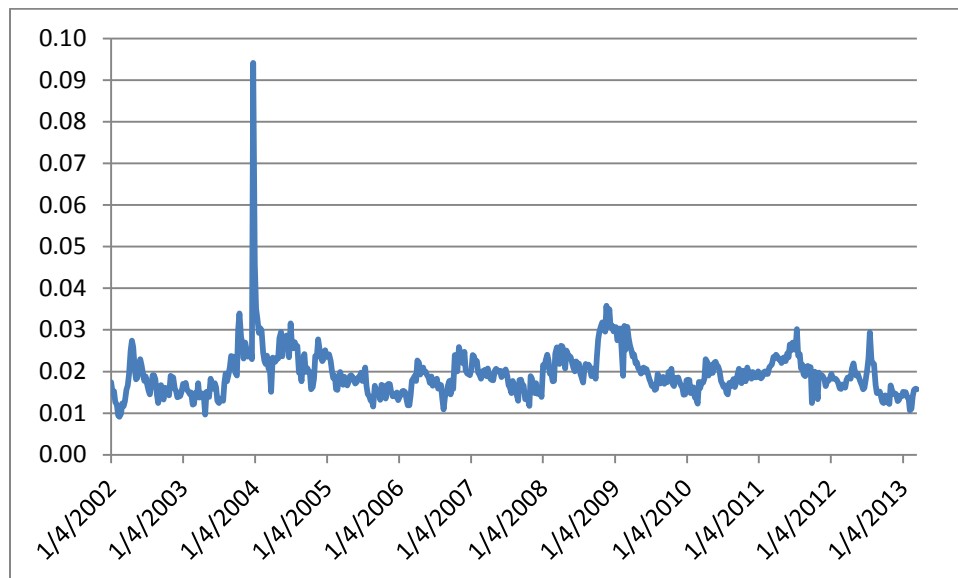


While the price risk of purchasing feedstuffs has increased over the 2002-2013 time period, the relative price risk (as measured by the COV) of purchasing feeder cattle appears to have remained relatively constant. Figure 5-14 shows a graph of the COV (calculated by dividing the simulated standard deviation by the simulated mean for a given week's simulations) of expected feeder cattle costs (the nearby futures price plus basis times placement weight) for Kansas feedlots. This measure of relative risk has consistently hovered near the 0.02 mark across the time period. A linear regression of the feeder cattle cost COV on a weekly time trend revealed that the time trend was not a significant factor in explaining the COV (i.e., COV has not significantly increased with time). This offers evidence that there has been no significant increase in the relative volatility of feeder cattle costs.

One significant spike in the COV of expected feeder cattle costs is observed in late 2003, corresponding to the BSE outbreak in the U.S. The metric used to estimate forward looking volatility of feeder cattle prices, the implied volatility of feeder cattle options, experienced a notable increase immediately following the BSE event. The spike in feeder cattle implied

volatility would cause the variance of expected feeder cattle prices in this model to increase, explaining the spike in the COV.

**Figure 5-14: Coefficient of Variation for Simulated Expected Feeder Cattle Cost for Kansas Feedlots 1/2/2002 - 3/15/2013**



### ***5.3.5 - Drivers of Cattle Feeding Profit: Revenues***

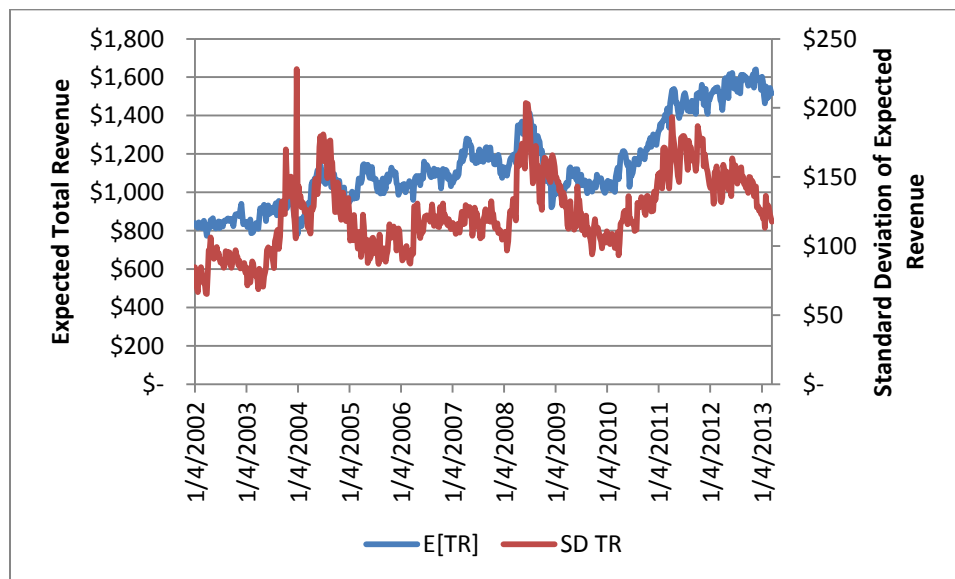
The second piece in analyzing how the expected profit risk of cattle feeding in Kansas has changed involves revenue risk. It is well documented that live cattle prices contribute the most significant source of risk to feed lot operations (Langemeier, Schroeder, and Mintert, 1002; Lawrence, Wang, and Loy, 1999; Belasco et al. 2009). It is relevant, then, to examine how this principle drive of cattle feeding revenues and risk has changed.

Figure 5-15 shows the expected total revenue and its standard deviation for Kansas feedlots. Over the past eleven years, expected total revenues from cattle feeding operations have increased significantly. The standard deviation around these expected revenues has also generally trended upward, including several prominent peaks. The first of these peaks occurs at the same time as the BSE outbreak, which as discussed earlier for feeder cattle, caused extreme volatility in cattle markets and caused options implied volatilities to spike.

The second two peaks (during June, 2008 and April, 2011) seem to occur with significant uptrends in live cattle prices. One possible explanation for this is that as options

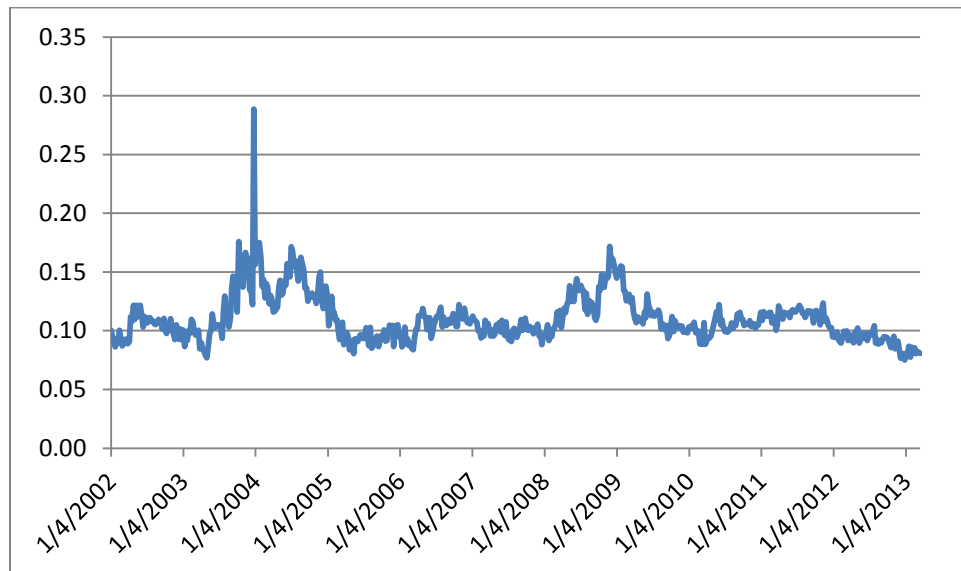
traders see a market trend develop they may perceive greater volatility and bid in higher options premiums, thereby increasing options implied volatilities. Because options implied volatilities are the sole predictor of future volatility for this model, such systematic increases in options implied volatilities will increase the variance of expected live cattle prices in this model, along with the variance of expected total revenue.

**Figure 5-15: Mean and Standard Deviation of Simulated Expected Total Revenues for Kansas Feedlots 1/2/2002 - 3/15/2013**



Again, to examine the change in the variance of expected total revenues without including effects of the distribution's changing mean, the coefficient of variation is calculated for expected total revenues. As Figure 5-16 shows, the variation of expected revenues for cattle feeding has experienced two periods of significant volatility but overall, has remained relatively constant near the 0.1 mark. Indeed, during the past two years, when projected feedlot profits have been highly negative, the relative variability of cattle feeding revenues has decreased to near record lows.

**Figure 5-16: Coefficient of Variation for Simulated Expected Total Revenue for Kansas Feedlots 1/2/2002 - 3/15/2013**



Again, to add statistical rigor to the analysis of how the COV of total revenue has changed over time, the COV was regressed on a linear time trend. The time trend coefficient was significant at the 1% level and suggests the COV has decreased at the rate of -0.000025 units per week (see Table A-2 in the Appendix A). This indicates that cattle feeders are facing, on average, less relative risk in expected revenues. While relative risks (measured by the COV) of expected revenues have decreased, it is important to note this measure masks (intentionally, to some degree) the total number of dollars per head that are at stake.

### ***5.3.6 – Sensitivity Analysis of Cattle Feeding Profits***

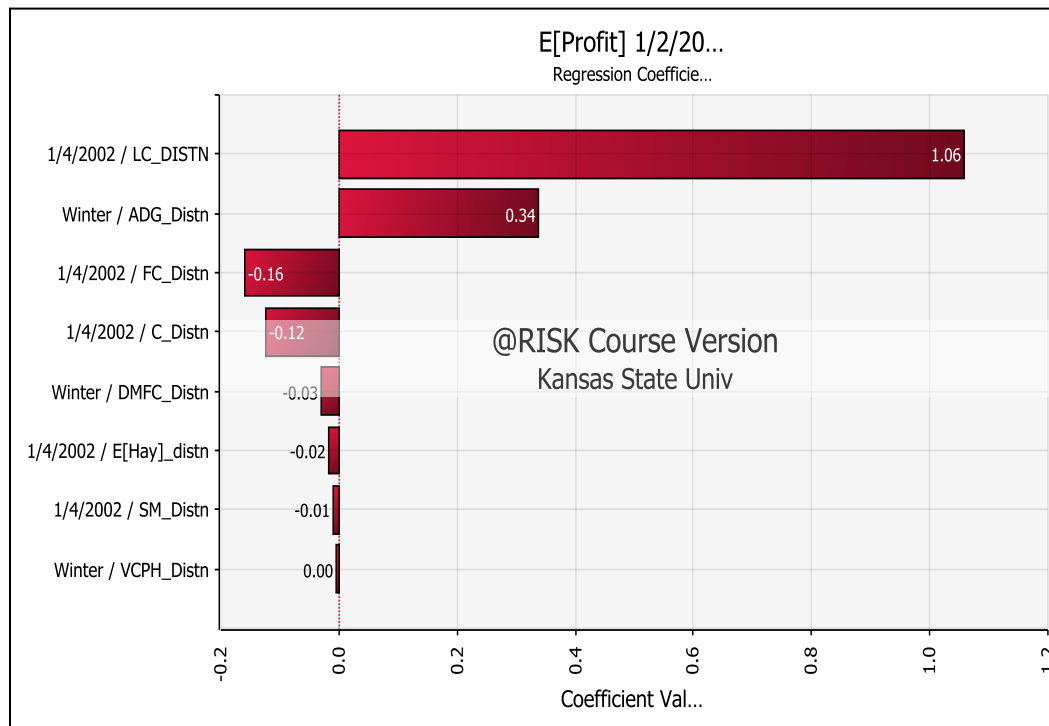
To further analyze potential drivers behind changing expected profit risks in cattle feeding, a sensitivity analysis was conducted to determine which variables exerted the greatest influence on profits. A multivariate stepwise regression was conducted in @Risk to analyze the sensitivity of expected profits per-head to each input variable. Multivariate stepwise regression is performed in @Risk according to the following steps (Palisade Decision Tools, 2013b):

- 1) The input with the highest correlation to the output is entered into the regression model

- 2) The partial correlation coefficient of every input not yet in the regression equation is calculated and the variable with the largest partial correlation coefficient is entered into the equation.
- 3) A regression equation is generated for each input entered into the equation. These entered inputs are tested for significance using the F-test and all insignificant variables are removed from the regression model.
- 4) Steps 2 and 3 are repeated until only significant variables are left in the equation.
- 5) A final regression model is analyzed using the significant inputs and normalized coefficients are reported.

