ECONOMIC ANALYSIS OF STRUCTURAL CHANGE IN FEEDLOT CATTLE DEATH LOSS

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Abstract:

Anecdotal evidence suggesting that feedlot cattle death loss is increasing over time has revived a need for further research on death loss in feedlots. Death loss may be related to controllable factors including technology adoption, feed rations, and cattle sourcing, as well as uncontrollable factors such as weather. This dissertation uses information from cattle feeding operations in the Southern Great Plains to understand the situation. The first study implements tests of structural change, including the cumulative sum (CUSUM test), CUSUM of squares test, and Bai and Perron tests, on a basic model of steer death loss rate. The basic model is estimated using a monthly observations where death loss rate is a function of in-weight, days on feed, time trend, and monthly dummies. The results suggest that there is structural change during the period of December 2000 – September 2010, which is also supported by a test of unequal means and variances. The second study use a Tobit model to estimate feedlot death loss rate using pen-level data. A Tobit model is used because not every observed pen has dead cattle which censors the data at zero. In addition to in-weight, pen size, sick head days, and cattle treatments, the results found that cattle source, geographic location, and market source type are important determinants for death loss. In the third study, expected net returns are computed based on a recursive system model for feedlot. The expected net returns take into account the expected death loss rate from the second study. Twelve scenarios for steers with a mix of in-weights, pen sizes, closeout months, and market origins are created. The results suggest that heavier in-weights and country-sourced (directly sourced from ranches) cattle yield greater returns, depending on the closeout months. Net returns for heavier in-weights are also found to be very sensitive to corn price changes.

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CHAPTER I

INTRODUCTION

A common research focus in feedlot economics is price risk in input and output markets. However, another risk that affects feedlot profitability is the death loss (mortality) rate. Though some death loss is expected in cattle feedlot operations, it raises concern among feedlot operators when the degree of death loss is higher than usual. Changes in mortality rates may be attributed to various factors such as weather, animal health management, feed ingredients, or cattle sourcing decisions. These factors, in turn, may be reactions to prices or policies. Death loss impacts feedlot profitability, making it a topic of importance for the industry.

In the first study (Chapter II), the primary objective is to determine whether structural change has occurred in feedlot death loss rates (mortality). Anecdotal evidence suggests that feedlot death loss is increasing over time. If so, it is important to understand the nature of the change and identify the sources of change in death loss. A first step toward greater understanding of changes in feedlot death loss is to understand the nature of the change at an aggregate level. Catalysts of change may effect gradual, immediate or delayed impacts. This study uses data from the Kansas Feedlot Performance and Feed Cost Summary, a monthly summary of feedlot performance measures from January 1992 to July 2017, to examine structural change in feedlot death loss. A basic model of steer death loss percentage is specified as a function of in-weight, days on feed, time trend, and monthly dummies. After correcting for autocorrelation, tests of structural change, including the cumulative sum (CUSUM) test, CUSUM of squares test, and Bai and Perron tests are implemented to examine whether structural change exists and, if so, to identify the nature of that structural change. The parallels between evidence of structural change and possible catalysts are examined.

The second study (Chapter III) uses disaggregate data from a private feedlot in the Southern Plains to examine factors that appear to influence death loss in feedlot cattle. A total of 5773 pen level observations from January 2009 to January 2017 are used in this study. Cattle placements, sources, treatment frequency, and seasonality are examined as factors that may affect feedlot death loss. Details in the dataset allow this study to explain the impacts of cattle placements on death loss, determine which cattle characteristics influence death loss the most, and describe the relationship between treatment incidence and death loss. A Tobit model is used to estimate feedlot death loss rate since the nature of the data yields a lower bound of zero because death loss rates cannot take negative values. Marginal effects yielded from the estimated model account for effects of the explanatory variables on both change in death loss rate and probability of death loss.

The main objective of the third study (Chapter IV) is to estimate expected feedlot revenue and total cost per head based on the placement decision and the geographical and market source of feeder cattle, incorporating expected mortality rates. Expected net returns are computed based on a recursive system for the feedlot. The recursive system accounts for expected death loss using the model in the second study (Chapter III). Prices and cost in the system are estimated using data from the Livestock Marketing Information Center, while feedlot performance measures are taken from the private feedlot in the Southern Plains. Twelve scenarios for steers account for different in-weights, pen sizes, closeout months, and market origins, when computing expected net returns. These scenarios account for the impact of these choice variables on expected death loss. Sensitivity analysis of the expected net return with respect to change in corn price is also conducted for each scenario.

CHAPTER II

STRUCTURAL CHANGE IN FEEDLOT CATTLE DEATH LOSS

Introduction

Some degree of death loss (mortality) is typical in beef cattle feedlot operations. That is, the number of fed cattle sold (output) will be less than the number of feeder calves purchased (input) because of death loss. However, evidence suggests that feedlot death loss is increasing over time. USDA National Health Monitoring System (NAHMS) data indicates that death loss increased by 69 percent (6 percent per year on average) from 1994 to 2003 because of respiratory disease (Peck 2006). From January 1992 to July 2017, the mean monthly death loss percentage for steers increased from 0.70 percent to 1.74 percent in feedlots represented by the Kansas Feedlot Performance and Feed Cost Summary (LMIC 2018a). Elanco Animal Health shared feedlot data obtained from Benchmark® Performance Program, AgSpan, Overland Park, Kansas indicating that death loss was flat during the period of 2005 – 2010, but began to increase after 2010, with an average death loss rate for combined steers and heifers of 1.49 percent (Vogel, et al. 2015). The same study indicates that from January 2005 to September 2014, steer death loss increased from 1.34 percent to 1.71 percent and heifer death loss increased from 1.41 percent to 1.84 percent. Professional Cattle Consultants (PCC) data also indicate that death loss has increased, doubling from 2010 to 2015 (Maday 2016).

When feedlot death loss rates increase, it potentially impacts economic profits. Pounds of saleable product are affected as are feed conversions, average daily gain, and cost of gain (Babcock, Jones and Langemeier 2006). Irsik, et al. (2006) reported that a one percent increase in death loss per pen resulted in a 0.27 pound increase in feed to gain ratio and a 0.08 pound decrease in average daily gain, indicating that more feed is needed to gain the same amount of weight on average. Loneragan, et al. (2001) stated that death loss contributes to economic losses through feed cost, medical cost, increased labor, manure disposal, animal disposal, and other increased costs. Economic loss from death loss is highly correlated with morbidity (sickness) (Roeber, et al. 2001). Irsik, et al. (2006) found that a one percent increase in death loss per pen increased feedlot cost by $1 per head and death loss per pen increased by 0.14 percent for a percentage increase in the number of medical treatments.

Past research has evaluated feedlot death loss over time. Babcock, Jones and Langemeier (2006) estimate monthly death loss percentage from 1992 to 2004. Results indicate that feedlot death loss increased significantly from 1992 to 2004, with seasonal trends within year in both steer and heifer death loss. Unusual weather patterns during the period of January 1993 to June 1993 also significantly affected heifer death loss. Using private data from feedlot veterinary consultants, Loneragan, et al. (2001) evaluated trends of feedlot death loss by estimating yearly death loss relative to body system-specific death (BRD, digestive disorders, and other disorders) using Poisson regression techniques. Yearly death loss ratios were calculated overall and by animal type (beef steers, beef heifers, dairy animal) from monthly data. Overall, they found that death loss increased 38 percent from 1994 to 1999. Though most feedlot death loss research is not recent, Engler, et al. (2014) used descriptive statistics and simple regression on private feedlot data (2001 – 2013) and concluded that feedlot death loss for three placement weight classes of steers (600 pounds, 700 pounds, and 800 pounds) exhibits an increasing trend.

The purpose of this study is to determine whether feedlot death loss has changed over time, to analyze the nature of the change, and to identify the sources of change in death loss. This study differs from Babcock, Jones and Langemeier (2006) by considering days on feed in addition to placement weight and seasonality that may influence death loss. This study attempt to detect any structural change in feedlot death loss and determine whether the structural change is systematic or abrupt or both using cumulative sum test (CUSUM), CUSUM of squares test, and Bai and Perron testing procedures.

Catalysts of Structural Change

Structural change can be defined as shifts or evolutions in market or industry functions, and is evidenced in parameter instability. Parameter instability is caused by an event (or events) that significantly changes the parameters. The change can be gradual or abrupt and permanent or temporary. If death loss is changing over time, it is important to understand the nature of the change.

Death loss change could be attributed to events such as extreme weather or disease outbreak which have an immediate impact. Alternatively, death loss changes may be the indirect or delayed impact of policy change, technology advancements, or even changes in management or sourcing. These factors can also be categorized into controllable and uncontrollable factors. Controllable factors include technology adoption, feed rations, and cattle sourcing. Technology advancement in animal health management or efficiency may impact feedlot death loss. Feedlot decisions regarding the technology adoption may depend on immediate costs and returns projections, but long-term implications may be less clear.

Producers may alter feed rations based on availability and relative prices of feed ingredients, which may be influenced indirectly by policy. While policy is not controllable, producers make decisions based on the market environment created by the policy. For example, the Renewable Fuels Standard aims to reduce greenhouse gas emissions, but it also impacts corn prices – a primary input in cattle feeding. Increased prices and price risk associated with variation in corn prices might drive producers in cattle feeding operations to use alternative feed ingredients or feed additives with unclear long-term impacts.

As more corn is processed for ethanol, less is available for animal feed and increasing corn prices (Daley 2007). This situation induced beef industry players to alter the input combination of feed rations by including the relatively less expensive by-product of the ethanol industry, distillers' grain. Later in 2007, a beta-agonist feed additive, zilpaterol hydrochloride[1], was introduced to the cattle feeding industry to enhance cattle's natural ability to convert feed into lean meat. The use of zilpaterol hydrochloride was approved by U.S. Food and Drug Administration's Department of Health and Human Services in August 2006 (U.S. FDA 2017). Animal welfare concerns regarding the use of zilpaterol hydrochloride led Tyson Foods Inc. to ban zilpaterol

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[1] Marketed under the name Zilmax by Merck Animal Health.
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hydrochloride-fed cattle from their beef operations in August 2013. Cargill, JBS, and National Beef Packing soon followed suit, representing over 80 percent of the beef packing industry (Tyson 25%, Cargill 21%, JBS 18.5%, National Beef Packing 10.5%). While zilpaterol hydrochloride was withdrawn from the market, distillers' grain continues to be available from ethanol production plants. It is possible that the use of distillers' grain (Drewnoski, Pogge and Hansen 2014; Crawford 2012) and zilpaterol hydrochloride (Loneragan, Thomson and Scott 2014; Waters 2013) in the post-Renewable Fuels Standard years impacted death loss in feedlot.

Uncontrollable factors such as weather may also impact feedlot death loss. Both severe cold and extreme heat often leads to increased death in feedlot cattle. From 1990 to 2016, there were multiple reports of abnormal weather conditions in the Southern Plains region. For example, there were early snowstorms in 1992 and 1997 and heavy snowstorms in winter 2006 (Hicks 2007). From fall 2010 to summer 2013, drought conditions in the Southern Plains region were considered extreme (Strom 2013). Feedlot death loss may be higher than usual during such abnormal weather conditions, as such conditions place increased physical stress on cattle.

Data

Data from the Kansas Feedlot Performance and Feed Cost Summary is used for this study and was obtained from the Livestock Marketing Information Center (LMIC). The monthly summary contains feedlot performance and closeout data from Kansas commercial cattle feeding operations. A survey is sent every month to a set number of Kansas feedlots with the number of respondents varying by month. We use data from

January 1992 to July 2017 since death loss percentage is not available in prior reports. We examine only steer data for this study. Data includes death loss percentage, in-weight, and average days on feed. A summary of the data is given in Table 2.1. Figure 2.1 shows monthly death loss percentages for steers in Kansas feedlots from January 1992 to July 2017. The sample is divided into period 1 (January 1992 – December 2000), period 2 (January 2001 – September 2010), and period 3 (October 2010 – July 2017) to illustrate potential differences across those periods.

Model and Procedures

Figure 2.1 illustrates that the three different periods depict different average rates of death loss over time, suggesting that structural change may have occurred across these periods. Tests of equal means and variances was conducted for death loss of these three periods.

Structurally, a basic model of death loss in feedlot production can be written as

$$\text{Ln}(DL_t) = \beta_0 + \beta_1 \text{Ln}(INWT_t) + \beta_2 \text{Ln}(DOF_t) + \beta_3 t + \sum_{k=1}^{11} \delta_k MD_{kt} + \varepsilon_t \tag{2.1}$$

where $t = 1, \dots, T$ denotes as closeout month, $\text{Ln}(DL_t)$ is the natural log of death loss percentage, $\text{Ln}(INWT_t)$ is the natural log of in-weight, $\text{Ln}(DOF_t)$ is the natural log of days on feed, t is also represents monthly time trend, MD_{kt} are monthly dummy variables from October to August, ε_t is the error term, and $\varepsilon_t \sim N(0, \sigma^2)$.

Previous research suggests that placement weight may influence death loss (Babcock, Jones and Langemeier 2006). Light weight feeder calves may be more prone to sickness and stress, increasing the possibility of death relative to heavier feeder calves during the early stage of feeding period. Intuitively, lighter placement weights would lead to longer days on feed and vice versa. However, recent trends in cattle feeding do not strictly associate longer days on feed with lighter placement weight (Bondurant, et al. 2016; Wilken, et al. 2015; Tatum, et al. 2012). Feedlots may feed cattle longer in order to add as many pounds as possible in response to market signals such as high fed cattle prices and low feeder supply, possible in part due to advancements in cattle feeding technology. These technology advancements may shift the point of diminishing returns to weight gain for an individual animal. However, despite the economic incentive, feeding cattle longer may also lead to higher death rates. Thus, days on feed is included in the model. Monthly dummy variables are included in the model to capture seasonal patterns in feedlot death loss percentages. Differences may exist because of environmental factors such as temperature, relative humidity, snow, wind, rain, and mud.

Structural change can be examined using a variety of statistical methods. Possibilities include the Chow test, CUSUM test, and tests by Bai and Perron. Chow's (1960) test is commonly used to examine abrupt change when there is one known potential breakpoint, dividing the sample into two sub-samples at the suspected breakpoint. The null hypothesis presumes no structural change; that is, model parameters are stable over the full sample. The alternative hypothesis is structural change at the suspected breakpoint. The cumulative sum (CUSUM) test, CUSUM of squares test, and Bai and Perron testing procedures are the extensions of Chow test. In this study, the basic model in equation 2.1 was tested for structural change using these tests.

The cumulative sum (CUSUM) test can detect unknown breakpoints. The CUSUM test relies on recursive residuals to detect systematic change in the model. The sum of the recursive residuals is plotted and examined with respect to a critical bound. The test is based on the plot of the following quantities:

(2.2)
$$W_t = \sum_{t=n+1}^{m} \frac{w_t}{\hat{\sigma}_w}$$

where,

$$\hat{\sigma}_w^2 = \frac{\sum_{t=n+1}^{m}(w_t - \bar{w})^2}{T - n - 1}, \bar{w} = \frac{\sum_{t=n+1}^{m} w_t}{T - n}, m = n + 1, \dots, T$$

and where W_t is the sum of the recursive residuals, w_t is the recursive residual, $\hat{\sigma}_w$ is standard error of the recursive residual, *m* is the unknown breakpoint, *n* is the minimum sample size required for model fit, and *T* is total sample size. The critical bound is given as below:

(2.3)
$$B_W = \frac{a(2m + T - 3n)}{\sqrt{T - n}}$$

where a is equal to 0.948 for significance at the 5% level. The null hypothesis of no structural change will be rejected if W_t crosses the boundary of $[-B_W , B_W]$ (Farhani 2012). It should be noted that the CUSUM test only detects instability of the intercept (Hansen 1992; Kramer, Ploberger and Alt 1988).

Brown, Durbin and Evans (1975) suggest the CUSUM of squares test to determine whether structural change is random or abrupt, detecting variance instability. The CUSUM of squares test is similar to the CUSUM test, but uses the cumulative sum of squared recursive residuals. The cumulative sum of squared recursive residuals is computed as below.

(2.4)
$$S_t = \frac{\sum_{t=n+1}^{m} w_t^2}{\sum_{t=n+1}^{T} w_t^2}$$

where S_t is the cumulative sum of squared recursive residuals and m, n, and T are previously defined in equation 2.2. The critical bound is given as below.

(2.5)
$$B_S = c + \left(\frac{m-n}{T-n}\right)$$

where c is equal to 1.358 for significance at the 5% level. The CUSUM of squares test has poor asymptotic power because the possibility of rejecting the false null hypothesis (H_0: no structural change) becomes lower as the number of observations move toward infinity which means a greater chance of type II error (Hansen 1991; Ploberger and Krämer 1990). However, this is not an issue in this study because the number of observations is relatively small.

An alternative approach when the number of breakpoints is unknown is to use the tests proposed by Bai and Perron (1998; 2006; 2003). Bai and Perron propose three structural change tests to find the number and location of the breakpoints simultaneously. These tests use the sup-F statistic which is the maximum F-statistic of the Chow test (Bai and Perron 1998). The null hypothesis of no breakpoints is tested against the alternative of m known number of breakpoints. The sup-F statistic is given below.

(2.6)
$$\mathrm{supF}(\lambda_1, \ldots, \lambda_m, q) = \frac{T-(m+1)q-p}{mq} \times \frac{R'\hat{\beta}'\left[RI(\hat{\beta})^{-1}R'\right]^{-1}R\hat{\beta}}{SSR_m}$$

where T is total sample size, q is number of restriction, p is number of explanatory variables, R is conventional matrix such that $R'\hat{\beta}' = (\beta_1' - \beta_2', \ldots, \beta_m' - \beta_{m+1}')$, I is identity matrix, and SSR_m is the sum of squared residuals under the alternative hypothesis.

To improve the robustness of this test, Bai and Perron (2006) use a double maximum F-statistic given an upper bound and weighted upper bound. Fixing an upper bound for m, the double maximum F statistic is given below:

$$\mathrm{DmaxF}(M, d_1, \dots, d_M, q) = \max_{1<m<M} d_m \, \mathrm{supF}(\lambda_1, \dots, \lambda_m, q) \tag{2.7}$$

where *M* is the chosen upper bound for number of breaks and $(d_1, \dots, d_M)$ are fixed weights that reflect some information about the chosen upper bound. In the weighted double maximum F statistic, $d_1 = 1$ and $d_m = c(q, \alpha, m)$ for $m > 1$. The weighted double maximum F statistic can be written as:

$$\mathrm{WDmaxF}(M, q) = \max_{1<m<M} \frac{c(q, \alpha, 1)}{c(q, \alpha, m)} \mathrm{supF}(\lambda_1, \dots, \lambda_m, q) \tag{2.8}$$

where $c(q, \alpha, m)$ is the asymptotic critical value of the test $\mathrm{supF}(\lambda_1, \dots, \lambda_m, q)$ for a significance level α.

Bai and Perron (2003) test sequentially implements the Chow test by computing the F-statistic for every possible structural break. It tests the null hypothesis of *m* breakpoints versus the alternative of *m*+1 breakpoints using the sup-F statistics. In this case, the sup-F statistic is written as:

$$\mathrm{supF}(m+1|m) = \frac{\left[S_T(\hat{T}_1, \dots, \hat{T}_m) - \min_{1 \le i \le m+1} \inf_{\tau \in \Lambda_{i,\eta}} S_T(\hat{T}_1, \dots, \hat{T}_{i-1}, \dots, \tau, \hat{T}_i, \dots, \hat{T}_m)\right]}{\hat{\sigma}^2} \tag{2.9}$$

where

$$\Lambda_{i,\eta} = \left\{\tau; \hat{T}_{i-1} + \left(\hat{T}_1, \dots, \hat{T}_{i-1}\right)\eta \le \tau \le \hat{T}_i - (\hat{T}_i, \dots, \hat{T}_{i-1})\eta\right\}$$

and where $S_T(\hat{T}_1, \dots, \hat{T}_{i-1}, \dots, \tau, \hat{T}_i, \dots, \hat{T}_m)$ is the sum of squared residuals from least-squares estimation for each segment of the breaks, and $\hat{\sigma}^2$ is the variance estimator under null hypothesis. The procedure is conducted in sequence, beginning with testing the null hypothesis of no break vs alternative hypothesis of one break. When the null hypothesis is rejected, the first break is taken. Then a test for second break is conducted by testing the null hypothesis of one break vs alternative of two (1+1) breaks. The procedure continues in sequence until we fail to reject the null hypothesis. Carter and Smith (2007) and Herrington and Tonsor (2013) used these tests to assess structural change in grain markets and feedlot performance measures, respectively.

Results

Figure 2.1 shows annual high death loss percentages for steers across the sample did not exceed the upper bound of the mean (mean + standard deviation) of 1.71 percent before March 2000. However, it exceeded the upper bound three times from June 2000 to May 2002 when the annual highest death loss percentages were 2.01 (June 2000), 2.76 (April 2001), and 2.37 (May 2002). Though the annual high death loss percentage in 2003 is below 1.71 percent, the annual high death loss percentage values continue to exceed the upper bound until 2013.

Test for unequal means and variances of death loss percentages for the three periods found that means and variances were statistically different overall (Table 2.2). Period 1's mean is statistically different from periods 2 and 3. Though means for periods 2 and 3 are not statistically different, their variances are statistically unequal as are the variances for periods 1 and 2. Figure 2.2 shows the box plot of these tests. It shows that death loss percentages in period 2 is more varied than death loss percentages in period 1 and 3.

Estimated Model Results

The basic model in equation 2.1 was tested for misspecification including normality (Jarque-Bera and omnibus test), functional form (Kolmogorov-Gabor polynomial and Ramsey RESET tests), and autocorrelation. The model was corrected for first order autocorrelation. The model was estimated with SAS Enterprise Guide 6.1 using the PROC AUTOREG procedure. Coefficient estimates of the basic model in equation 1 are presented in Table 2.3. The estimated model has a R^2 of 0.5053. Most coefficients are significant at a 5% level including days on feed ($\widehat{\beta_2}$), nine of the monthly dummies ($\widehat{\delta_k}$), and time trend ($\widehat{\beta_3}$). This model indicates that days on feed significantly affects death loss percentage with higher death loss rates for longer feeding periods. In-weight is negative but is not statistically significant.

The significance of the time trend variable demonstrates a gradual increase of death loss percentage since January 1992. Death loss percentage increased by 0.018 percent ($\widehat{\beta_3}$ × mean of death loss percentage × 12 months) for each additional year on average. For example, the average death loss rate in 2015 was 1.50 percent, resulting in an expected average death loss rate in 2016 of 1.518 percent.

Figure 2.3 depicts the seasonal pattern of death loss estimated by the model. Death loss for September closeouts (early fall) is significantly lower than other months. Late spring closeouts (April and May) have the highest death loss. Feeder calves finished at this time are usually placed in the feedlot during the colder season.

Structural Change Results

Recall that the basic model was tested for structural change using the cumulative sum (CUSUM) test, CUSUM of squares test, and Bai and Perron testing procedures. The summary of breakpoints and close or coinciding events is shown in Table 2.4. The CUSUM test only detects instability in the intercept or systematic change in the model. Evidence of structural breaks in the basic model are indicated at December 2000 and December 2001 when the recursive residuals cross the upper critical bound. Though the time trend already included in the model represents some systematic change in death loss over time, the breaks detected by CUSUM test indicate other yet unexplained factors.

The CUSUM of squares test detects instability in the variance of the error terms, indicating abrupt change in the model. This test detects breakpoints at December 2006, May 2010, June 2010, and September 2010. The closest event to December 2006 is heavy snowstorms in the region (1000 mile path from central Oklahoma to northern Michigan) from Nov 30 to Dec 1, 2006 (Changnon and Kunkel 2007). Hicks (2007) reports that an estimated 10,000 to 30,000 head of feedlot cattle died in the Southern Great Plains due to these snowstorms. For May, June, and September 2010, the coinciding event is extreme heat during summer 2010, as temperatures in the region for June and September were “much above average” and for July and August were “above average” (NOAA 2010).

Recall that Bai and Perron tests use the maximum F-statistic (sup-F) among F-statistics from all possible breakpoints or the maximum F statistic of Chow test. The Bai and Perron tests suggest two breakpoints; January 1996 and December 2001. The coinciding event to January 1996 is the abnormal cold and snowy conditions during winter 1995/96 (Halpert and Bell n.d.).

The breakpoint of December 2001 detected through Bai and Perron tests align with breakpoints detected in CUSUM test (December 2000 and December 2001). There are ongoing factors that cause these breaks including a series of events related to the cattle industry. For example, feed ration changes as corn prices increased in early 2000 may influence cattle health. Feed rations began to include more fat and distillers' grains, while supplements such as ractopamine hydrochloride[2] (2003) and zilpaterol hydrochloride (2007) were used to improve cattle feeding efficiency. There were also a significant changes in implants and implanting strategies for beef cattle production when U.S. Food and Drug Administration approved an androgenic agent, trenbolone acetate (TBA) for use in growth-promoting implants in 1987 (Griffin and Mader 1997; Mader 1998; Zobell, et al. 2000).

The results of test for unequal means and variance (Figure 2.1 and Table 2.2) are consistent with the detected breakpoints in the structural change tests. This led us to modify the basic model in equation 2.1, in an effort to capture the impacts of close or coinciding events in model estimation. The bulk of the evidence suggests inclusion of a dummy variable for period of December 2000 – September 2010. The modified model is written as

$$\text{(2.10)} \quad \mathrm{Ln}(DL_t) = \beta_0 + \beta_1 \mathrm{Ln}(INWT_t) + \beta_2 \mathrm{Ln}(DOF_t) + \beta_3 t + \sum_{k=1}^{11} \delta_k MD_{kt} + \gamma_1 D1_t + \varepsilon_t$$

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[2] Marketed under the name Optaflexx by Elanco Animal Health.
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where *D1* is dummy for period of December 2000 – September 2010 and other variables are previously defined in equation 2.1.