@Risk ranks the variables included in the multivariate stepwise regression by the absolute value of the variable's normalized coefficient (Palisade Decision Tools, 2012b). These normalized regression coefficients can be shown as a 'Tornado Graph', in which the variable with the highest absolute value (i.e., exerting the greatest influence on expected profits) is placed on top. An example of such a graph is shown in Figure 5-17. In this example, taken from the simulated expected per-head feedlot profit for the week of 1/2/2002, live cattle prices (LC\_DISTN) had the largest normalized regression coefficient (1.06) and was accordingly deemed the most influential variable for expected feedlot profits.

**Figure 5-17: @Risk 'Tornado Graph' showing Sensitivity Analysis Results (Normalized Multivariate Stepwise Regression Coefficients) for Variables Affecting Expected Kansas Feedlot Profits (\$/hd.), 1/2/2002**



The normalized regression coefficients represent the change in the output variable's *standard deviation* that results from a *one standard deviation* in the input variable. To convert these normalized coefficients into absolute regression coefficients please see Appendix B. For each simulated expected profit in the study (one for each of the 585 weeks in the dataset) this multivariate stepwise regression sensitivity analysis was performed on the dependent variable *E[Profit]*. To simplify the analysis, only the top three ranking variables (i.e., the top three bars on the “Tornado Graph”) were analyzed.

The results of the sensitivity analysis provided some unique insights into sources of cattle feeding risk. It was noted that the live cattle price distribution was always the first ranked variable in the sensitivity analysis. This result is consistent with the expectations of this study and with other research (Langemeier, Schroeder, and Mintert, 1992; and Belasco et al. 2009).

For the second and third ranked variables, a seasonal pattern was noticed that appeared to change over time. The feeder cattle price distribution was the second ranked input for the majority of the study with ADG as the third ranked variable. However, during the spring and

summer periods, ADG was more frequently the second ranked variable with feeder cattle becoming the third ranked. Beginning in 2005, however, changes were observed in this pattern and the corn price variable gained in significance. This is likely due to increasing corn prices which occurred after the 2005 RFS implementation.

Following the 2005 RFS implementation, feeder cattle prices were still most often ranked as the second most influential variable but occasional weeks were observed when corn price was the second ranked variable. Furthermore, the third ranked variable was more frequently corn, whereas prior to 2005 ADG and feeder cattle prices switched between the second and third ranked variables. The clear indication of this is that corn prices are playing a more significant role in determining fed cattle profits. It is somewhat surprising that AGD is such a significant variable, but this is likely due to its direct link to fed cattle sale weights and dry matter feed price.

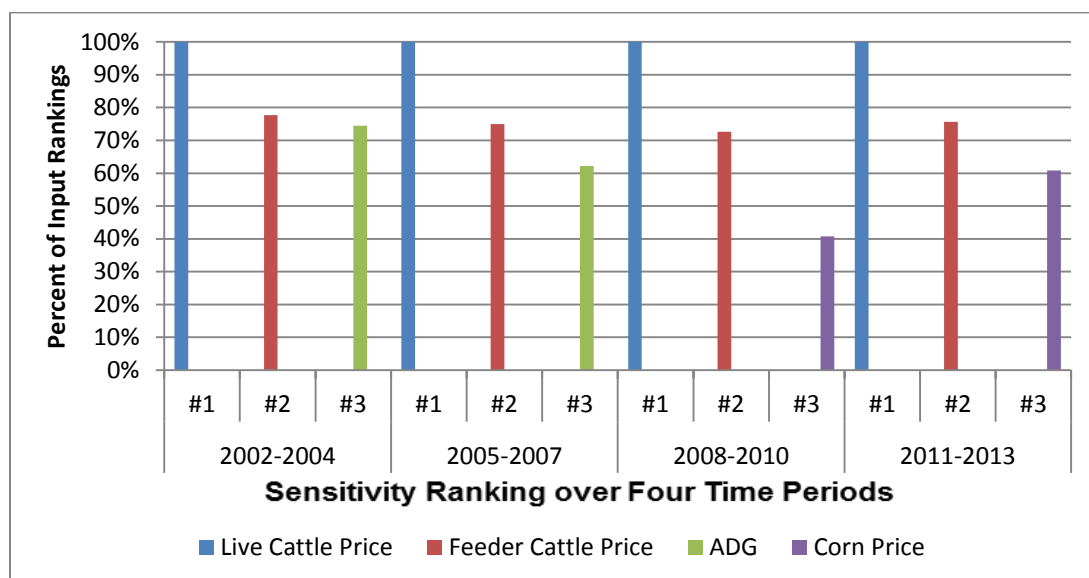
This paradigm shift in variables influencing expected fed cattle profits is shown in Table 5-5. This table presents the percentage of weeks during which a given variable was ranked as the first, second, or third most influential variable (i.e., one of the top three bars in the “Tornado Graph”) for expected fed cattle profits in the @Risk sensitivity analysis. The results show that live cattle prices are always the most influential variable while feeder cattle prices are most frequently ranked as the second most influential variable. Prior to 2008, corn prices were seldom ranked as the second most influential variable and ADG was frequently the second ranked variable. However, from 2008 to 2013, corn price has taken a significant portion of weeks as the second ranked influencing variable (variable with the second largest normalized regression coefficient). This trend is more pronounced in the third ranked variable category where, following 2008, corn prices are most often the third most influential variable on expected Kansas fed cattle profits.

**Table 5-5: Sensitivity Analysis Results: Percent of Weeks during which a Variable was Ranked as the First, Second, or Third Most Influential Variable on Expected Kansas Feedlot Profits, 1/2/2002 - 3/15/2013**

Year	#1: LC Price	#2: FC Price	#2: ADG	#2: Corn Price	#3: FC Price	#3: ADG	#3: Corn Price	N
2002	100%	60%	40%	0%	38%	60%	2%	52
2003	100%	79%	21%	0%	21%	79%	0%	53
2004	100%	94%	6%	0%	6%	85%	10%	52
2005	100%	62%	38%	0%	38%	62%	0%	52
2006	100%	81%	19%	0%	19%	77%	4%	52
<b>2007</b>	100%	83%	13%	4%	<b>13%</b>	<b>48%</b>	<b>38%</b>	52
<b>2008</b>	100%	<b>62%</b>	<b>0%</b>	<b>38%</b>	38%	9%	53%	53
2009	100%	87%	4%	10%	10%	38%	52%	52
2010	100%	69%	4%	27%	29%	54%	17%	52
2011	100%	67%	0%	33%	29%	15%	56%	52
2012	100%	83%	2%	15%	15%	21%	63%	52
2013	100%	82%	0%	18%	18%	9%	73%	11

The changing nature of the three most influential variables determining expected fed cattle profits is further illustrated in Figure 5-18. The sensitivity analysis results were separated into four time periods (2002 to 2004, 2005 to 2007, 2008 to 2010, and 2011 to 2013) and the total number of weeks during which a variable (live cattle, feeder cattle, and corn prices and average daily gain) was first, second, or third ranked variable in the sensitivity analysis was calculated. For each time period, the variable that was *most frequently* observed as ranked first, second, or third was placed in Figure 5-18. For example, for the 2002 to 2004 time period, ADG was most frequently observed input that was ranked as the third most influential variable.

**Figure 5-18: Sensitivity Analysis Results Showing Changes in Top Three Variables Influencing Expected Kansas Fed Cattle Profit, 1/2/2002 – 3/15/2013.**



The bottom line of Table 5-5 and Figure 5-18 is that corn prices are becoming a more significant driver of expected fed cattle profits. While these results are not particularly surprising (other studies have shown the impact of changing corn prices on feedlot profits) they confirm results from other studies and serve to highlight the magnitude of the rising importance of corn prices. The results from the sensitivity analysis support other findings in this study, namely that feed prices are contributing a larger share of risk to cattle feeders. The point should not be lost, however, that fed cattle prices are still the most significant driver of expected feedlot profits and risks. Therefore, while cattle feeders should consider, perhaps, additional risk management in grain procurement, they should not abandon the management of risk in live cattle prices.

### ***5.3.7 - A Note on Cattle Feeding Equations***

While sections 5.3.1 and 5.3.2 have discussed the share of risk to the cattle feeding profit margin that is contributed by costs and revenues, assumptions made in construction of this model may restrict the application of these findings. One fundamental assumption made in this model is to hold input and output quantities constant across time. In equation format, the coefficients by which various prices are multiplied do not change over the study's time frame. For example, the input quantity of feeder cattle price in the Feeder Cattle Cost equation (Equation (12)) is 750 lbs. for all calculated feeder cattle costs in the study. Maintaining constant coefficients on price

variables implicitly assumes input and output quantities have not changed and that any changes in relative risks have come solely from price changes.

However, input and output quantities have likely changed from 2002 to 2013 and cattle feeders are facing changes to relative risks from *both* prices and quantities. Because the industry has likely experienced changes in the input quantity demanded (i.e. feeder cattle placement weights or pounds of corn fed per animal) or supplied (heavier fed cattle sale weights) the coefficients on the industry's profit equations have changed over time. For example, in 2002 the average feeder cattle placement weight may have been 725 lbs., and cattle feeders would have calculated feeder cattle costs by multiplying 725 by the feeder cattle price. In 2013, however, the average feeder cattle placement weight may be 775 lbs. and cattle feeders would calculate feeder cattle costs by multiplying 775 by the feeder cattle price. Further assuming that the feeder cattle price has stayed constant over 2002 to 2013, cattle feeders would still face increased relative risk of feeder cattle costs in 2013 as a \$1 change in feeder cattle price would create a larger impact on costs when multiplied by a 775 lb. placement weight than a 725 lb. placement weight.

A second caveat to the results of this study is that cattle performance variables are assumed to have stayed constant across time. The performance distributions used in this study are taken from Belasco, et al. (2009) who used pen-level data from 1995-2004. It is likely that the means and variances of cattle performance variables were changing during this time and have continued to change since. This study does not reflect these changes in cattle efficiency or production and likely underestimates the production efficiency of feedlot cattle.

As noted earlier, such changes in input or output quantities are not reflected in this model. These quantities were held constant to simplify the model and to isolate the effects of changes in market prices and volatilities over time. Furthermore, it was assumed that cattle performance variables have remained constant since 2002. Due to these assumptions it is difficult to make inferences on relative risk changes in the industry or to improve risk management strategy recommendations. Cattle feeders should make changes to risk management strategies based on actual changes to their input and output quantities. The incorporation of changing input and output quantities is an excellent starting point for future research.