Table 2.5 summarizes the estimates of the modified model in equation 2. Most coefficients are significant at the 5% level. When the structural change for December 2000 – September 2010 is included, in-weight still lacks significance and days on feed remains significant. The seasonality component of death loss remains relatively stable, with September closeouts exhibiting the lowest death loss rates and peaks in death loss rates for April and May closeouts. Time trend is still significant, indicating a gradual increase in death loss similar in magnitude to the basic model. The structural change dummy representing December 2000 – September 2010 demonstrates that death loss is 0.117 percent ($\widehat{\gamma_1}$ × mean of death loss percentage) higher on average during this period. For example, average monthly death loss rate is 1.22 percent for the whole sample period (January 1992 – July 2017), resulting in an expected average monthly death loss rate during the period of December 2000 – September 2010 of 1.337 percent.

Conclusions

Death loss is significantly affected by days on feed, indicating that longer feeding periods lead to higher death loss rates. A one percent increase in days on feed will increase death loss percentage by 1.96 percentage points. Death loss also has a seasonal pattern with the lowest death loss occurring in September closeouts (early fall). The highest death loss take place in late spring closeouts (April and May). The time trend variable is also significant indicating a gradual increase of death loss over time.

The significance of time trend and the detection of seven breakpoints by structural change tests (CUSUM, CUSUM of squares, Bai and Perron) imply that death loss percentage did changing throughout the sample period (January 1992 – July 2017). There were few abrupt changes cause by extreme weather during winter and summer, but overall a systematic change from December 2000 to September 2010 define much of the structural change in feedlot death loss. Variance of death loss percentage is high during this period. There may be ongoing factors that cause this systematic change such as changes is feed ration and improvement of feeding technology. However, there is no clear evidence to directly associate these factors to feedlot death loss. These factors may be more positive for feedlot operation rather than bring harm to it.

Since there are evidence of structural change in feedlot death loss rate, future research using disaggregate data may help to determine the drivers of increased death loss rate at feedlot level. With aggregate data, the information that we gain is in terms of the beef industry overall. Meanwhile, disaggregate data may allow us to look closely at management aspects of the feedlot. Comparing the same models estimated using aggregate and disaggregate data may illustrate the benefits and disadvantages of both data types.

Table 2.1. Monthly Death Loss Percentage, Placement Weight, and Average Days on Feed, Kansas, January 1992 – July 2017

Variables	Unit	Mean	Standard Deviation	Minimum	Maximum
Steer					
Death loss percentage	%	1.22	0.49	0.35	2.78
Placement weight	lbs.	784.56	40.80	681.30	876.60
Average days on feed	days	151	12	119	186

Source: Livestock Marketing Information Center (LMIC 2018a)

Table 2.2. Results of Tests for Unequal Means and Variances of Death Loss Percentages

	Period 1 & 2	Period 2 & 3	Period 1 & 3	Overall
Variance Difference	0.223	0.240	0.125	Pr > F
Pr > F	0.000	0.000	0.750	0.000
Mean Difference	-0.405	-0.024	-0.429	Pr > F
Pr > |t|	0.000	0.713	0.000	0.000

Table 2.3. Estimated Coefficients of the Basic Model (Equation 2.1) for Monthly Death Loss Percentage in Feedlots, Kansas, January 1992 – July 2017

Variables	Parameter	Coefficients	Standard Error
Intercept	$\widehat{\beta_0}$	-5.1036	2.9380
Ln(In-Weight)	$\widehat{\beta_1}$	-0.0514	0.6293
Ln(Days on feed)	$\widehat{\beta_2}$	1.8934	0.3742**
Time trend	$\widehat{\beta_3}$	0.0012	0.0004**
October	$\widehat{\delta_1}$	0.0477	0.0489
November	$\widehat{\delta_2}$	0.0873	0.0601
December	$\widehat{\delta_3}$	0.1730	0.0635**
January	$\widehat{\delta_4}$	0.2709	0.0656**
February	$\widehat{\delta_5}$	0.2549	0.0677**
March	$\widehat{\delta_6}$	0.3255	0.0721**
April	$\widehat{\delta_7}$	0.4670	0.0835**
May	$\widehat{\delta_8}$	0.4984	0.0842**
June	$\widehat{\delta_9}$	0.3885	0.0764**
July	$\widehat{\delta_{10}}$	0.2031	0.0648**
August	$\widehat{\delta_{11}}$	0.1188	0.0510**
	ρ	0.4603	0.0508**
	R^2	0.5053	

Note: Double asterisks (**) indicates significance at 5% level.

Table 2.4. Structural Change Test Results and Coinciding Events

	Test	Breakpoints Indicated	Close or Coinciding Events
Systematic	CUSUM	December 2000 December 2001	• Change of input combination in feed rations. • Use of ractopamine hydrochloride (2003) and zilpaterol hydrochloride (2007).
Abrupt	CUSUM of squares	December 2006	• Heavy snowstorms in the region (1000 mile path from central Oklahoma to northern Michigan) from Nov 30 to Dec 1.
		May 2010 June 2010 September 2010	• Extreme heat during summer 2010.
Multiple Breakpoints	Bai and Perron	January 1996	• Abnormal cold and snowy condition during winter 1995/96.
		December 2001	• Same as events close to CUSUM breakpoints.

Table 2.5. Estimated Coefficients of the Modified Model (Equation 2.10) for Monthly Death Loss Percentage in Feedlots, Kansas, January 1992 – July 2017

Variables	Parameter	Coefficients	Standard Error
Intercept	$\widehat{\beta_0}$	-6.4600	2.9565**
Ln(In-Weight)	$\widehat{\beta_1}$	0.3095	0.6454
Ln(Days on feed)	$\widehat{\beta_2}$	1.9363	0.3738**
Time trend	$\widehat{\beta_3}$	0.0011	0.0004**
October	$\widehat{\delta_1}$	0.0530	0.0486
November	$\widehat{\delta_2}$	0.0927	0.0598
December	$\widehat{\delta_3}$	0.1750	0.0632**
January	$\widehat{\delta_4}$	0.2764	0.0654**
February	$\widehat{\delta_5}$	0.2647	0.0676**
March	$\widehat{\delta_6}$	0.3419	0.0722**
April	$\widehat{\delta_7}$	0.4977	0.0843**
May	$\widehat{\delta_8}$	0.5297	0.0851**
June	$\widehat{\delta_9}$	0.4158	0.0770**
July	$\widehat{\delta_{10}}$	0.2207	0.0649**
August	$\widehat{\delta_{11}}$	0.1263	0.0507**
D1 (December 2000 – September 2010)	$\widehat{\gamma_1}$	0.0963	0.0466**
	ρ	0.4661	0.0507**
	R^2	0.5103	

Note: Double asterisks (**) indicate significance at 5% level.

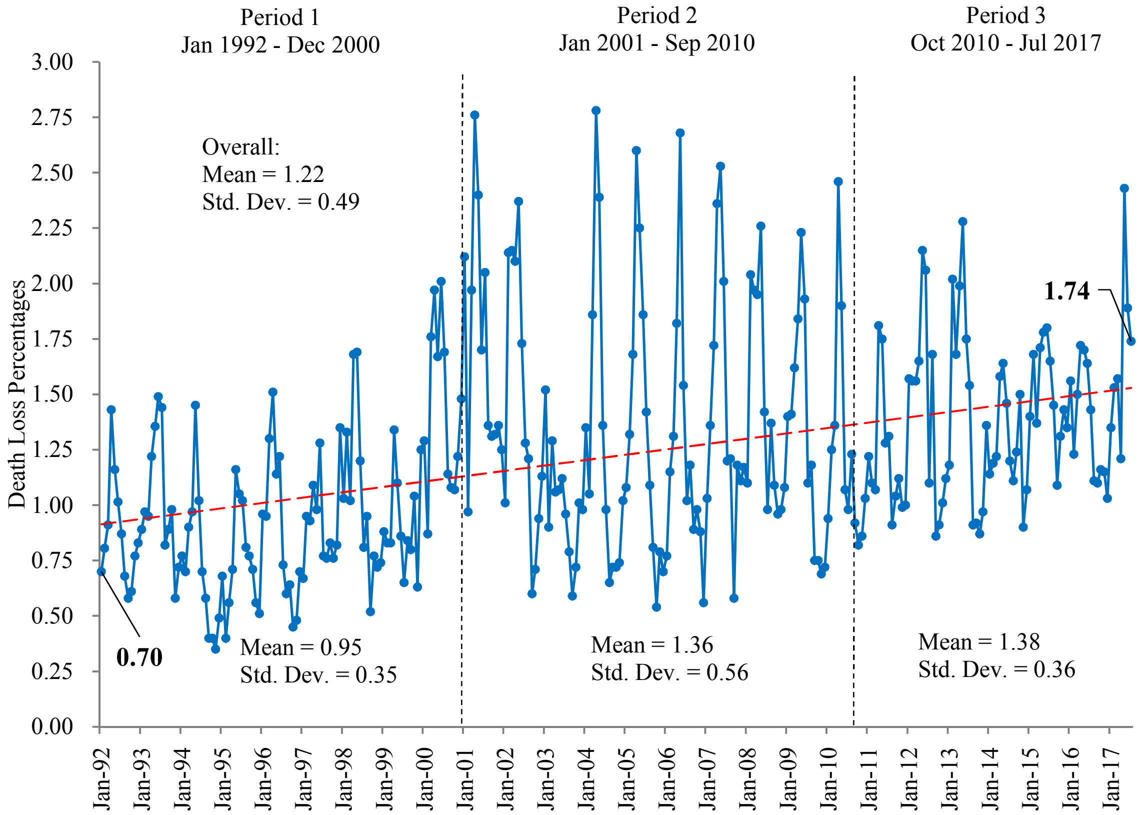
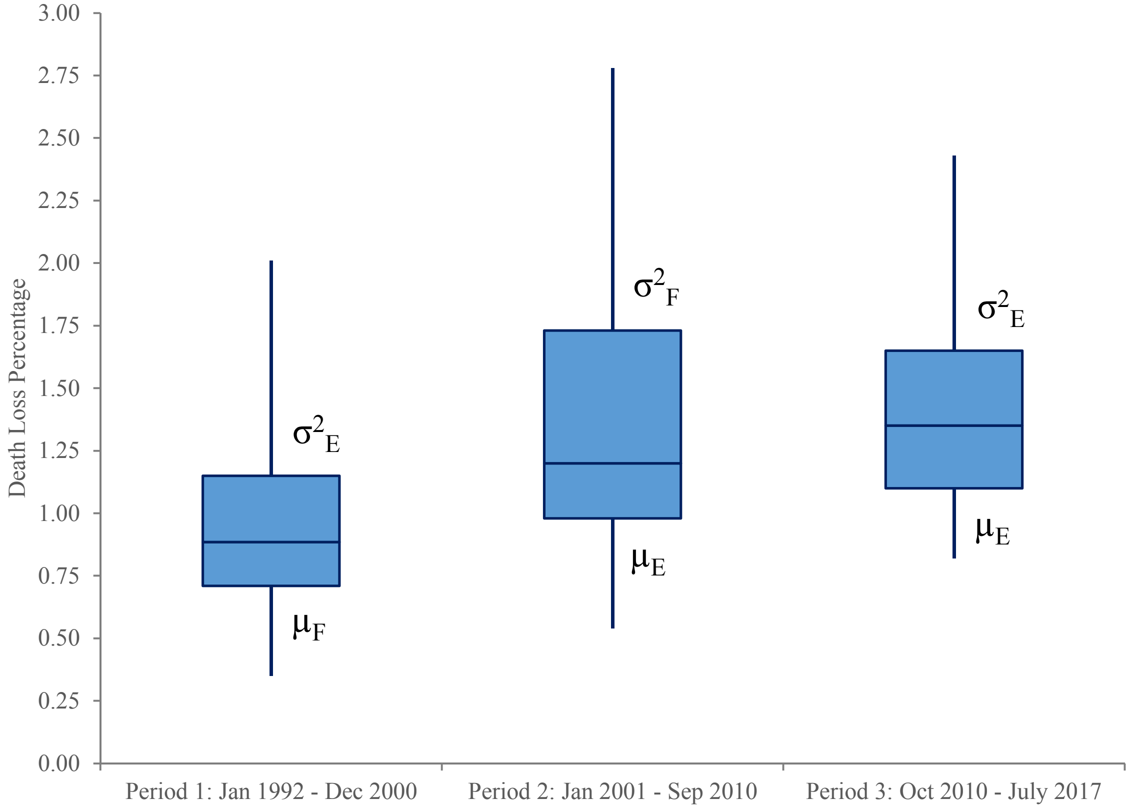


Figure 2.1. Death Loss Percentages for Steers, Kansas, January 1992 – July 2017



Note: σ^2_E indicates statistically equal σ^2, σ^2_F indicates statistically unequal σ^2, μ_E indicates statistically equal μ, and μ_F indicates statistically unequal μ.

Figure 2.2. Box Plot of Death Loss Percentages for Steers by Periods

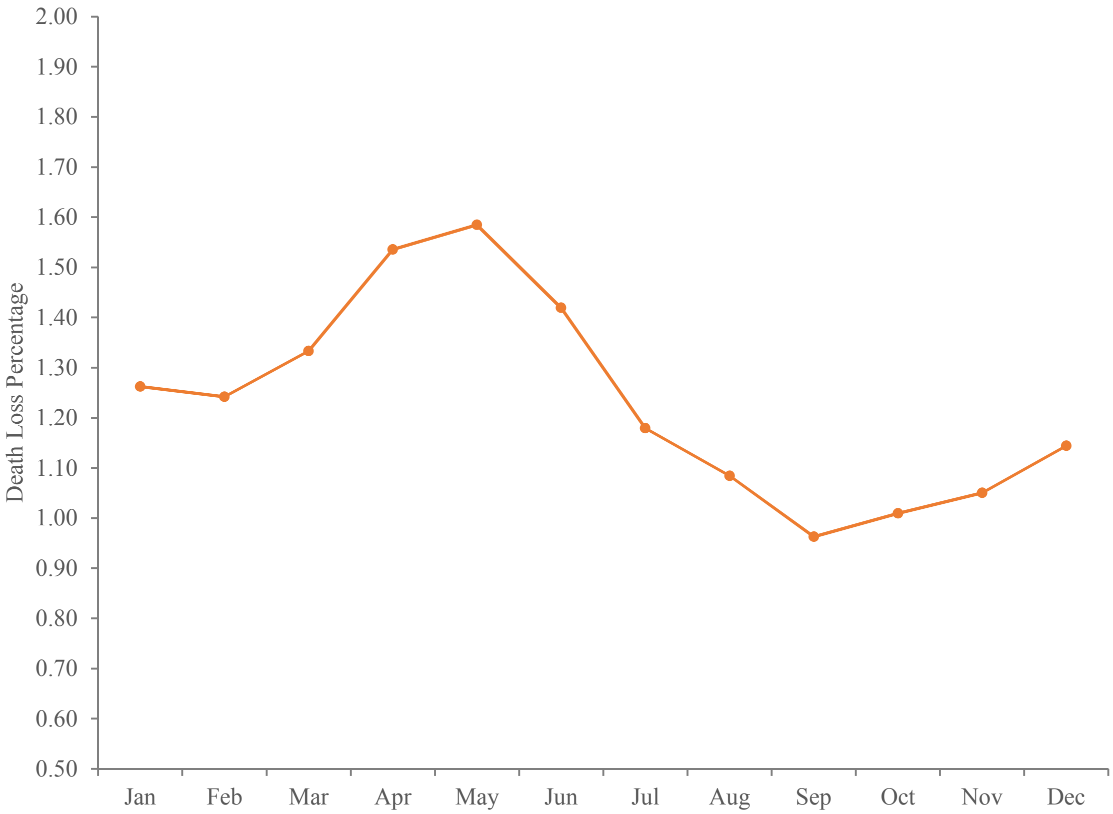


Figure 2.3. Seasonal Pattern of Death Loss Percentage from Estimated Model

CHAPTER III

DETERMINANTS OF FEEDLOTS CATTLE DEATH LOSS RATES

Introduction

Death loss in feedlot cattle can have significant impacts on feedlot profitability. Not only does death loss result in foregone revenue, but the operation also incurs the costs associated with those animals. Death loss contributes to economic losses through unrecovered feed cost, medical cost, increased labor, manure disposal, animal disposal, and other increased cost (Loneragan, et al. 2001). Economic loss from death loss is highly correlated with morbidity (sickness) (Roeber, et al. 2001). Irsik, et al. (2006) estimate that a one percent increase in death loss per pen increased feedlot cost by $1 per head and that death loss per pen would increase by 0.14 percent for one percentage increase in number of medical treatments.

Many factors may influence feedlot death loss rates. Some, such as weather and policy, are uncontrollable. Extreme weather may increase animal stress and lead to higher death loss rates. Policy changes may inadvertently influence death loss. For example, when the Renewable Fuels Standard Program was introduced in 2005 and expanded in 2007, corn prices increased significantly. In response, feedlot diets for cattle began to include significant amounts of distillers' grain and new feed additives, potentially exposing cattle to sulfur toxicity that could lead to polioencephalomalacia, a neurologic disease (Drewnoski, Pogge and Hansen 2014; Crawford 2012). Feed additives introduced to increase animal efficiency such as zilpaterol hydrochloride, a beta-agonist drug that enhances the natural ability of cattle to convert feed into lean meat, might cause ambulatory problems in cattle that could lead to death (Loneragan, Thomson and Scott 2014; Waters 2013).

Controllable factors such as cattle source may also influence death loss rates. Feeder cattle come from different origins including sale barns, country ranches, growing yards, and other backgrounding operations. Compared to ranch-sourced steers, sale barn-sourced steers are treated more often for bovine respiratory disease and have higher death loss rates (Step, et al. 2008). Meanwhile, cattle brought from locations far from the feedlot could experience greater stress and potential exposure to disease. Death loss rates may also be influenced by the type of cattle (steer, heifer, dairy, etc.). For example, compared to heifers, steers have lower death loss rates (Vogel, et al. 2015; Babcock, Jones and Langemeier 2006).

Causes of death for feeder cattle can be classified into predator-related and non-predator-related. Non-predator-related deaths cost the beef cattle industry more than 2.35 billion dollars per year (USDA 2011). Bovine respiratory disease (BRD) is the primary reason for death loss in feedlots (Brooks, et al. 2011; Snowder, et al. 2006; Loneragan, et al. 2001; Smith 1998). BRD is caused by pathogen attacks on the animal's respiratory tract. A single pathogen or a variety of pathogens interact with the animal's immune system leading to a full-blown disease. Vogel, et al. (2015) found that average days on feed at death caused by respiratory disease is day 62 for both steers and heifers. Factors that may influence BRD susceptibility include initial animal weight, transportation process, commingling, and feedlot personnel experience (Loneragan, et al. 2001; Lechtenberg, Smith and Stokka 1998).

Meanwhile, digestive disorders are related to what cattle eat, including feed and feed additives. The most common digestive disorders are acidosis and bloat (Glock and Degroot 1998). Acidosis happens when the pH of the rumen becomes acidic for an extended period of time, possibly caused by excess high energy feeds and feed particle size. Acidosis leads to low feed consumption and dehydration and may lead to death (Owens, et al. 1998). Bloat occurs when fermentation gases build up in the rumen, causing breathing difficulty and possible death (Cheng, et al. 1998). Animals that die of digestive disorders usually do so at later stages of the feeding period (Loneragan, Dargatz, et al. 2001). Vogel, et al. (2015) found that average days on feed at death caused by digestive disorders are day 99 for steers and day 98 for heifers. Loneragan, Thomson and Scott (2014) associated death close to the end of feeding periods with the use of beta-agonist drugs in cattle confinement. However, Maday (2016) suggested that the beta-agonist drug (zilpaterol hydrochloride) has only small impacts on death loss as death loss rates actually increased after its withdrawal from the market. Past research investigates death loss from the perspective of animal health (Engler, et al. 2014; Irsik, et al. 2006; Loneragan, et al. 2001; Smith 1998). However, no distinction in sources of cattle were included in these research.

The purpose of this study is to examine factors that appear to influence death loss in feedlot cattle, including cattle characteristics, management characteristics and treatment incidence. This study first presents data and implementation of a Tobit model. This is followed by a discussion of the Tobit model results.

Data

This study uses pen level feedlot data from a private feedlot in the Southern Great Plains. Each observation is the average value among cattle in each pen. Data include overall death loss percentage and death loss by cause of death (respiratory disease, digestive disorders, others) number of cattle treated for respiratory disease, digestive disorders, others, number of deads, placement head count (pen size), in weight (placement weight after shrink), days on feed, feed to gain ratio, shrink percentage, sick head days, cattle type, cattle origin, and geographic state of origin. There are 5773 observations (pens) collected from January 2009 (open date) to January 2017 (close out date). Placement head count for the observed time period is 636,042 with a close out head count at 623,291.

Year and month refer to close out date. Pen type includes steers, heifers, and other type. Other type consists of steer and heifer mix, Holstein, and cow. Cattle origin includes sale barn, country ranch, combination of sale barn and other (country ranch, wheat pasture, growing yard), and other origin. Other origin consists of wheat pasture, growing yard, and backgrounding program. State of origin is used to compile a geographic region origin variable comprised of Southern Great Plains, Northern Great Plains, Midwest, West, and East. Summary statistics are discussed in the results section.

Model and Procedures

Since death loss is observed as a censored variable taking on only values that are zero or positive, a Tobit model is considered for analysis. According to Wooldridge (2002), Tobit regression is applicable when data are censored on the left. In this case, since the dependent variable, death loss (*DL*) is observable, it may be more appropriate to refer to this model as corner solution model rather than censored regression model. At pen level, *DL* takes the value of zero with positive probability and a continuous variable with only positive values. This implies that the producer is solving an optimization problem where the optimal solution will be the corner, *DL* = 0. There is no exact definition for latent variable *DL** in this study because death loss *DL* is observable. The interest of this study is to estimate the expected *DL* which is non-negative, as well as the probability that *DL* is not zero.

In Tobit regression, the likelihood function is comprised of two parts. The first part is related to the classical regression of the uncensored observations (*DL* > 0). The second part takes into account the relevant probabilities that an observation is censored. The likelihood function for the Tobit model is

$$L(\beta,\sigma) = \prod_{DL_i>0}\left[(2\pi\sigma^2(z_i\eta))^{\frac{-1}{2}} \exp\left(\frac{-1}{2\sigma^2(z_i\eta)}(DL_i - \boldsymbol{x_i}'\beta)^2\right)\right] \times \prod_{DL_i=0}\left[1-\Phi\left(\frac{\boldsymbol{x_i}'\beta}{\sigma^2(z_i\eta)}\right)\right] \tag{3.1}$$

where DL_i is the dependent variable, $\boldsymbol{x_i}$ is the vector of explanatory variables, z_i contains explanatory variables that affect the variance, and Φ is the normal cumulative distribution function (CDF).

If OLS is used to estimate *DL* using the whole sample or only the uncensored sample, estimates will be biased and inconsistent. Expected *DL* for the whole sample is a non-linear function of explanatory variables, corresponding coefficients, and sigma, but OLS assumes linearity. OLS using only the uncensored sample omits sigma in the regression, leading to correlation between explanatory variables and the error term.

The Tobit regression in this study is quite similar to the Tobit model for death loss by Belasco, et al. (2009). However, death loss is modeled with heteroskedasticity in this study assuming that variance is different by in-weight. The log-likelihood function from the death loss Tobit model can be written as:

$$\text{Ln}L = \sum_{DL_i>0} \frac{-1}{2}\left[\text{Ln}2\pi + \text{Ln}(\sigma^2) + INWT_i\eta + \frac{DL_i - \boldsymbol{x_i}'\beta}{\sigma^2.\exp(INWT_i\eta)}\right] + \sum_{DL_i=0} \text{Ln}\left[\Phi\left(\frac{\boldsymbol{x_i}'\beta}{\sigma^2.\exp(INWT_i\eta)}\right)\right] \tag{3.2}$$

where,

$$\boldsymbol{x_i}'\beta = \beta_0 + \beta_1 INWT_i + \beta_2 PSIZE_i + \beta_3 SHD_i + \beta_4 CTRES_i + \beta_5 CTDIG_i + \beta_6 SHRINK_i + \beta_7 REGION_i + \sum_{k=1}^{2} \alpha_k CTYPE_{ik} + \sum_{l=1}^{3} \gamma_l ORIGIN_{il} + \sum_{q=1}^{11} \delta_q MD_{iq} \tag{3.3}$$

and where DL_i is percentage of death loss observed in pen *i*, $INWT_i$ is average in-weight, $PSIZE_i$ is pen size, SHD_i is sick head days percentage for pen *i*, $CTRES_i$ is percentage of cattle treated with antibiotics for respiratory disease in pen *i*, $CTDIG_i$ is percentage of cattle treated for digestive disorders in pen *i*, $SHRINK_i$ equals one for pens with shrinkage of more than 5.5 percent and zero otherwise, $REGION_i$ equals one for cattle sourced from the Southern Plains and zero otherwise, $CTYPE_{ik}$ is pen type k where $k = \begin{Bmatrix} \text{0 Steers} & \text{2 Other Cattle} \\ \text{1 Heifers} & \end{Bmatrix}$, $ORIGIN_{il}$ indicates cattle source, l, for pen i where $l = \begin{Bmatrix} \text{0 Sale barn} & \text{2 Sale barn \& Other} \\ \text{1 Country} & \text{3 Other Origin} \end{Bmatrix}$, and MD_{iq} are monthly dummy variables from October to August. Days on feed is not included as an explanatory variable because it is highly correlated with in-weight (>0.8).

Death loss percentage may differ among cattle sources. For example, cattle from sale barns may be exposed to more viruses and greater stress prior to arrival that could lead to higher death loss risk than other sources. Similarly, death loss for cattle from the Southern Plains may be lower than for cattle from other regions given feedlot location. Cattle that travel further or longer may be more prone to stress and sickness that could lead to death. Higher percentages of cattle treated for respiratory disease in a pen may lead to lower death loss; however, it may also a sign that disease has spread, leading to higher death loss. Treatment for digestive disorders may lessen death loss caused by digestion problems.