## **5.4 - Changes in Cattle Feeding Risk**

The primary purpose of this study is to examine how the risk of financial profit has changed in the cattle feeding industry over time. While analysis of realized and expected returns is highly valuable, analysis of the associated variability of cattle feeding returns is equally important. Variability of returns may have several important implications for cattle feeders and investors. If negative returns to placing cattle on feed are expected but those returns are less volatile than other investment opportunities (say the stock market during the recent financial crisis), then it may be rational to place cattle on feed when negative profit expectations exist. Additionally, if the expected profit risk from placing cattle on feed has increased, it may signal feedlot managers to take more aggressive risk management measures.

In this model, the variance of profit is the same as the variance of returns above variable costs. This occurs because fixed costs (a component of profit and not of returns above variable costs) are incorporated as a fixed value. Because there is no distribution associated with fixed costs, adding fixed costs to the variable cost distribution does not change the shape (e.g., variance) of the cost distribution. Therefore, conclusions from analysis of variance of profits can be applied directly to the variance of returns above variable costs.

To analyze changes in cattle feeding profit risk, the variance of expected profits was calculated for each week of simulated expected profits. Summary statistics for the standard deviation of expected profits are shown in Table 5-6. The average standard deviation (the measure of ‘risk’ or variability in expected profits) was \$105.76/hd. over the eleven year study. The standard deviation of expected profits ranged from \$58.90 to \$188.69.

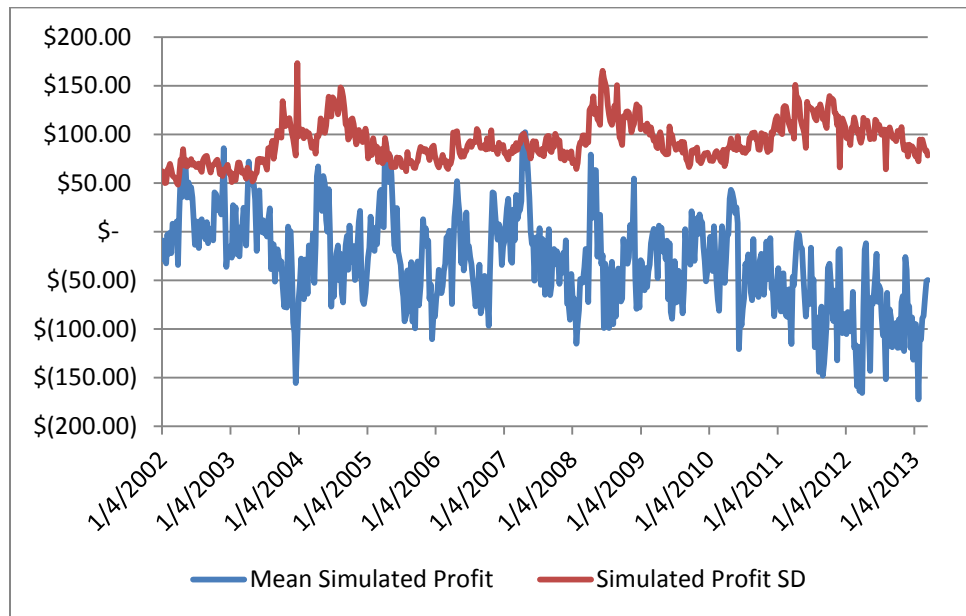
**Table 5-6: Summary Statistics for Standard Deviation of Expected Kansas Feedlot Profits, 1/2/2002 - 3/15/2013**

Mean	105.76
SD	24.61
COV	0.23
Min	58.90
Max	188.69

Three noticeable increases in standard deviation are present in Figure 5-19. It is likely that the first two (occurring at 12/26/2003 and 6/6/2008) were respectively caused by the 2003 BSE outbreak in the US and by a highly volatile grains market in the summer of 2008 (which was likely compounded by the financial crisis which occurred during 2008 and 2009). The third increase in the standard deviation of expected returns during April, 2011 does not correspond with any known market event and is likely a function of higher than normal live cattle implied volatilities. Live cattle prices were beginning a steady uptrend during this time and it is likely that options markets increased premiums (and, therefore, implied volatilities) due to market uncertainty.

Visually, it appears that there has been a general increase in cattle feeding profit standard deviation over the past eleven years. Indeed, a linear regression of the standard deviation of cattle feeding profits upon a weekly, linear time trend yielded a significant, positive time trend coefficient (results of this Variance/Time Trend model are presented in Table 5-7 ). The regression coefficient suggests that for each week in the sample period, the standard deviation of cattle feeding profits increased by 0.069 \$/hd.

**Figure 5-19: Mean and Standard Deviation of Simulated Expected Kansas Cattle Feeding Profits 1/2/2002 – 3/15/2013**



**Table 5-7: Results for Variance/Time Trend Model**

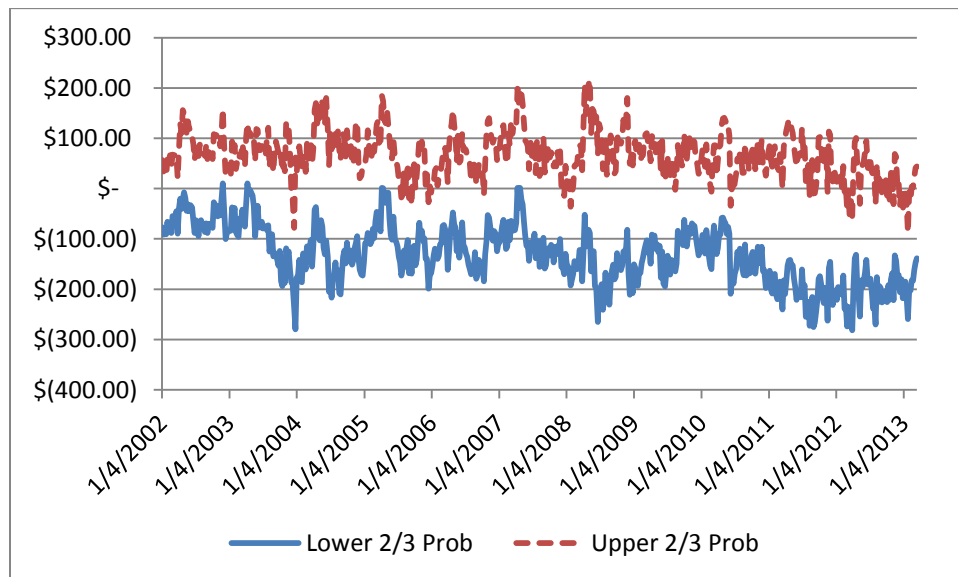
Model:	Y =	$\alpha$	+	$\beta_1$ *Time
	Coefficient	85.28***		0.0698***
	SE	1.788		0.00529
	R <sup>2</sup>	0.403		
	F	113.08		

Where: Y= standard deviation of cattle feeding profits and T= weekly time trend  
 \*\*\* indicates significance at the 1% level

The coefficient of variation was not calculated as dividing the standard deviation by very small expected profits (say, \$0.33/hd.) created extremely high and low COV figures and made interpretation of long-run trends difficult. Accordingly, the 2/3 probability of expected feedlot returns is analyzed as an additional measure of risk. The upper and lower 2/3 probability values (values of the simulated expected profit distribution at the 17<sup>th</sup> and 83<sup>rd</sup> percentile, respectively) are graphed in Figure 5-20. The results show significant variability from 2002 to 2013 and the general trend appears to be towards more negative expected profits. Indeed, linear regressions of the Upper and Lower 2/3 probability values on a linear, weekly time trend were both negative and significant at the 1% level (see Table A-3 and Table A-4 in Appendix A).

The regression results indicate the upper 2/3 probability limit is decreasing at a slower rate than the lower 2/3 probability limit, indicating an increase in the range of expected profits. This increasing range (the difference between the upper and lower 2/3 of the expected profit distribution would indicate the presence of increasing expected profit risk in cattle feeding. To confirm this finding, the 2/3 probability range (the difference between the 83<sup>rd</sup> percentile value and the 17<sup>th</sup> percentile value for expected feedlot profits) was regressed on a linear, weekly time trend. The results of this model are shown in Table 5-8. The regression coefficient on the time trend variable was positive and significant at the 1% level, indicating that the 2/3 probability range of expected cattle feeding profits has increased over time.

**Figure 5-20: 2/3 Probability Range of Expected Kansas Feedlot Profits (\$/hd.), 1/2/2002 - 3/15/2013**



**Table 5-8: Results of Linear Regression of 2/3 Probability Range of Expected Kansas Cattle Feeding Profits on Weekly Time Trend, 1/2/2002 - 3/1/2013**

Model:	Y =	$\alpha$	+	$\beta_1$ *Time
	Coefficient	161.06***		0.13***
	SE	3.26		0.00965
	R <sup>2</sup>	0.237		
	F	181.6		
Where: Y= 2/3 probability range of expected cattle feeding profits and T= weekly time trend				
*** indicates significance at the 1% level				

Practically, the results of the regressions in Table 5-7 and Table 5-8 indicate that cattle feeding has become ‘riskier’ (returns are more variable) over time. This could signal that cattle feeders should consider additional risk management strategies to mitigate the effects of increasing financial risk. It could also provide insight into the behavior of cattle feeders that place cattle on feed when negative profits are expected.

#### ***5.4.1 – Risk and Utility in Cattle Feeding***

If cattle feeders are continuing to place cattle on feed during both negative and increasingly ‘risky’ expected profits, three rationales are possible. The first is that cattle feeders are unaware of the increasing risk in their industry and do not use expected profits at placement time to guide placement decisions. Secondly, cattle feeders may believe market biases or inefficiencies exist or that price fluctuations following placement of cattle on feed will allow for profitable hedging opportunities. The third is that cattle feeders do not follow the risk-neutral assumptions of neo-classical economics. A brief discussion of these possibilities follows.

The hypothesis that cattle feeders are unaware of the increasing risk in feedlot profits seems unlikely to be true. There currently exists a wide array of extension publications on the subject, an abundant availability of market data, and even news articles on volatility and prices. Many universities with Agricultural Economics programs frequently publish estimates of cattle feeding returns and prices relevant to cattle feeders. A plethora of magazines and news articles also discuss cattle feeding, the overall beef industry, and commodity prices. If cattle feeders simply do not trust these information sources, there are a number of businesses which provide market analysis and price forecasting (Informa Economics and Cattle-Fax, to mention two).

Thus, to say in this ‘information age’ that cattle feeders are ill-informed seems presumptuous and erroneous.

Perhaps, then, cattle feeders use a different metric than expected profits to guide placement decisions. Kastens and Schroeder (1994) revealed feeder cattle placements were more significantly influenced by past profits than by expected profits. While this theory begins to explain cattle placements during stormy market conditions, it does not explain why cattle feeders are, in 2013, still placing cattle on feed after nearly two years of negative expected (and estimated) profits. It appears, then, cattle feeders use neither expected nor past realized profits as sole basis to justify placing cattle on feed.

A possible justification for placing cattle on feed under risky and negative expected profits could lie in perceptions of high returns to cattle feeding. Perceptions of higher returns may exist if cattle feeders believe futures markets are biased (as noted by Kastens and Schroeder, 1994) or if expected profit distributions are positively skewed. Beliefs of market bias contradict the efficient market hypothesis and only few academic studies have found sufficient bias as to generate returns to trading. It is possible that expected profits are right-skewed and cattle feeders face a higher probability of higher-than-expected profits than lower-than-expected profits. However, this study is ill-equipped to perform such an analysis and this topic is left to further research.