Since the dependent variable is observable with a minimum value of zero (pen with no death loss), there is no clear interpretation for the value of coefficient estimates. Instead, the effects of explanatory variables on the observed variable are explained by the marginal effects computed as the followings.

$$(3.4) \quad \frac{\partial \mathrm{E}(DL|x)}{\partial x} = \mathrm{Prob}(DL > 0)\frac{\partial \mathrm{E}(DL|x, DL > 0)}{\partial x} + \mathrm{E}(DL|x, DL > 0)\frac{\partial \mathrm{Prob}(DL>0)}{\partial x}$$

These marginal effects account for the fact that changes in explanatory variables affect both the conditional mean of death loss percentage as well as the probability that a pen has death loss.

Results

Summary Statistics of Death Loss by Group

Figure 3.1 shows average death loss percentages by year. Since year 2009 and 2017 do not have complete year observations, they are not included for comparison. From 2010 to 2015, yearly death loss percentage doubles from 1.75 to 3.60, though it decreases to 2.86 in 2016. Figures 3.2, 3.3, 3.4, and 3.5 illustrate the distribution of in-weight, pen size, percentage of cattle treated for respiratory disease, and cattle origin, respectively, for 2010 and 2015. Pens with an in-weight of 400 pounds or less comprised a higher proportion of pens in 2010 as compared to 2015. Meanwhile, in 2015, a greater percentage of pens had in-weights of 800 pounds or more as compared to 2010. There was a greater percentage of pens with large pen size (>125 head) in 2010, while in 2015 the percentage of pens with small pen size (<75 head) was greater. In 2010, a greater percentage of pens had no cattle treated for respiratory disease, while 2015 reports a greater percentage of pens with more than 10 percent of cattle treated for respiratory disease. In term of cattle origin, there was a greater percentage of pens with sale barn-sourced cattle in 2015 as compared to 2010.

Figure 3.6 shows that death loss percentage decreases with increasing pen size. Pen sizes less than 50 have an average death loss percentage of 4.09, while pen sizes greater than 200 have an average death loss rate of 1.68. Figure 3.7 illustrates death loss percentages by in-weight group. Death loss rates are highest for pens with average in-weights of less than 400 pounds at 5.02 percent. Death loss percentage decreases through in-weights of 900 pounds to a low of 1.43 percent before beginning to increase for in-weights of 950 pounds and greater.

Death loss percentages for this dataset exhibit a seasonal pattern as shown in Figure 3.8. Higher death loss percentages are observed for late spring and summer (April, May, June) closeouts. This corresponds to cattle placement during fall and winter. The lowest death loss percentage is for September closeouts, corresponding to spring cattle placement.

Estimation Results

The estimated model in equations 3.2 and 3.3 is presented in Table 3.2. The model was estimated with SAS Enterprise Guide 6.1 using the PROC QLIM (qualitative and limited dependent variable model) procedure as Tobit regression with a heteroskedastic adjustment by in-weight. In Table 3.2, coefficients refer to the effects of explanatory variables on the latent variable DL^*. Marginal effects from equation 4 are also reported in Table 3.2.

Coefficient estimates of all continuous explanatory variables are significant at a 5 percent level. As expected, the marginal effect for in-weight is negative, indicating that pens with lighter in-weights have higher death loss rates. A hundred weight increase of in-weight will decrease death loss percentage by 0.2. For example, this suggest that moving from an in-weight of 450 pounds to an in-weight of 850 pounds decreases death loss rate by 0.8, all else equal.

Marginal effects for pen size and sick head days are positive, suggesting that larger pen size and more sick head days contribute to a higher death loss. More cattle in a pen translates to more cattle exposed and possibly infected by sickness, potentially leading to death loss. Death loss percentage increases by 0.4 for each additional hundred head of cattle in a pen. More sick head days indicates that a pen has higher risk of more cattle getting sick, eventually leading to death loss. A one percent increase in sick head days increased death loss rate by 0.185.

The two treatment marginal effects have opposite signs. The marginal effect for percentage of cattle treated for respiratory disease is positive, indicating that a higher percentage of cattle treated for respiratory disease in a pen is a precursor to greater death loss in that pen, likely because respiratory disease is highly infectious. Here, percentage of cattle treated for respiratory likely represents the incidence of respiratory disease instead of the treatment outcome itself. Death loss percentage for a pen increases by 0.126 with a one percent increase in incidence of respiratory disease. The marginal effect for percentage of cattle treated for digestive disorders is negative, suggesting that this treatment reduces death loss in a pen, though the magnitude is relatively small. A one percent increase in cattle treated for digestive disorder reduces the pen's death loss rate by 0.058 percent.

Estimates of categorical explanatory variables highlight the influence of region origin, pen type, and market origin. The coefficient for pen with shrink greater than 5.5 percent is not statistically significant. As expected, pens with cattle sourced from the Southern Plains have lower death loss rates compared to other regions, likely because cattle that travel further or longer are more prone to stress and sickness. The death loss percentage for cattle sourced from the Southern Plains is 0.557 less than cattle sourced from other regions.

The death loss rate for pens with cattle sourced from country ranches is significantly lower than for sale barn cattle, supporting the suggestion that cattle from sale barn may be exposed to more viruses and greater stress as they come through the process. They also be more likely to be commingled with other cattle from different ranch. Cattle sourced directly from country ranches have death loss 0.323 percent lower than cattle sourced from sale barns. In contrast, the death loss rate for pens with cattle sourced from other origins (wheat pasture, growing yard, or backgrounding program) is significantly higher than for sale barn cattle with death loss of 0.483 percent more than sale barn.

In terms of pen type (cattle type), steers have lower death loss rates compared to other cattle (cows, Holsteins, or mix of steers and heifers). The coefficient for heifers is not statistically significant. Cattle categorized as other have a death loss percentage 0.634 higher than steers.

The estimated model does not depict a strong seasonal pattern. However, there is at least some degree of seasonality unexplained by other variables as death loss rate in April, June, and November are significantly higher than in September. Both April and November have death loss greater than September at a 10% significant level, which are 0.232 and 0.228, respectively. Death loss percentage is the highest in June with 0.337 greater than in September (significant at 5% level).

Conclusions

In-weight, pen size, percentage of sick head days, percentage of cattle treated for respiratory disease, and percentage of cattle treated for digestive disorders are all statistically significant determinants of feedlot cattle death loss rates. Distribution of these variables may be varied throughout the sample period which may contribute to different death loss rates over time. The results also imply that cattle source, both in term of cattle source geographic location and market source type, plays an important role in managing death loss rate. To reduce stress and potential exposure to viruses, cattle may be sourced from local region and country ranches. Relative increases in death loss percentage may suggest a change in how feedlots sourced cattle from 2010 to 2016.

For example, the results imply that increased respiratory disease incidence explains much of the high death loss rate in 2015 at 3.60 percent as compared to the low death loss rate in 2010 at 1.75 percent when disease incidence was also lower. In 2015, cattle were placed at heavier in-weights and in smaller pen sizes, both of which are shown to be negatively related to death loss rates. However, cattle were also sourced more heavily from auction barns than in 2010, resulting in a pool of cattle likely more susceptible to disease exposure. Together, these variables explain the high death loss in 2015.

For future research, it may be helpful to look at the death loss percentage by timing and cause of death. The frequency of treatment received by an animal may also be considered when estimating death loss rate. This study uses only the percentage of cattle treated in a pen, implicitly accounting for only one treatment per animal cattle treated. Treatment frequency by head could provide better estimates. Future research could also consider performance measures such as feed to gain ratio and average daily gain, perhaps categorizing death loss by these performance measures to examine the relationship between increased physical performance and death loss.

Table 3.1. Descriptive Statistics

Variable	Unit	Mean	Std. Dev.	Minimum	Maximum
Continuous					
All Pens					
Death Loss	%	2.28	3.22	0.00	50.00
In-Weight	lbs.	697.91	117.18	262.76	1388.85
Pen Size	head	110	54	2	389
Sick Head Days	%	0.84	1.46	0.00	67.33
Cattle Treated with Antibiotic for Respiratory Disease	%	12.08	12.70	0.00	91.11
Cattle Treated for Digestive Disorder	%	6.13	10.22	0.00	79.73
Non-Zero Death Loss Pens					
Death Loss	%	3.09	3.40	0.35	50.00
In-Weight	lbs.	685.66	114.32	262.76	1095.09
Pen Size	head	119	53	2	389
Sick Head Days	%	0.94	1.27	0.00	24.18
Cattle Treated with Antibiotic for Respiratory Disease	%	13.75	13.40	0.00	91.11
Cattle Treated for Digestive Disorder	%	6.86	10.87	0.00	79.73

Table 3.1. Descriptive Statistics (cont.)

Variable	Description	% of Pens in Category
Categorical		
Shrink		
Shrink > 5.5 percent	Outlier shrink	9.87
Shrink <= 5.5 percent	Normal shrink	90.13
Region Origin		
Southern Plains	Cattle sourced from Southern Plains	90.40
Other Region	Cattle sourced from other region	9.60
Pen Type (Cattle Type)		
Other Cattle	Other cattle including cows, Holsteins, and mix of steers and heifers	5.13
Heifer	Heifers	35.49
Steer	Steers	59.38
Origin		
Other Origin	Cattle sourced from wheat pasture, growing yard or backgrounding program	4.94
Sale barn & Other	Cattle sourced from combination of sale barn and country ranch, wheat pasture or growing yard	2.27
Country	Cattle sourced from country ranches	32.53
Sale barn	Cattle sourced from sale barn	60.26
Month		
January	Closeout in January	10.24
February	Closeout in February	7.40
March	Closeout in March	7.34
April	Closeout in April	8.70
May	Closeout in May	8.05
June	Closeout in June	7.57
July	Closeout in July	10.57
August	Closeout in August	8.73
September	Closeout in September	8.63
October	Closeout in October	7.78
November	Closeout in November	7.38
December	Closeout in December	7.62

Note: Variable category in *Italics* is used as reference in the estimations.

Table 3.2. Estimation Results

Variable	Coefficients	Std. Error	Marginal effects
Intercept	1.520	0.424**	
Continuous			
In-Weight	-0.003	0.000**	-0.002
Pen Size	0.006	0.001**	0.004
Sick Head Days	0.280	0.033**	0.185
Cattle Treated with Antibiotic for Respiratory Disease	0.190	0.005**	0.126
Cattle Treated for Digestive Disorder	-0.088	0.005**	-0.058
Categorical			
Shrink			
Shrink > 5.5 percent	0.015	0.154	0.010
Shrink <= 5.5 percent	-	-	-
Region Origin			
Southern Plains	-0.841	0.156**	-0.557
Other Region	-	-	-
Pen Type (Cattle Type)			
Other Cattle	0.957	0.225**	0.634
Heifer	0.002	0.981	0.002
Steer	-	-	-
Origin			
Other Origin	0.729	0.210**	0.483
Sale barn & Other	-0.444	0.270	-0.294
Country	-0.488	0.095**	-0.323
Sale barn	-	-	-
Month			
January	0.197	0.190	0.130
February	-0.038	0.207	-0.025
March	0.221	0.209	0.146
April	0.350	0.200*	0.232
May	0.218	0.204	0.145
June	0.509	0.204**	0.337
July	0.114	0.188	0.076
August	0.204	0.196	0.135
September	-	-	-
October	0.135	0.202	0.089
November	0.345	0.206*	0.228
December	0.028	0.205	0.018
Conditional variance			
Constant (σ)	2.780	0.070**	
In-Weight (η)	-0.003	0.001**	
Log-Likelihood	-11820		

Note: Double and single asterisks (**, *) indicate significant at 5% and 10% level.

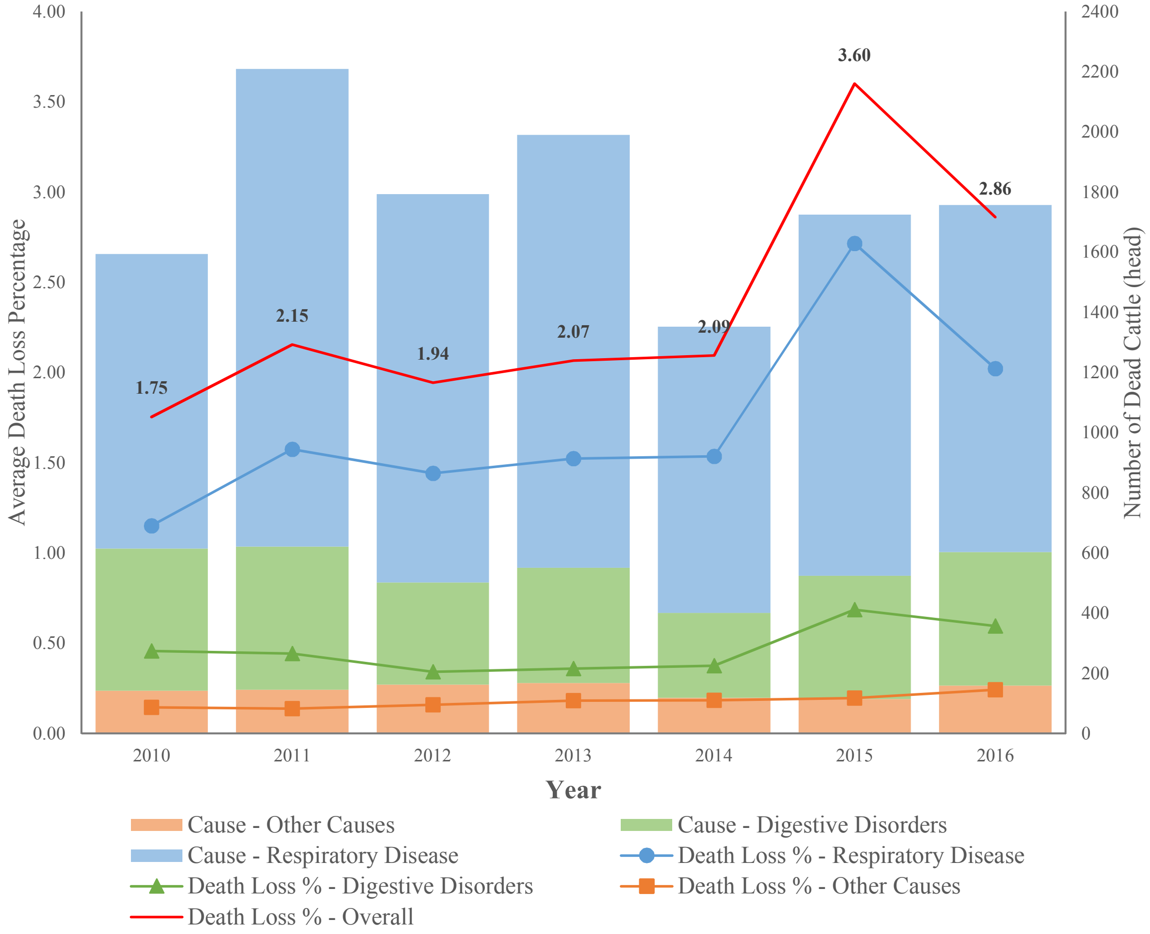


Figure 3.1. Feedlot Death Loss by Year

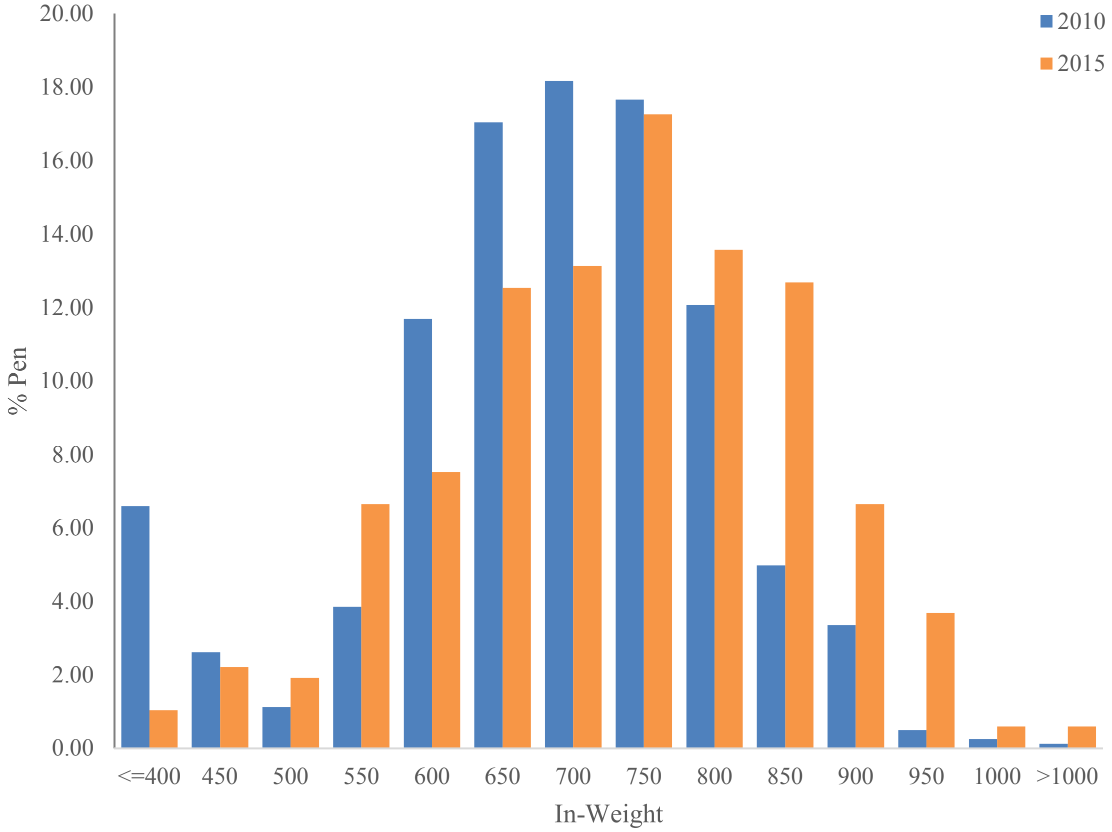


Figure 3.2. Distribution of In-Weight in 2010 and 2015

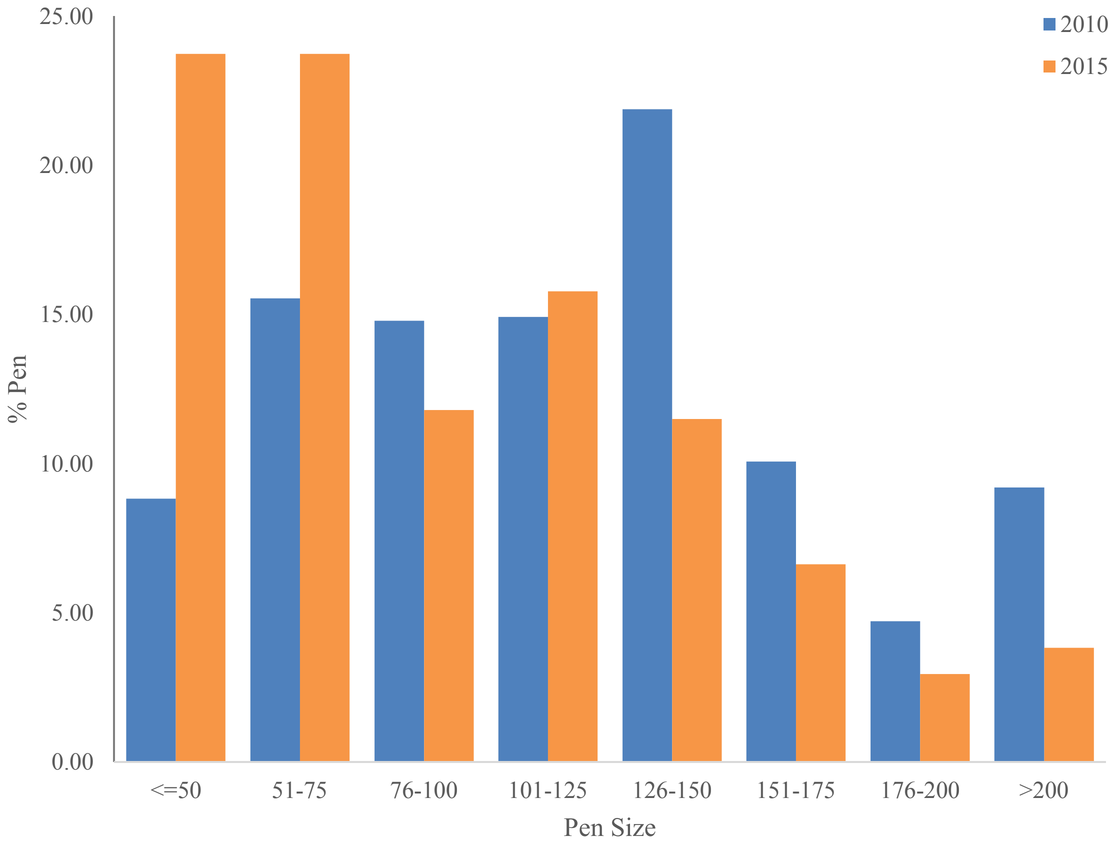


Figure 3.3. Distribution of Pen Size in 2010 and 2015

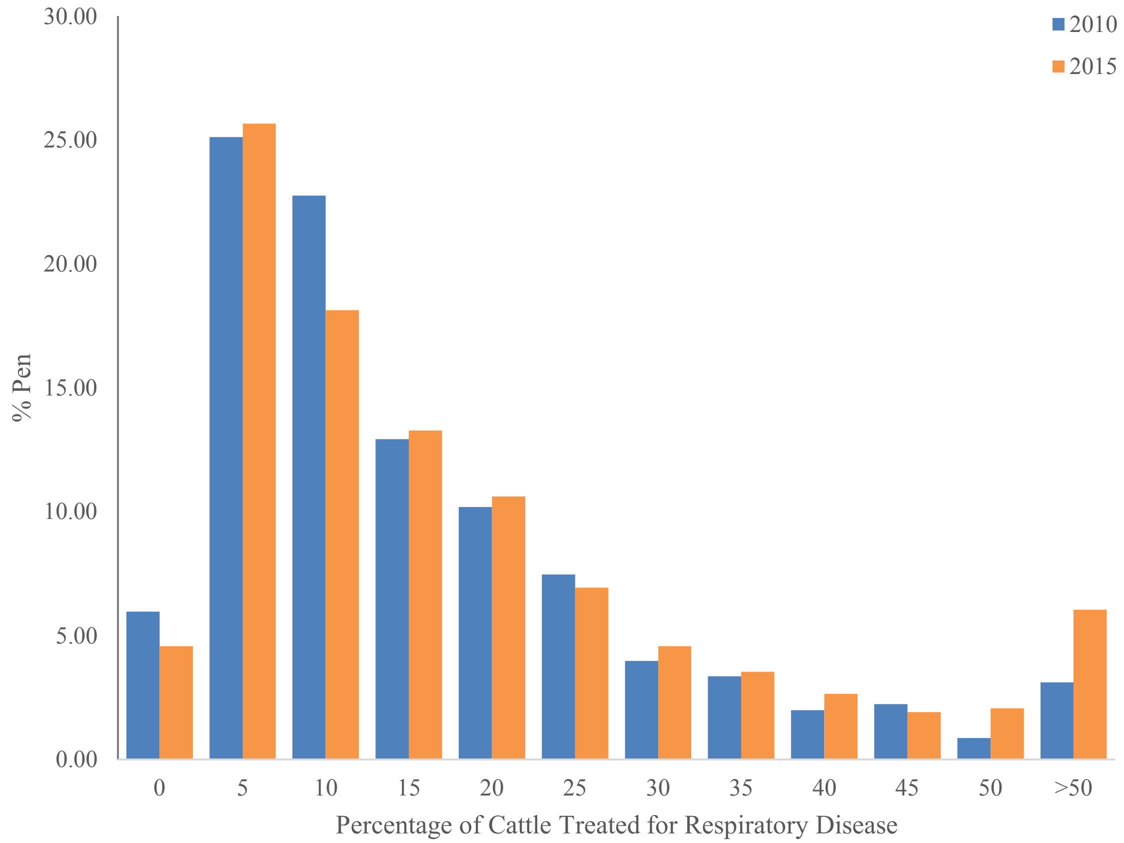


Figure 3.4. Distribution of Percentage of Cattle Treated for Respiratory Disease in 2010 and 2015