While long-term bias in futures markets has never been clearly, empirically proven (and, indeed, the Efficient Market Hypothesis states that bias should not exist) a similar thought may explain feedlot placements during negative expected profits. When making placement decisions, cattle feeders may compare the current live cattle price (and possibly the current feeder cattle and corn prices) to their projected breakeven live cattle price. The breakeven price is the price at which cattle feeders will exactly cover costs and not incur profit (where total revenue equals total costs). If the current cattle price is close to the expected breakeven price, cattle feeders may place cattle on feed in hopes that subsequent market movements will push prices to the breakeven price or higher. These thoughts may especially persist if cattle feeders perceive futures markets to be wildly fluctuating. If cattle feeders hold such a view, they may believe future market fluctuations will cause the futures price, at least temporarily, to rise above the breakeven price, thereby allowing for profit hedging opportunities. However, if such a belief is common, it does not explain why cattle feeders seldom hedge profits using futures market contracts.

The analysis of breakeven live cattle prices performed in section 5.3.3 of this study offers support for the rationality of small price fluctuations following placement to provide hedging opportunities. The pre-2011 difference between the expected Kansas cash live cattle price at marketing time and the expected cash breakeven price for Kansas feedlots was less than \$2/cwt. on average. Thus, cattle feeders may have once expected small price fluctuations (less than \$2/cwt.) to provide hedging opportunities. However, since 2011, the difference between the two prices has increased to over \$6/cwt. on average, implying that cattle feeder employing such strategies must believe in more volatile markets (provide wider price swings) or more inefficient markets. As noted earlier, however, such beliefs contradict the Efficient Market Hypothesis (Fama, 1970) and ignore the reality that futures prices are equally likely to move up or down. Thus, strategies of waiting to ‘time’ the market and hedge profits still appear irrational and insufficient to justify placing cattle on feed when negative profits are expected.

If cattle feeders are likely informed on the condition of their industry and do not utilize two proposed methods to guide placement decisions, perhaps the explanation to placing cattle on feed when economic shut down conditions should prevail (i.e., cattle feeders cannot expect to cover variable costs) lies in their risk preference. Neo-classical microeconomics is largely built upon the theory that people are risk-averse and they maximize utility by minimizing risk exposure. In this framework, risk is a negative good in a person’s utility function.

Since, as it has been shown, cattle feeders do not appear to minimize risk then they must have a different utility function. Such a utility function could exist where risk is a positive input into cattle feeders’ utility functions and where cattle feeders would increase their utility by accepting more risk. Cattle feeders may gain more utility from strategies leaving perceived ‘upside’ potential in place (i.e., not hedging) than mitigating ‘downside’ risk. This would explain their infrequent use of options and hedging instruments (Kastens and Schroeder, 2004) as the possibility of high returns would still exist (as opposed to hedging strategies, which offer less risky but lower returns). The historic riskiness of cattle feeding may draw more risk-loving individuals to the industry, thereby influencing the manner in which risk is mitigated or entered into.

Finally, it is possible cattle feeders’ have non-monetary variables included in their utility functions. Cattle feeders may gain utility from looking out the window at pens of cattle and from maintaining their reputation as a ‘cattle feeder’. Human attitudes may also prevail, such as a

personal pride in maintaining a full feedyard even when calf prices are high. Taking risks may even be promoted and esteemed in social interactions, and cattle feeders who ‘bet the farm’ and turned a profit may be more highly regarded than their more risk-averse counterparts. While such attitudes are likely influences on cattle feeder behavior, they are extremely difficult to quantify. Thus, incorporation of social values and personal risk preferences is left for future research.

## **5.5 - Standardizing Risk Metrics**

To this point in this analysis the focus has been on analyzing the standard deviation of expected cattle feeding profits as a measure of risk. Creating time-series graphs of changing risks in cattle feeding provides useful risk measurement and allows for comparison to previous time periods. However, the unit-dependent nature of standard deviation measure may be confusing to some producers. In effort to create a simple, easy-to-understand measurement of expected risk in cattle feeding, the expected variance of feedlot profits has been normalized into a risk index. The end goal of this effort is to provide a risk measure than can be summarized in a ‘X % more or less risky than a previous time period’ format.

The index presented here was created by dividing the observations in the dataset by a specified base. Two index bases are explored in this study, using the observations for January 2, 2002 (the start of this dataset) and a rolling 6-month average of the variable in question. The first method, indexing to a specific date provides an easily interpretable number which measures the subsequent changes that have occurred (in percentage terms) since the specific date. The Consumer Price Index, a commonly used measure of inflation in the U.S. economy, is created using such a format. The second option, indexing against a rolling 6-month average provides a current context for risk estimates and excludes potentially irrelevant historic data.

January 2, 2002 was chosen as the base date for the first index for several reasons. First, 2002 was likely one of the last “normal” years in cattle feeding. Known market shocks occurred during the 2003 BSE event which increased risk levels. Following BSE, the 2005 RFS introduced shocks to the grains markets (which likely appeared in 2007 or 2008), again increasing cattle feeding risks. These two events are important to cattle feeding profit margins and a comparison again “how things used to be” is germane. The second reason is that many current feedlot managers were likely starting their careers in the late 1990’s and early 2000’s and this index base may have an intuitive appeal of comparing current risks to the risks present when

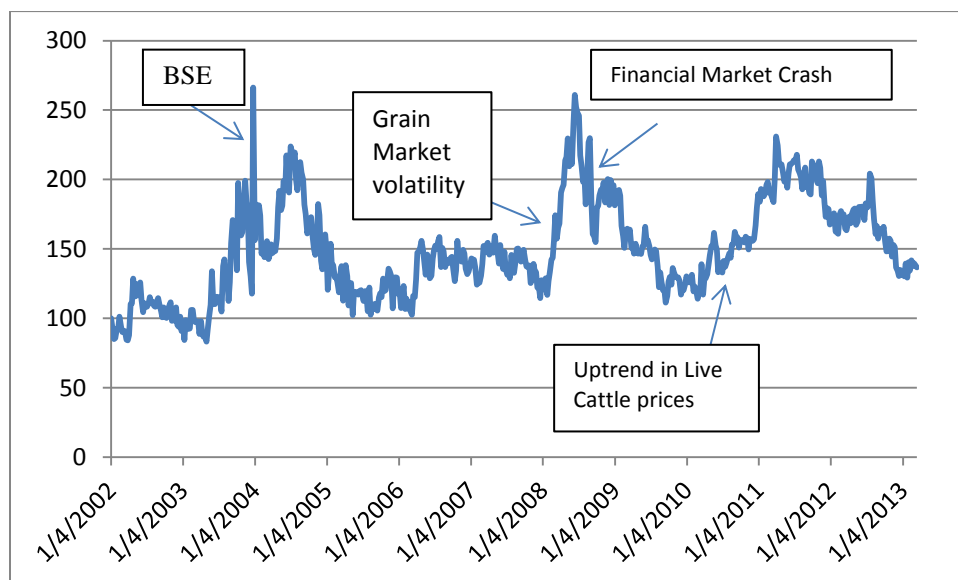
they began their careers. Additionally, the cattle performance variable distributions used in this study were developed from a dataset spanning the years 1995 to 2004. Thus, indexing to 2002 is consistent with the variability in cattle performance estimated during that time.

Both indexes (with bases January 2, 2002 and a rolling 6-month average, respectively) are calculated for two potentially useful risk measures, the standard deviation of expected profits and the 2/3 probability range of expected profits. Both risk measures are used as the standard deviation of expected profits provides a clear, simple measure but does not reflect differences in upside or downside risk. The 2/3 probability measure provides such analysis and is incorporated accordingly.

### ***5.5.1 - Index of Standard Deviation of Expected Profits***

The index of standard deviation of expected profits using January 2, 2002 as the base week is shown in Figure 5-21. The graph shows a clear increase in the risk of expected cattle feeding profits and indicates risk levels on 3/15/2013 were 36% higher than at the start of 2002. The same patterns are found in this graph as in others (i.e., extreme volatility during the 2003 BSE event, the 2008 grains market volatility, 2008-9 financial market crash, and the 2010 uptrend in live cattle prices) but are presented in, perhaps, clearer terms.

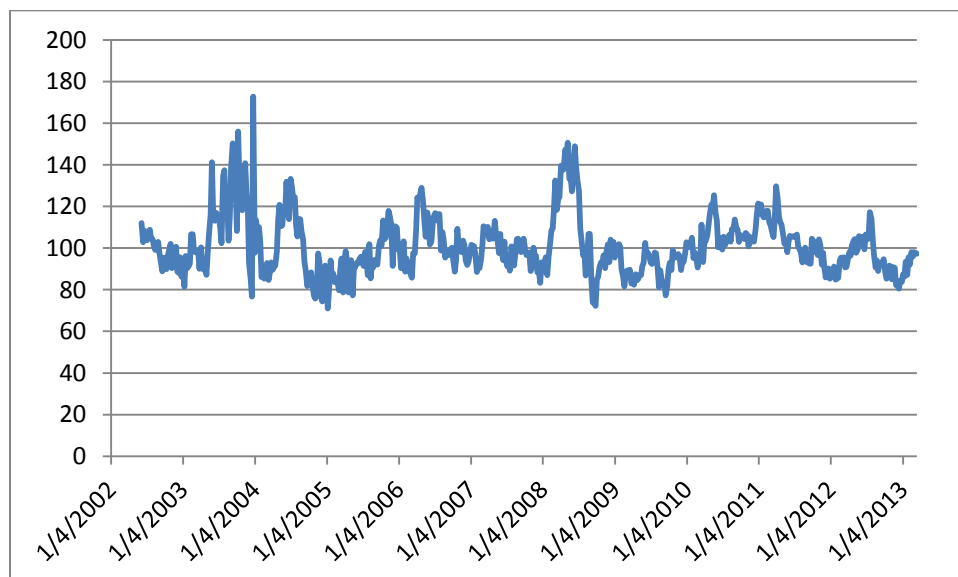
**Figure 5-21: Index of Standard Deviation of Expected Kansas Feedlot Profits, January 2, 2002 base, 1/2/2002 - 3/15/2013**



The indexed standard deviation shows that risk has been increasing since 2002. However, current risks are less than those estimated during the BSE event, the 2008 grain market volatility, 2008-2009 financial market crash, and the uptrend in live cattle prices seen from 2010 to 2012. Thus, current risks are between the index base period and the extreme values caused by significant market shocks.

The standard deviation of expected feedlot profits was also indexed using a rolling 6-month average as the base time frame. This provides interpretation that current risks are above or below a recent and easily recalled period. The graph of this index is shown in Figure 5-22. The 6-month rolling average base index shows significantly different results than the index using a fixed-date base. The figure shows marked changes in risk, again reflecting the 2003 BSE event and the 2008 grains market volatility and results swing above and below 100% (indicating more and less risky periods). This occurs because, following periods of high market volatility, the 6-month lagged variance estimate remains high while current risks appear less. It must be stressed that values below 100% do not reflect the absence of risk, only that current risks are less than the previous six months' risks.