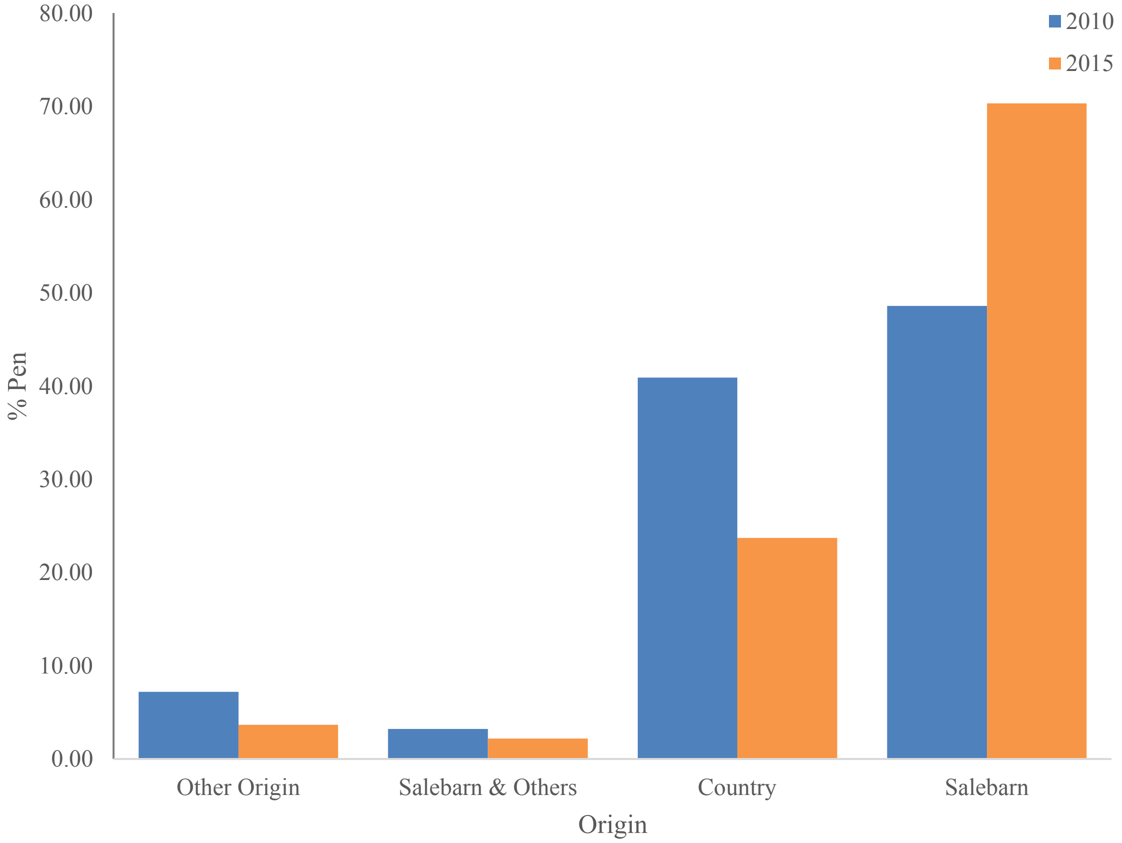


Figure 3.5. Distribution of Cattle Origin (Market Source) in 2010 and 2015

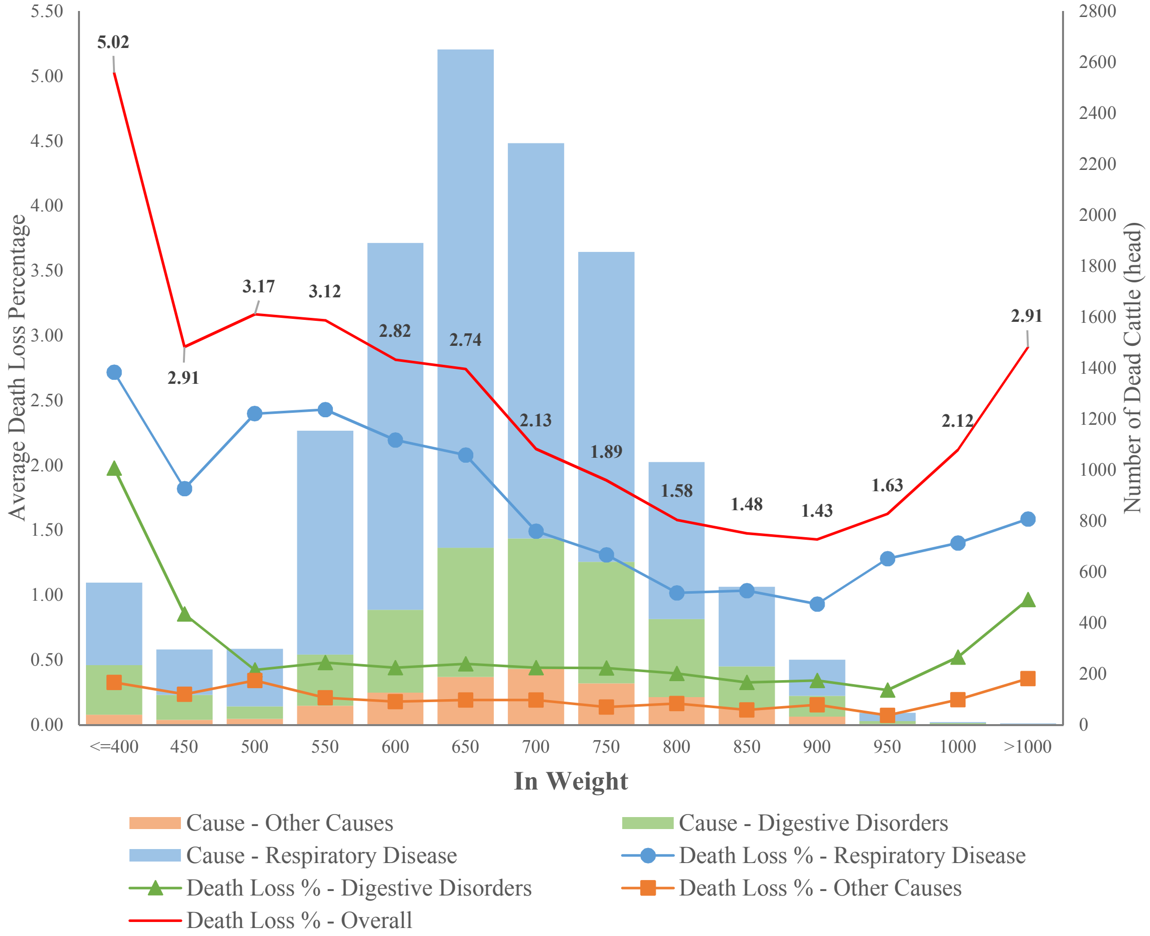


Figure 3.6. Feedlot Death Loss by In-Weight

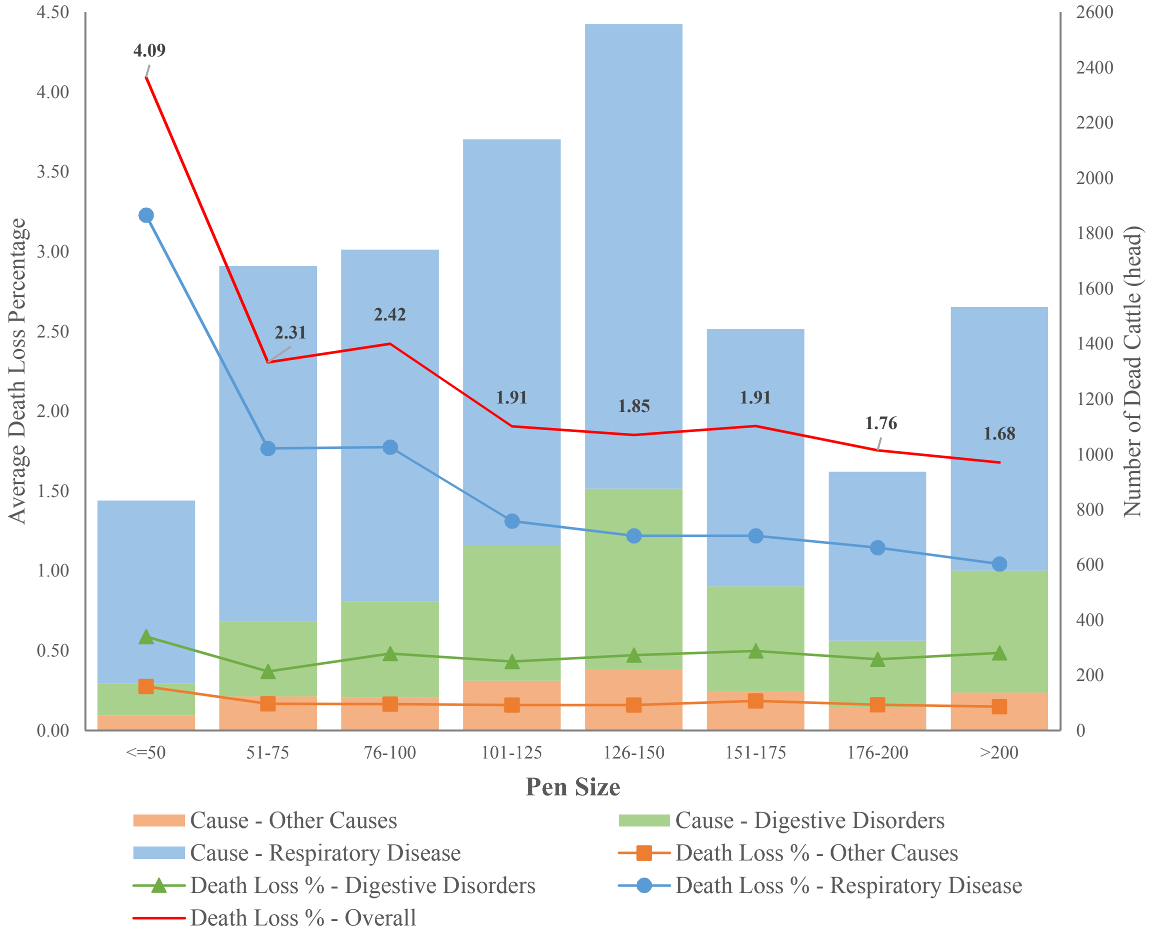


Figure 3.7. Feedlot Death Loss by Pen Size

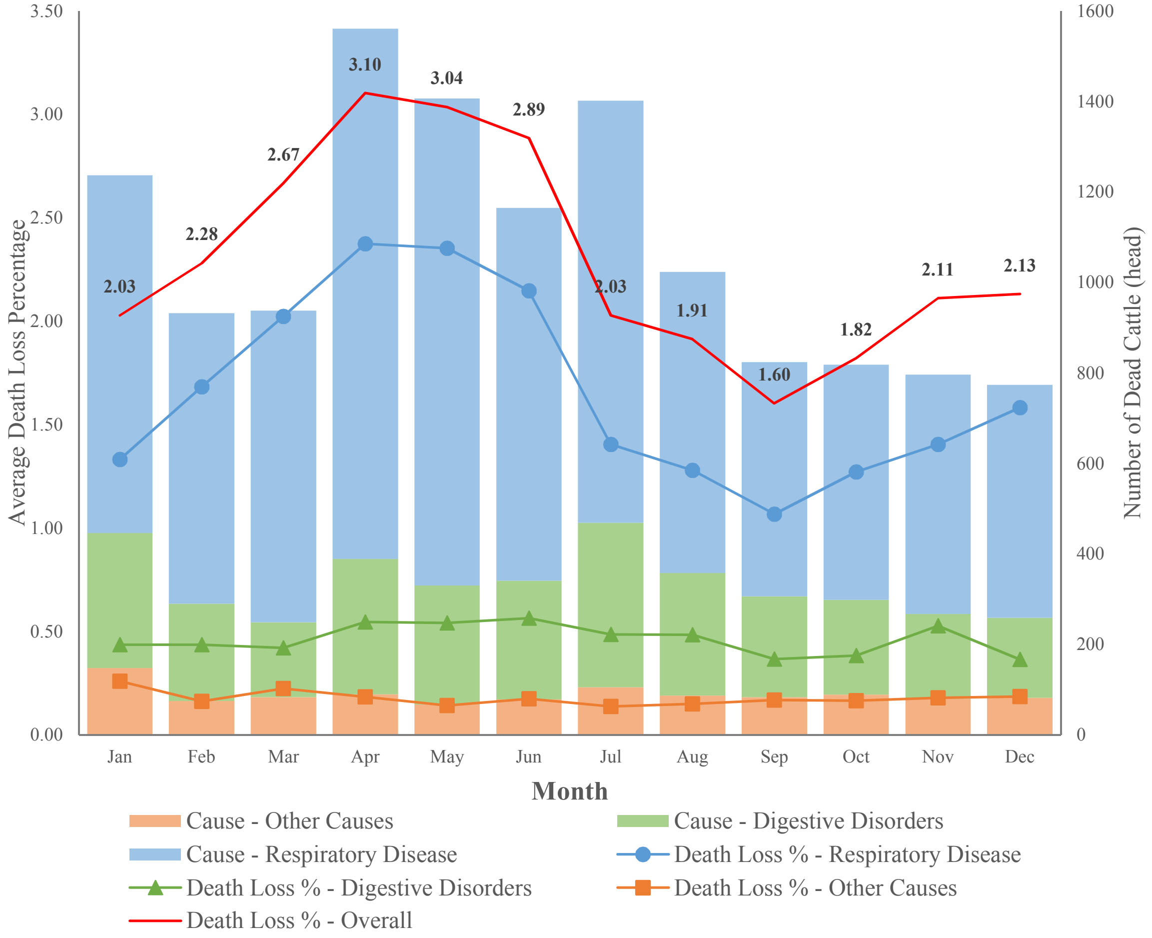


Figure 3.8. Feedlot Death Loss by Month

CHAPTER IV

THE IMPACT OF STEER PLACEMENT CHARACTERISTICS ON FEEDLOT PROFITABILITY

Introduction

Net returns for cattle feeding operation are highly varied, caused mostly by variation in fed, feeder and corn prices. During the period of January 2002 – January 2018, monthly net returns for steer finishing in Kansas feedlots ranged from $522 loss to $384 profit per head (Tonsor 2018). During the same period, fed steer prices and feeder steer prices ranged between $63 and $170 per cwt and between $78 and $238 per cwt, respectively. While variation in prices of fed and feeder cattle sometimes have greater impacts on net returns, corn price impacts feed cost. Monthly corn price fluctuated between $2.25 and $8.05 per bushel during the period of January 2001 – December 2017 (LMIC 2018a). Corn price exceeded $4.00 for the first time in January 2007, reaching a peak of $8.05 in October 2012. Since January 2016, corn prices have remained below $4.00 again.