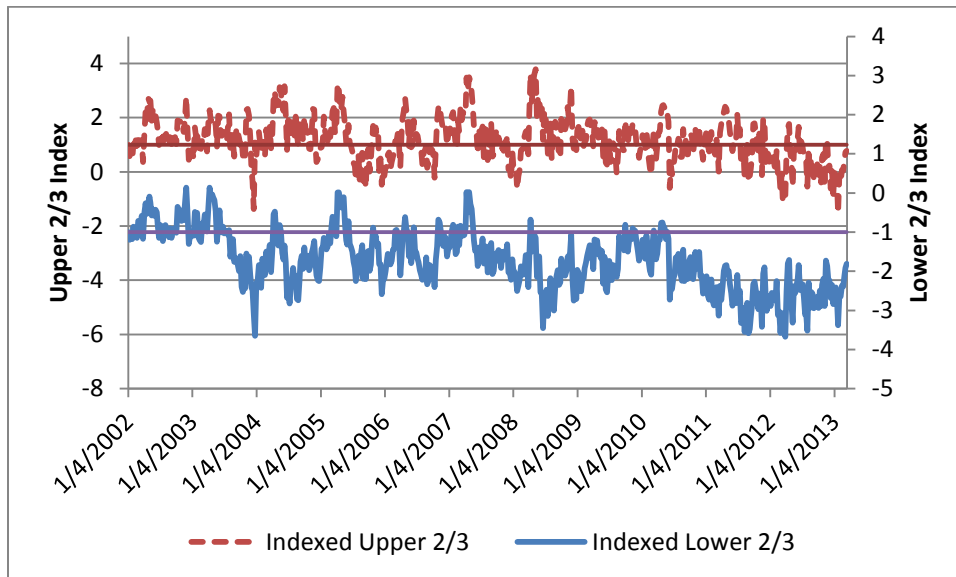
**Figure 5-22: Indexed Standard Deviation of Expected Kansas Feedlot Profits, rolling 6-month average as base time period, 6/7/2002 -3/15-2013**



### 5.5.2 – Index of 2/3 Probability Range of Expected Feedlot Profits

The upper and lower 2/3 probability values, indexed to the base date of January 2, 2002, are shown in Figure 5-23. The analysis shows that the risk in cattle feeding, both upside potential and downside risk have increased since 2002. Recently, the lower 2/3 probability value appears to be holding steady near 2 while the upper 2/3 value is decreasing. This indicates that the overall risk in cattle feeding is moderating, but this is coming due to limited upside potential. The range between the 83<sup>rd</sup> percentile and the 17<sup>th</sup> percentile (i.e., the 2/3 probability of expected profits) is shown in Figure 5-24. This provides a clearer measure of the distance between the upper and lower 2/3 values and illustrates the overall increase in the risk of expected cattle feeding profits.

**Figure 5-23: Indexed Upper and Lower 2/3 Probability Values of Expected Kansas Cattle Feeding Profits, 1/2/2002 Base date, 1/2/2002-3/15/2013**



**Figure 5-24: 2/3 Probability Range of Expected Kansas Cattle Feeding Profits, 1/2/2002 - 3/15/2013**

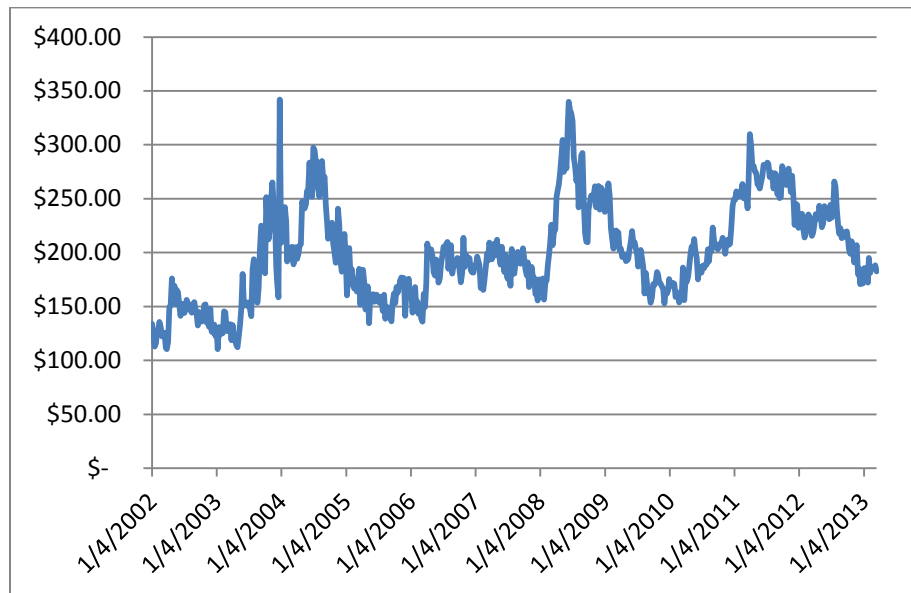
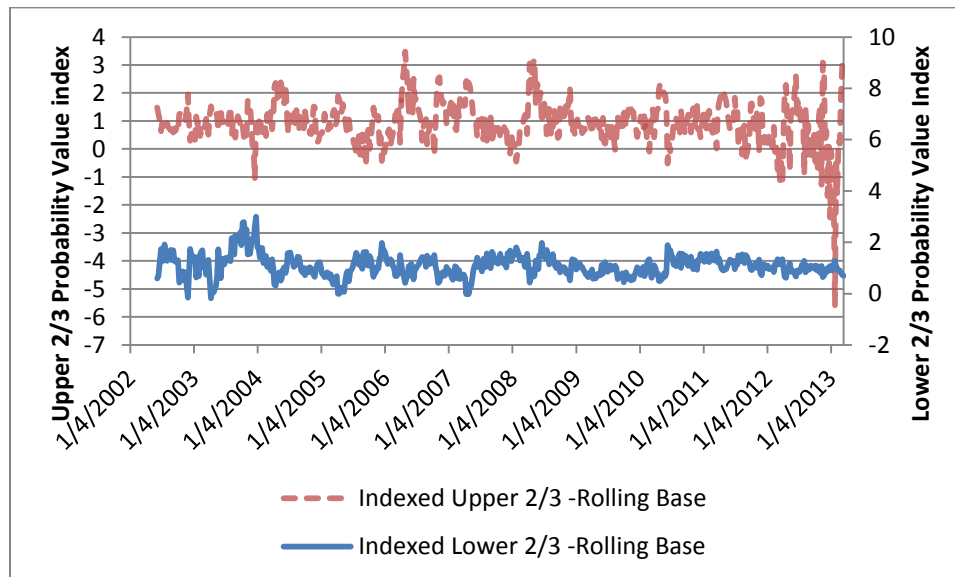


Figure 5-25 shows the results of the upper and lower 2/3 probability values of expected cattle feeding profits as indexed using a rolling 6-month average of the upper and lower probability values, respectively. As noted with the use of COV to analyze expected profits, periods of time where the denominator of the index (the rolling 6-month average of the upper or lower 2/3 probability value) is very small (0.03, as in the case of the 6-month average of the upper 2/3 probability value which occurred at 3/8/2013) creates wildly swinging index values. Thus, this approach may overstate the volatility and risk present in the cattle feeding industry. However, the chart shows overall higher levels of volatility and risk in the upper 2/3 probability values than the lower 2/3 values. This would imply cattle feeders are facing somewhat steady downside risk but highly volatile upside potential in profits. This could offer explanations for cattle feeders placing cattle on feed during negative expected profits. They may see no significant difference in expected losses than before and feel “safe” placing cattle on feed. This is, of course, a relative measure of risk and with high feed and cattle prices, cattle feeders have more money “on the line” than ever before.

**Figure 5-25: Indexed 2/3 Probability Range of Expected Kansas Cattle Feeding Profits, rolling 6-month average Base Period, 6/7/2002 -3/15-2013**



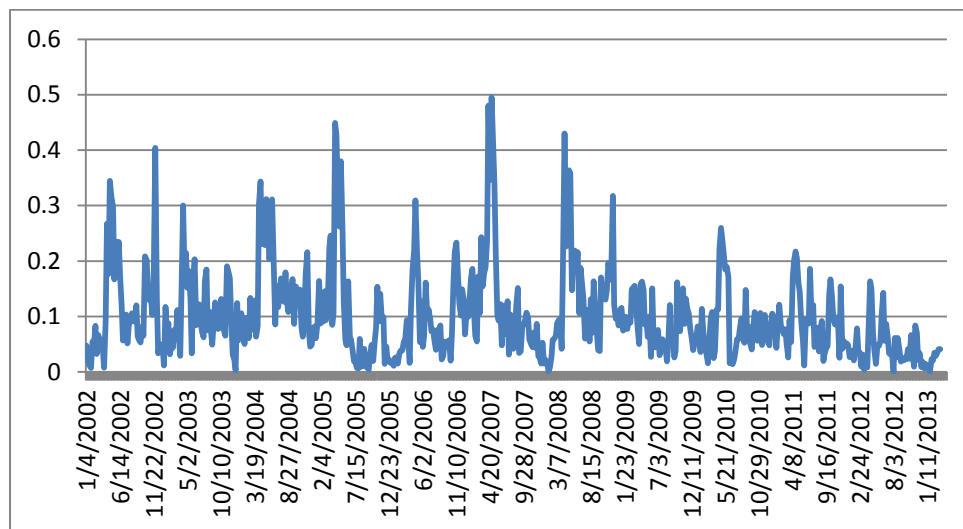
The goal of providing this indexed analysis of the standard deviation of expected profits is to streamline the risk analysis process. For producer groups, it is unlikely that highly complicated statistical methods will provide a coherent, simple tool by which relative risk can be gauged. By creating this indexed risk measure, the goal is to have a single number that can be made available to producers to compare the current expected profit risk against historic levels. If the indexed standard deviation of expected profit was 1.25, for example, then extension economists (or others disseminating this information to producers) could say “For placements of cattle on feed in the coming week, the expected risk of profit is 1.25 times the risk in January, 2002 (or the previous 6 months, depending on the index used).” Such an analysis would likely resonate well with producers and avoid the confusion sometimes associated with complicated statistics.

### ***5.5.3 – Probability of Expected Profits of \$100 and \$-100***

In the search for a risk measure acceptable to participants in the cattle feeding industry, two final measures are presented. The expected probability that cattle feeders will receive per-head profits greater or less than \$100 and \$-100 are examined. These probabilities are presented as concise measures of both upside and downside risk.

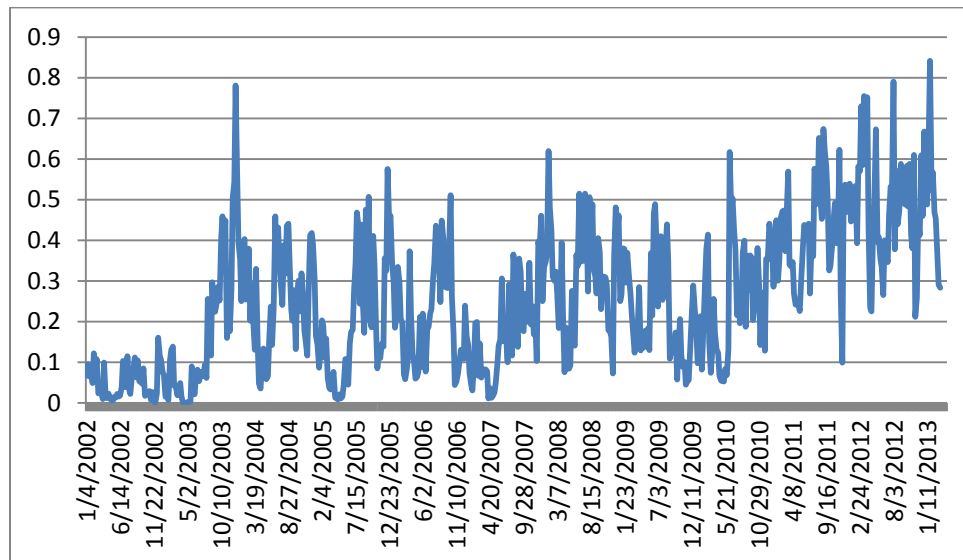
The probability of realized profits over \$100 is presented in Figure 5-26. The figure shows, prior to 2008, cattle feeders frequently experienced periods where the probability of realizing \$100/hd. profits was greater than 25%. However, these probabilities levels have fall dramatically in recent times and cattle feeders currently face a 2% probability of market conditions at fed cattle marketing being such that \$100/hd. profits would be realized. This offers further support that cattle feeders placing cattle on feed face increasingly poor odds of realizing significant profits.

**Figure 5-26: Probability that Kansas Cattle Feedlots will Realize Profits greater than \$100/hd., 1/2/2002 - 3/15/2013**



Similarly, Figure 5-27 shows the level of downside risk in cattle feeding has significantly increased. In 2002, there was less than a 10% chance of losing over \$100/hd. when feeding cattle. However, these probabilities have changed greatly since 2002 and cattle feeders currently face a 30% chance of losing \$100/hd. The probability of losing \$100/hd. has been increasing significantly since 2009 and appears to have become more volatile.

**Figure 5-27: Probability that Kansas Cattle Feedlots will Realize Losses greater than \$-100/hd., 1/2/2002 - 3/15/2013**



The cumulative value of this section is to show that the risk in feeding cattle has significantly increased over the past decade. This section presents three risk measures which have been created to provide clear, concise, easy-to-understand risk measure to producers. The goal is to provide cattle feeders with tools to understand the probabilistic risks they face and to highlight potential needs for risk management.

## 5.6 - Value-At-Risk Analysis of Cattle Feeding Risk

Value-at-Risk (VAR) analysis has become an increasingly popular method to measure the risk of loss in portfolios. Linsmeier and Pearson (2012) note that VAR is a single number representing a probable loss to a portfolio resulting from ‘normal’ market movements. They go on to define VAR as: “the loss that is expected to be exceeded with a probability of only  $x$  percent during the next  $t$ -day holding period” (pg. 48). In this definition,  $x$  is a specified probability level (say, 5%) and  $t$  is the length of time a position is to be held (for cattle feeding investments, it would be a 150 day feeding period). They also provide an alternative definition which is summarized as VAR is the loss that will likely be exceeded during  $x$  percent of the next  $t$ -length holding periods. Linsmeier and Pearson show that VAR analysis can be performed via three broad methods, historical simulation (using historic market change data), the Delta-Normal approach, and Monte Carlo simulations.

Manfredo and Leuthold (1999) conducted a brief review of VAR use in financial literature and suggested that it had many potential applications for agricultural settings. The note cattle feeding, due to its complex arrangement of input and output prices, offers a unique setting for VAR analysis. They also note that VAR can be used in the examination of multiproduct hedging portfolios.

Manfredo and Leuthold (2001) used VAR to examine the risk to cattle feeders implied by the cattle crush. Their study used several different volatility forecasts, including historic lagged volatility and options implied volatility. Similarly, Tonsor and Schroeder (2011) used VAR violations to analyze the most effective volatility forecast method in their study of joint probability estimations of the cattle feeding margin.

Following Manfredo and Leuthold (2001) and Tonsor and Schroeder (2011) a VAR analysis was conducted for this study. The Monte Carlo approach (as outlined by Linsmeier and Pearson, 2012) was used for this study. Linsmeier and Pearson (2012) outline the steps for Monte Carlo simulation of VAR as: 1) identification of the relevant market factors, 2) determination of the distributions of market factors, 3) simulating hypothetical values of the market factors, 4) ordering the profits and losses from largest to smallest. Once the simulated profits are ordered, the VAR is the loss that is exceeded only 5% of the time.

Applying these steps to this analysis, the identification of market factors was accomplished in the profit function specification. Profits in this model are a function of various commodity prices and cattle performance variables, satisfying step 1. Statistical distributions (step 2 in Monte Carlo VAR studies) have been assumed and simulating values of these distributions was accomplished in building the expected profit distributions. Step 4 from Linsmeier and Pearson (2012) was done automatically in @Risk (the software used for the Monte Carlo simulations) and to find the 5% VAR an @Risk equation was used which returned the expected profit at the 5<sup>th</sup> percentile of the simulated distribution. Because the VAR was calculated directly from the per-head expected profits, the VAR represents the per-head profit below which values are expected only 5% of the time.

### ***5.6.1 VAR Results***

The Summary statistics for the estimated VAR are presented in Table 5-9. The mean VAR was \$-176.07, and the standard deviation of the VAR values was \$65.07. The interpretation

of these figures is somewhat complex, given the nature of this model, and warrants further exploration.

**Table 5-9: Value-at-Risk (5% level) Summary Statistics for Kansas Feedlot Profits (\$/hd.), 1/2/2002 - 3/15/2013**

Mean	-176.07
SD	65.07
COV	-0.37
Min	-361.92
Max	-9.96

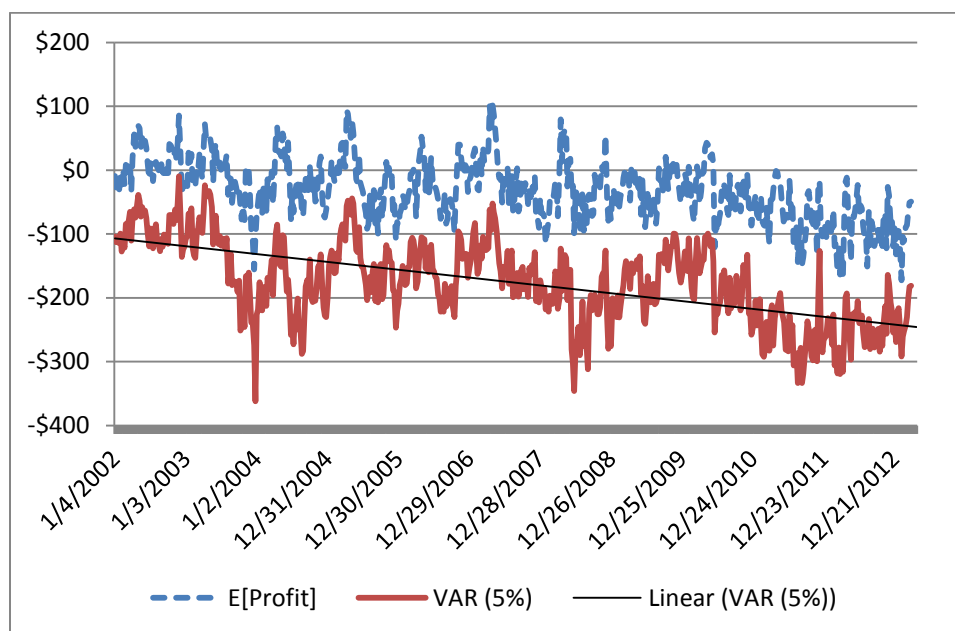
When interpreting the VAR values for this model, it is important to remember that this model forecasts the mean and variance of profits that will occur if cattle are placed on feed in the coming week and sold after a subsequent 150 day feeding period. VAR values are an assessment of the lower tail of an expected distribution of returns to a portfolio and the ‘value-at-risk’ is the financial loss that is expected to be exceeded only  $x$  percent of the time (Linsmeier & Pearson, 2000). When applied to this model of expected cattle feeding profits, the VAR is the *negative expected returns to cattle feeding that will be exceeded only 5% of the time*.

The results of this VAR study suggest show the average VAR at \$-176.07. Practically, over the eleven year study, if Kansas cattle feeders placed cattle on feed the week following the model’s estimation, they expected to lose more than \$-176.07/hd. only 5% of the time. The average expected profit over this same time period was \$-31/hd. (see Table 5-2). Combining these two numbers into a cohesive interpretation it can be said that, over the past eleven years, Kansas cattle feeders faced, on average, expected profits of \$-31/hd. and could expect to realize profits less than \$-176.07 5% of the time.

Figure 5-28 shows how the VAR for Kansas feedlots has changed over time. The VAR has seen several significantly negative periods, corresponding to the U.S. BSE outbreak and increased volatility in the U.S. grains complex. In mid-2011, Kansas feedlot VAR experienced another significant drop in value but has since moderated. Indeed, the VAR has been on a steady uptrend since 2011. This indicates that while expected feedlot profits are still negative (expected to be \$-49.57 for placement during the week of 3/15/2013) the relative risk faced by feedlots has decreased. However, results from a regression of the VAR on a linear time trend indicate that,

over the whole dataset, the VAR has been decreasing (becoming more negative) at the rate of \$0.24/week (see Table 5-10).

**Figure 5-28: Expected Profit and Value-at-Risk (5% level) of Expected Profits for Kansas Feedlots 1/2/2002 - 3/15/2013**



**Table 5-10: Linear Regression of Value-at-Risk of Kansas Cattle Feeding Profits**

Model:	Y =	$\alpha$	+	$\beta_1$ *Time
	Coefficient	-106.85***		-0.236***
	SE	4.275		0.0126
	R <sup>2</sup>	0.376		
	F	350.03		
Where: Y= VAR (5% level)of expected cattle feeding profits and T= weekly time trend				
*** indicates significance at the 1% level				

Again, the purpose behind estimating the VAR is to provide a single number which captures, to the extent possible, the per-head profit risk of placing cattle on feed. VAR has been widely used in the financial literature (according to Linsmeier and Pearson, 2000, and Manfredo and Leuthold, 2003) and is gaining rapid popularity for its ability to summarize the risk of loss associated with holding a portfolio for a given time period. Given its acceptance into the financial industry, it is likely that it may soon become an accepted measure of risk in agriculture.

The advantage of VAR is it provides a simple summary of potential losses and can be easily presented to producer groups. This study aims to provide analysis which will aid cattle feeders in understanding current risk levels, not only profit expectations. By analyzing the results in a VAR framework, and capturing some of the benefits outlined above, the goal is to improve understanding of financial risks in cattle feeding and aid in producer decision making.

The question of what are the significant factors behind risk in feedlot profits is both an interesting question and a challenge worthy of attempt. However, this study's purpose is to provide a template for analyzing *how* risk in feedlot profits has change and leaves the question of risk in feedlot profits has change and leaves the question of *why* to future research.

## **5.7 - Summary of Chapter 5**

This chapter has provided the results from models simulating the expected returns to cattle feeders that would result if cattle were placed on feed in the coming week. This study found that, over the past eleven years, profits at the time of placement were often negative. The average expected profit was \$-31/hd. over the study's time period and placements in the past two years were done in the face of expected profits ranging as low as \$-171/hd.

This study also examined the expected returns above variable costs as economic theory dictates that firms facing negative returns above fixed plus variable costs can still remain operation if they can expect to cover fixed costs. This analysis shows that the average returns above variable costs was \$28, perhaps explaining why feedlots place cattle on feed during times of expected negative profits. However, this analysis also shows expected negative returns above variable costs for the majority of the past two years, which leaves the question of why cattle are still being placed on feed unanswered.

The risk of expected profits over time was also analyzed. The results of this study show that cattle feeding profit risk has been somewhat cyclical, with approximately three 'peaks' in risk. Current risk levels, despite significantly negative projected profits, have decreased over the past two years (see Figure 5-21). The profit risk of placing cattle on feed was also analyzed to provide a simple risk metric which can be made available to producers. Producers currently face significant probabilities of losing more than \$-100/hd. and face limited upside potential as the probability of realizing profits over \$100/hd. is The results from the VAR analysis also show a reduction in the profit risk faced by Kansas feedlots in the past two years.

## Chapter 6 - Conclusion

Cattle feeding has historically been a risky venture and recent changes to livestock and grains markets and the U.S. cattle industry have likely increased that risk. This study adds to existing literature and cattle feeding profit estimates by including additional variables in cattle feeding profit functions which have been previously omitted and by creating an expected risk index. By including additional variables, the expected profits from this study are likely to be more representative of actual expected profits faced by the industry. Additionally, this study provides a ten year time series analysis of how expected profits risks have changed over time. Thus, comparison of cattle feeding profit risks before the 2003 BSE event to risks following the 2008-2009 financial market crisis is possible. This study also focuses on the drivers of these changing risks which will allow feedlot managers to perhaps adjust their risk management strategies.

This study estimates the expected profit risk of placing cattle on feed during the following week, given current futures prices and options implied volatilities. Futures prices, under the efficient market hypothesis, incorporate all known information and are the more accurate price forecasts available. Similarly, options implied volatilities are the markets' estimate of the future volatility of a commodity. Futures prices and options implied volatilities are frequently used to forecast future prices and the standard deviation around the price forecast, and that approach is applied to this study.

Using weekly futures and options data from 2002 to 2013, this study estimates joint probability distributions for corn, soybean meal, live cattle, and feeder cattle prices. Historic average basis levels for Kansas are used as basis forecasts. These basis forecasts are added to futures price forecasts to create the expected cash price that will be realized by feedlots. These expected price distributions are used, in conjunction with results of cattle production variables published by Belasco et al. (2009), to build probability distributions of expected feedlot profits. Monte Carlo simulation techniques are used to take correlated draws from the joint probability input distributions and estimate the resulting expected profit distributions. Over the study's time period, 585 expected profit distributions are estimated; one expected profit distribution for each week in the study.

The results of this study are intended to provide a macro-level barometer of expected Kansas feedlot profits. As such, they do not reflect the expected profit of any individual cattle feeding operation. It is very likely that individual cattle feeders are more or less economically efficient than the results of this model suggest.

## **6.1 – Empirical Results**

Distributional aspects of the expected profit distributions are used to make inferences about expected Kansas cattle feeding profits and the risk associated with placing cattle on feed. Results from this study indicate significant volatility in the expected profit over the past 11 years. Expected profits per-head ranged from \$102.37 to \$-172.72 while the past two years show nearly constant negative expected profits. The results from this study agree with results from other studies that have estimated expected feedlot profit numbers. Differences in model assumptions regarding historic basis calculations, mortality rates, and other factors explain many of the observed differences between competing forecast models.

Results from this, and other, studies have estimated strongly negative profits for Kansas cattle feeders since 2011. One of the biggest remaining questions from these finding is, why, after extended periods of negative expected (and estimated realized) profits, are cattle still being placed on feed? Economic theory may provide an answer as the classic criteria for a firm to ‘shut down’ is when the firm’s revenues do not exceed variable costs. If revenues do exceed variable costs, firms may defer payments on fixed costs until later, more profitable times. This study estimated the returns above variable costs for Kansas cattle feeders and found that, prior to 2011, cattle feeders could most often expect to cover variable costs. Following 2011, however, cattle feeders have expected returns to be less than variable costs and have faced small probabilities of covering their variable costs.

The composition of cattle feeding variable costs has changed over time as well. Feeder cattle costs as a percent of variable costs have decreased over the study’s time frame while feed costs have become much larger portion of variable costs. At the beginning of the study, feed costs accounted for approximately 20% of variable costs and by 2013 they accounted for nearly 30% of variable costs. Because feed costs are becoming a larger component of variable costs, increased risk in feedstuffs markets will increase the overall risk faced by cattle feeders. This study shows the risk of feedstuffs prices has significantly increased over the study time period.

Therefore, it appears cattle feeders are spending more money on feedstuffs; a production input which has become increasingly risky in its price. This may signal the need for additional strategies to aid cattle feeders in managing feedstuffs price risk. Although feedstuffs prices have become ‘riskier’, the price risks associated with feeder cattle and live cattle were not significantly increasing over the dataset.

This study also confirmed the results of other studies which have shown the increasing importance of corn prices in determining cattle feeding profits. A sensitivity analysis of expected profits was conducted and input variables were ranked by the magnitude of the normalized regression coefficient. The sensitivity analysis showed live cattle prices to always be the most important variable influencing expected feedlot profits. Feeder cattle costs were most frequently ranked as the second most important variable and ADG was most often the third ranked variable before 2007. However, following 2007 when structural changes began to appear in the grains markets, corn prices are playing a far greater role in determining expected feedlot profits. Since 2007, corn prices are most frequently ranked as the third most influential variable and are often the second most important variable.

Finding that corn is playing an increasingly important role in determining feedlot profits is not a particularly surprising finding; academic and industry-level researchers have both noted the impacts of increasing corn prices on feedlot profits. However, this study provides insight into the magnitude of these changes and begins to quantify the nature of changing profit risks for cattle feeders. Given these results, it appears cattle feedlot managers should consider additional risk management efforts for feed and grain prices.

The expected variance of expected feedlot profits was also estimated. The variance of expected profits is the primary measure of ‘risk’ used in this study. Expected profit risk has followed a slightly cyclical pattern and is influenced by changes in options implied volatilities resulting from the 2003 Bovine Spongiform Encephalopathy outbreak in the U.S. and by increased volatility in the grains markets. The expected profit risk when cattle are placed on feed has generally been increasing over the study’s time period. However, despite recently negative expected profits, the risk associated with those profit expectations has been decreasing slightly since 2011. The average standard deviation of expected profit risk across the dataset was \$93.32/hd while the standard deviation of expected profits for placements during the week following 3/15/2013 was \$79.81/hd.

In effort to produce a risk metric that can be easily presented to and understood by participants in the cattle industry, two indexed measures of risk were calculated. The standard deviation of expected profits and the upper and lower 2/3 probability values of expected profits were indexed. Two indexes were also used. The first indexed the risk measures back to January, 2, 2002, the beginning of the dataset. The second indexed risk using a 6-months rolling average of each series' values. Both measures provide information useful to cattle feeders in assessing current risks relative to historic levels. The standard deviation of expected profits indexed to January 2, 2002 shows current (3/15/2013) risks at 136% of the January 2, 2002 value.

Also in effort to produce an industry-level risk assessment tool, the Value-at-Risk (VAR) was calculated for each week in the dataset. VAR has gained wide popularity in financial analysis and is starting to be used in studies of agricultural risks. The VAR provides a single-valued assessment of the downside risk that is likely to occur when holding a portfolio for a given length of time. In application to expected cattle feeding profits, it is the expected loss that will be exceeded only 5% of the time.

The VAR analysis shows, over the eleven year dataset, the average expected negative returns to cattle feeding were \$-226.92. The interpretation is that, on average, cattle feeders placing cattle on feed in the coming week expect negative profits greater than \$-225.92 to occur only 5% of the time. It should be noted that VAR does not provide interpretation on the expected value, only a measure of the expected downside risk. The downside risk faced by cattle feeders appears to be increasing (VAR becoming more negative) based on results from a linear regression of VAR on a weekly time trend. The coefficient on the time trend (Table 5-10) suggests that the VAR increases at the rate of \$-0.177/week. However, the VAR over the past two years has been decreasing (drawing nearer to zero) indicating a reduction in the downside risk of expected cattle feeding profits.

To summarize the results of this study, cattle feeding remains a highly risky business and cattle feeders have recently been placing cattle on feed facing significantly negative expected returns. Though the returns are negative, the level of risk (both downside and upside) appears to be moderating. Over the study's time frame, the relative risk to cattle feeding profits accounted for by feed costs has been increasing, while risk levels from feeder cattle and fed cattle prices remain relatively steady.

## **6.2 - Implications**

This study has several practical implications. The first is that results of this study can be used as extension tools to aid cattle feeders in understanding the risk they face when placing cattle on feed. Several of the risk measures in this study have been calculated in such a way as to provide easy interpretation for an industry audience.

The second implication is that it appears that more risk management emphasis should be placed on feedstuffs prices. Feedstuff prices are increasing in risk relative to fed cattle and feeder cattle prices and appropriate risk management strategies should be adopted by cattle feeders. Additionally, the importance of corn prices in determining expected cattle feeding profits has been increasing since 2002. However, this study assumes constant placement weights, sale weights that vary only by season (and do not show a long run trend), and constant feed input rates. If these variables have changed over time (i.e., if feedlots are using less corn and more soybean meal than is estimated here) assessments of changing relative risks may not be accurate.

A third possible use of this model to analyze the impacts of proposed policy changes on the cattle feeding industry. For example, changes to U.S. ethanol policy that are expected to have supply and demand impacts on grains markets can use this model to identify potential financial gains or losses that would occur in the cattle feeding industry. This tool could, perhaps, be used to analyze proposed agricultural policy changes by providing estimates of how social welfare would change for cattle feeders.

Similarly, this tool could be used to develop an insurance program for cattle producers. By having both financial and production risks incorporated, this study provides a holistic view of the risks expected by cattle feeders at the time of placement. Currently, there are few options available for insurance on livestock. Insurance writers could use this information to develop insurance policies designed to cover one or more of the risk elements modeled in this study.

Finally, this study can be used in determining optimal risk management strategies for cattle feeders. Researchers could, for example, examine the effectiveness of strategies involving hedging in futures markets only compared to strategies involving positions in options markets. Because this study focuses both on expected returns and expected risk, risk management programs can be evaluated by their ability to balance between risk reduction and profit maximization.

### **6.3 – Future Research**

Future research and improve upon this model through many of the avenues discussed in earlier chapters. Some of these areas to potentially improve this research include incorporating changes to cattle performance variables, improving basis forecasting, and finding additional ways to assess model accuracy.

Most significantly the incorporation of basis risk as an element in cattle feeding risk should be considered. Basis risk has a significant effect on cattle feeding profits and adds a layer of risk to the cattle feeding equation. This study holds basis risk constant for three reasons, 1) to simplify the study, 2) to isolate the effects of changing price risks and 3) because there are limited studies examining forecasted basis *variability*. Additional research should develop methods to forecast basis volatility and incorporate it into models examining expected cattle feeding profits.

Future research should also include changes in cattle performance variables. This study assumes variables like ADG have stayed constant since 2002, an assumption which ignores the reality of technological change in the cattle feeding industry (Langemeier, Jones, and Kuhl, 2001; Herrington and Tonsor, forthcoming). Additional research should estimate time-series changes to the means and variances of cattle performance variables (ADG, DMFC, VCPH, and mortality), placement weights, finish weights, and DOF. Furthermore, correlations between performance variables and DOF should be estimated to ensure future expected profit simulations reflect the reality of the interactions between these variables.

Another final area for future research involves the examination of changing correlation structures on expected cattle feeding profits. The correlation structures in this model were estimated over a time period when significant structural changes occurred in the cattle feeding industry. Examination of when these structural changes occurred and how correlation between variables changed as a result would provide highly valuable information.

### **6.4 - Summary**

Cattle feeders have historically faced high levels of risk associated with returns on production. While this fact is not likely to change in the near future, the goal of this research is to provide information on expected profits and risks at the time of placement to better guide producers through placement and risk management decisions. By providing summary measures

of profit risk, this research attempts to further understanding of the levels and sources of expected profit risk feedlots assume when cattle are placed. Perhaps this increased understanding will aid risk management decisions and increase the stability and profitability of the cattle feeding industry.

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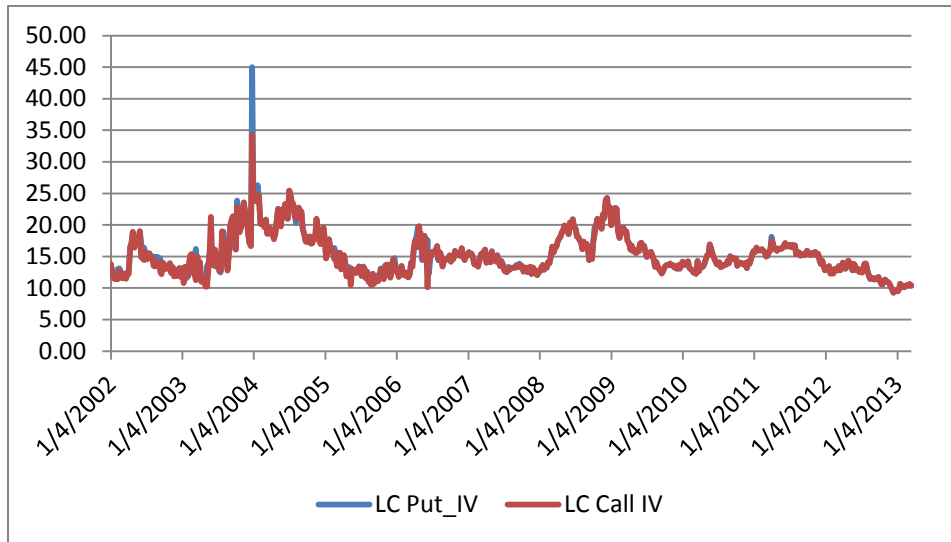
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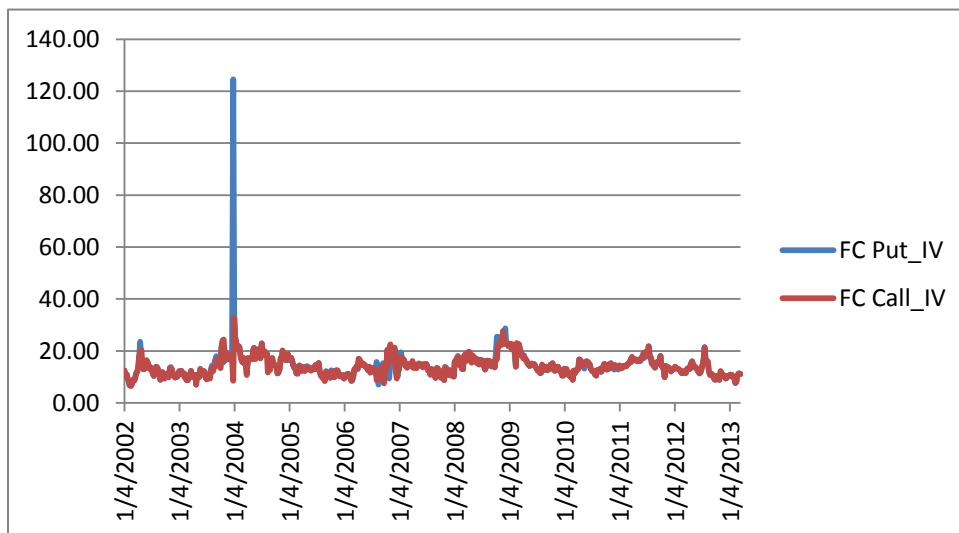
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## Appendix A - Supplementary Tables and Graphs

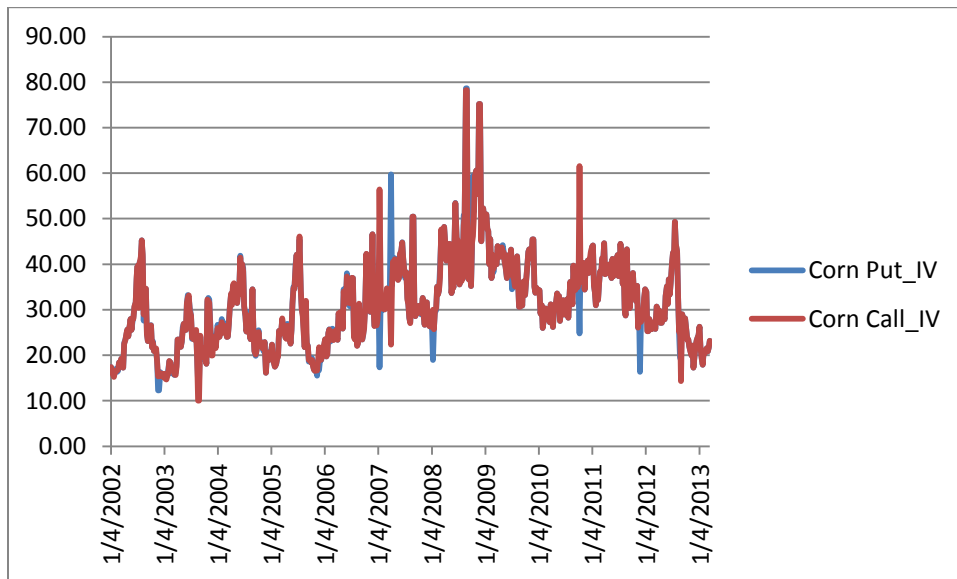
**Figure A-1: Live Cattle Put and Call Implied Volatilities 1/2/2002 - 3/15/2013**



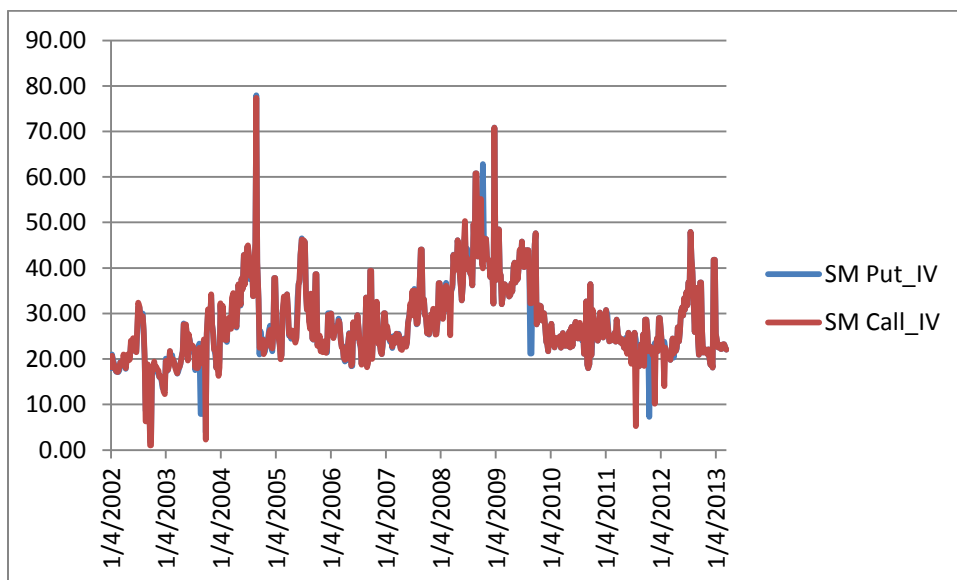
**Figure A-2: Feeder Cattle Put and Call Implied Volatilities 1/2/2002 - 3/15/2013**



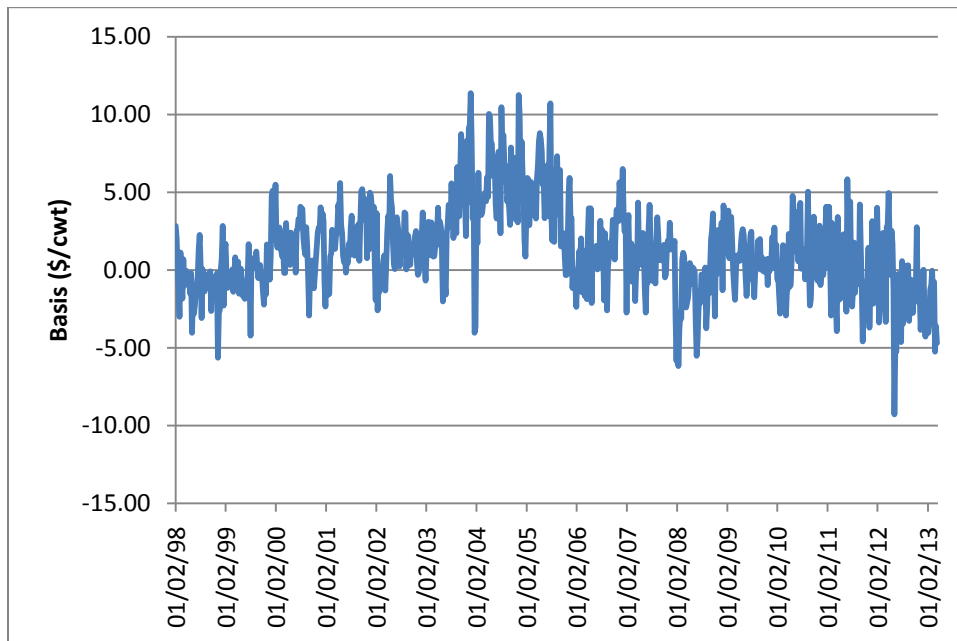
**Figure A-3: Corn Implied Put and Call Volatilities 1/2/200 - 3/15/2013**



**Figure A-4: Soybean Meal Put and Call Implied Volatilities 1/2/2002 - 3/15/2013**



**Figure A-5: Oklahoma City Medium No. 1 Feeder Steer basis, 1/2/1998-3/15/2013**



**Table A-1: Results from linear regression of the COV of Expected Feed Costs on a weekly Time Trend for the period 1/2/2002-3/13/2013**

Model:	Y =	$\alpha$	+	$\beta_1$ *Time
	Coefficient	0.1517		0.000077***
	SE	0.0023		0.000007***
	R <sup>2</sup>	0.179		
	F	127.25		
Where: Y= COV of Expected Feed Costs and T= weekly time trend				
*** indicates significance at the 1% level				

**Table A-2: Results from linear regression of the COV of Expected Total Revenue on a weekly Time Trend for 1/2/2002 - 3/15/2013**

Model:	Y =	$\alpha$	+	$\beta_1$ *Time
	Coefficient	0.1169***		-0.0000257***
	SE	0.00165		0.0000049
	R <sup>2</sup>	0.045		
	F	27.62		

Where: Y= COV of Expected Total Revenue and T= weekly time trend  
 \*\*\* indicates significance at the 1% level.

**Table A-3: Results from linear regression of the Lower 2/3 Probability Value of Expected Kansas Feedlot Profits on a weekly Time Trend for 1/2/2002 -3/15/2013**

Model:	Y =	$\alpha$	+	$\beta_1$ *Time
	Coefficient	-69.56***		-0.214***
	SE	3.809		0.0113
	R <sup>2</sup>	0.382		
	F	359.68		

Where: Y= Lower 2/3 Probability Value of expected profits and T= weekly time trend  
 \*\*\* indicates significance at the 1% level.

**Table A-4: Results from linear regression of the Upper 2/3 Probability Value of Expected Kansas Feedlot Profits on a weekly Time Trend for 1/2/2002 - 3/15/2013**

Model:	Y =	$\alpha$	+	$\beta_1$ *Time
	Coefficient	91.73***		-0.0842***
	SE	3.725		0.011
	R <sup>2</sup>	0.091		
	F	58.46		

Where: Y= Upper 2/3 Probability Value of expected profits and T= weekly time trend  
 \*\*\* indicates significance at the 1% level.

## Appendix B - Conversion of Normalized Regression Coefficients

The normalized regression coefficients represent the change in the output variable's *standard deviation* that results from a *one standard deviation* in the input variable. To convert these normalized coefficients into absolute regression coefficients (which measure per-unit change effects), the following equation can be used (Palisade Decision Tools, 2013b):

$$(1) \quad a_i = p_i * \sqrt{\frac{\sum y^2}{\sum x^2}}.$$

Where:

$$(2) \quad \sum y^2 = \sum_{j=1}^N Y_j^2 - \frac{1}{N} (\sum_{j=1}^N Y_j)^2, Y_j \text{ are points in the output dataset,}$$

$$(3) \quad \sum x^2 = \sum_{j=1}^N X_{i,j}^2 - \frac{1}{N} (\sum_{j=1}^N X_j)^2, X_j \text{ are the points in the input dataset,}$$

$a_i$  is the absolute regression coefficient, and  $p_i$  is the normalized regression coefficient.