Besides the uncertainty of prices, net returns are also affected by cattle sickness (morbidity) and death loss (mortality). Cattle sickness and death loss cost the feedlot in terms of feed, treatment, and labor, in addition to lost revenue (Loneragan, et al. 2001). Generally, when placement weight increases, the impact of feeder cattle prices on net returns is more (Daley 2007). At the same time, heavy weight feeder cattle are more resistant to sickness and stress, reducing the possibility of death. Sickness can be easily spread in feedlot. Intuitively, there is greater chance for more cattle to be affected by sickness in a pen with a large number of cattle compared to a pen with smaller number of cattle. Additinally, sick cattle may be more easily detected in a small pen.

The possibility of morbidity and death loss may be impacted by cattle sourcing. Feeder cattle that travel longer distance may experience greater stress and potential exposure to sickness. The origin of feeder cattle such as sale barns, country ranches, growing yards, and other backgrounding operations may influence the likelihood of sickness and death loss. For example, Step, et al. (2008) found that sale barn-sourced steers are treated more often for bovine respiratory disease and have higher death loss rates compared to ranch-sourced steers.

Seasonality in prices and in illness or death loss may also affect net returns. The impact of feeder cattle prices on net returns is higher for cattle placed in spring and fall (Daley 2007). Death loss rates for catlle closeouts in April is higher than other months (Babcock, Jones and Langemeier 2006). Fed price are usually highest in late spring.

In study by Anderson and Trapp (2000), placement weights, slaughter weights, ration cost, feed conversion rates, and death loss were incorporated in a feeder price model. However, inclusion of death loss is only for conceptual completeness and they suggest that death loss only has a small impact on revenue variable. Thompson, et al. (2016) use relatively similar model to estimate net return for feedlot cattle in three different marketing methods. Death loss was predetermined rather than estimated in this study because the main objective is to estimate the expected value of genetic information.

Both previous studies (Thompson, et al. 2016; Anderson and Trapp 2000) treat death loss as a predetermined factor. In this study, however, death loss is estimated rather than predetermined. The purpose of this study is to estimate expected revenue and total cost for a feedlot based on placement characteristics decisions, including in-weights, feeder steer geographic source, market source, and cattle type. Placement, source, and treatment determine expected death loss rate in this study. The results of this study represent, in part, the economic value of managing death loss in feedlot operation.

Modeling, Data, and Assumption

A conceptual model of recursive system for feedlot expected net returns is shown in Figure 4.1. The recursive system is modified based on the model by Anderson and Trapp (2000). Feedlots are assumed to maximize expected profit by choosing placement weight, cattle type (pen type), source of cattle, and pen size. Percentages of cattle treated for respiratory disease and digestive disorder are random variables that are jointly distributed. The general equations based on the recursive system are given below.

(4.1) *Placement Weight = In-Weight / (1 – Shrinkage)*

(4.2) *Sale Weight = f (In-Weight, Structural Break, Monthly Dummies)*

(4.3) *Fed Price = f (Monthly Dummies)*

(4.4) *Expected Death Loss = f (In-Weight, Pen Size, Percentage of Sick Head Days, Dummy for Shrinkage > 5.5%, Percentage of Cattle Treated for Respiratory Disease, Percentage of Cattle Treated for Digestive Disorders, Cattle Geographical Source, Cattle Type, Cattle Market Source, Monthly Dummies)*

(4.5) *Feeder Price = f (In-Weight Classes, Monthly Dummies)*

(4.6) *Ration Cost = f (Corn Price, Time Trend, Monthly Dummies)*

(4.7) *Feed Cost = Feed Intake × Ration Cost × Days on Feed*

(4.8) *Expected Revenue = Feeder Price × Sale Weight × (1 – Pencil Shrink) × (1 – Death Loss)*

(4.9) *Total Cost = Feeder Price × Placement Weight + Feed Cost + Treatment Cost + Yard Cost*

(4.10) *Expected Net Return = Expected Revenue – Total Cost – Interest Cost*

Specifically, expected profit per head (net return) can be written as follows:

$$\text{(4.11)} \quad \mathrm{E}[\Pi] = FEDP \times SALEWT \times (1 - PS) \times (1 - \mathrm{E}[DL]) \\ - (FEEDERP \times PWT) - FEEDC - TREATCR - TREATCD \\ - YARDC - INTC$$

where *FEDP* is fed price, *SALEWT* is sale weight, *PS* is pencil shrink upon sales of fed cattle, E[*DL*] is expected death loss percentage, *FEEDERP* is feeder price, *PWT* is placement weight, *FEEDC* is feed cost, *TREATCR* is treatment cost for respiratory disease, *TREATCD* is treatment cost for digestive disorders, *YARDC* is yardage cost, and *INTC* is interest cost.

Parameters for expected death loss percentage in Equation 4.4 were estimated with a Tobit model using cross-sectional data from a private feedlot in Southern Plains, as in Chapter III. It is specified as a function of in-weight (*INWT*) which is placement weight minus shrinkage, pen size (*PSIZE*), shrinkage where 1 = shrinkage greater than 5.5 percent (*SDUM*), sick head days as percentage of sick head days over total head days (*SHD*), percentage of cattle treated for respiratory disease (*CTRES*), percentage of cattle treated for digestive disorders (*CTDIG*), geographical source where 1 = cattle sourced from the Southern Plains (*SP*), cattle type either steer, heifer (*HEIFER*) or other cattle(*OTRCT*), cattle origin either sale barn, country (*COUNTRY*), combination of sale barn and other (*SBOTR*), or other origin (*OTROR*), and monthly dummies. A correction for heteroskedasticity associated with in-weight was implemented in the estimation. The model was estimated with SAS Enterprise Guide 6.1 using the PROC QLIM (qualitative and limited dependent variable model) procedure. The estimated death loss percentage model is given below with standard errors in parentheses.

$$
\begin{array}{lllllll}
(4.12) & \mathrm{E}[\mathit{DL}] & = 1.520 & -\ 0.003\ \mathit{INWT} & +\ 0.006\ \mathit{PSIZE} & +\ 0.015\ \mathit{SDUM} \\
 & & \ (0.424) & \ (0.000) & \ (0.001) & \ (0.154) \\[1em]
 & & & +\ 0.280\ \mathit{SHD} & +\ 0.190\ \mathit{CTRES} & -\ 0.088\ \mathit{CTDIG} \\
 & & & \ (0.033) & \ (0.005) & \ (0.005) \\[1em]
 & & & -\ 0.841\ \mathit{SP} & +\ 0.957\ \mathit{OTRCT} & +\ 0.002\ \mathit{HEIFER} \\
 & & & \ (0.156) & \ (0.225) & \ (0.096) \\[1em]
 & & & +\ 0.729\ \mathit{OTROR} & -\ 0.444\ \mathit{SBOTR} & -\ 0.488\ \mathit{COUNTRY} \\
 & & & \ (0.210) & \ (0.270) & \ (0.095) \\[1em]
 & & & +\ 0.135\ \mathit{OCT} & +\ 0.345\ \mathit{NOV} & +\ 0.028\ \mathit{DEC} \\
 & & & \ (0.202) & \ (0.206) & \ (0.205) \\[1em]
 & & & +\ 0.197\ \mathit{JAN} & -\ 0.038\ \mathit{FEB} & +\ 0.221\ \mathit{MAR} \\
 & & & \ (0.190) & \ (0.207) & \ (0.209) \\[1em]
 & & & +\ 0.350\ \mathit{APR} & +\ 0.218\ \mathit{MAY} & +\ 0.509\ \mathit{JUN} \\
 & & & \ (0.200) & \ (0.204) & \ (0.204) \\[1em]
 & & & +\ 0.114\ \mathit{JUL} & +\ 0.204\ \mathit{AUG} & \\
 & & & \ (0.188) & \ (0.196) &
\end{array}
$$

Sale weight in Equation 4.2 was estimated as mixed model with a year random effect using the same cross-sectional data from a private feedlot in Southern Plains. It is a function of in-weight and monthly dummies. The model was estimated with SAS

Enterprise Guide 6.1 using the PROC MIXED procedure. The estimated sale weight model for steer is given below with standard errors in parentheses.

$$
\begin{aligned}
(4.13)\quad SALEWT = {} & \underset{(12.447)}{1018.96} + \underset{(0.009)}{0.476}\, INWT + \underset{(4.284)}{4.261}\, OCT + \underset{(4.371)}{18.142}\, NOV \\
& + \underset{(4.378)}{13.369}\, DEC - \underset{(4.026)}{2.314}\, JAN - \underset{(4.263)}{35.200}\, FEB \\
& - \underset{(4.352)}{40.415}\, MAR - \underset{(4.214)}{53.577}\, APR - \underset{(4.398)}{34.408}\, MAY \\
& - \underset{(4.350)}{17.306}\, JUN - \underset{(3.988)}{2.143}\, JUL - \underset{(4.203)}{7.065}\, AUG
\end{aligned}
$$

Although fed price in Figure 4.1 is assumed to be exogenous, fed price in this study was actually estimated as a price response function incorporating seasonality. The five area average (Texas-Oklahoma, Kansas, Nebraska, Colorado, and Iowa-Minnesota) of monthly fed prices from January 2001 to December 2017, obtained from LMIC (2018c) was used to estimate fed steer price response. Fed price is specified as a function of monthly dummies and a dummy variable for the period beginning in January 2012 where fed price began to exceed \$100 per cwt (*BREAK*). The model was estimated with SAS Enterprise Guide 6.1 using the PROC AUTOREG procedure. The estimated fed steer price response function was corrected for autocorrelation using Yule-Walker method of generalized least squares and is given below with standard errors in parentheses:

$$\begin{array}{lllllll}
(4.14) & FEDP & = 95.070 & + \ 13.385\ BREAK & + \ 0.742\ OCT & + \ 2.504\ NOV \\
 & & \ \ \ (3.679) & \ \ \ (3.593) & \ \ \ (0.994) & \ \ \ (1.469) \\
 & & & + \ 1.465\ DEC & + \ 2.350\ JAN & + \ 2.858\ FEB \\
 & & & \ \ \ (1.767) & \ \ \ (1.966) & \ \ \ (2.069) \\
 & & & + \ 5.194\ MAR & + \ 4.867\ APR & + \ 3.759\ MAY \\
 & & & \ \ \ (2.101) & \ \ \ (2.066) & \ \ \ (1.961) \\
 & & & + \ 0.684\ JUN & - \ 0.692\ JUL & + \ 0.014\ AUG \\
 & & & \ \ \ (1.771) & \ \ \ (1.470) & \ \ \ (0.994)
\end{array}$$

$$\begin{array}{llll}
\rho_1 = - 1.109 & & \rho_2 = 0.196 \\
\quad\ \ (0.071) & & \quad\ \ (0.071)
\end{array}$$

Feeder price (Equation 4.5) was also estimated as a price response function of different weight classes and months. Monthly feeder prices for five different weight groups including 400 – 499 pounds (*WT1*), 500 – 599 pounds (*WT2*), 600 – 699 pounds (*WT3*), 700 – 799 pounds (*WT4*), and 800 – 899 pounds from January 2001 to December 2016, obtained from LMIC (2018b), were used to estimate feeder steer price response. The function was estimated as a mixed model with year random effect and heteroskedasticity induced by weight class. The model was estimated with SAS Enterprise Guide 6.1 using the PROC MIXED procedure. The estimated feeder steer price response function is given below with standard errors in parentheses.

$$\begin{array}{llllll}
(4.15) & FEEDERP = & 121.440 & + 36.873\,WT1 & + 23.593\,WT2 & + 13.133\,WT3 \\
 & & (10.297) & (1.739) & (1.409) & (1.204) \\
 & & & + 5.969\,WT4 & - 1.626\,OCT & - 1.156\,NOV \\
 & & & (1.125) & (2.080) & (2.080) \\
 & & & - 2.427\,DEC & - 6.475\,JAN & - 6.472\,FEB \\
 & & & (2.080) & (2.080) & (2.080) \\
 & & & - 4.065\,MAR & - 2.667\,APR & - 2.127\,MAY \\
 & & & (2.080) & (2.080) & (2.080) \\
 & & & - 0.379\,JUN & + 0.845\,JUL & + 1.511\,AUG \\
 & & & (2.080) & (2.080) & (2.080)
\end{array}$$

Feed cost is an identity equation defined as the followings.

$$FEEDC = FI \times RC \times DOF \tag{4.16}$$

where *FI* is daily feed intake, *RC* is daily ration cost, and *DOF* is days on feed. Daily feed intake and days on feed are predetermined by in-weight and cattle type. Mean values for feed intake and days on feed by in-weight and cattle type are based on the private feedlot in Southern Plains. These values togather with means of shrinkage percentage (*SHRINK*) and sick head days (*SHD*) are reported in Table 4.1. Ration cost was estimated from monthly data of Kansas feedlots from January 2001 to December 2017 period, obtained from LMIC (2018a). Monthly reported cost of gain (*COG*) and feed to gain ratio (*FG*) are used to calculate ration cost as:

$$RC = \frac{COG}{FG} \tag{4.17}$$

Ration cost (Equation 4.6) is then specified as a function of corn price (*CORNP*), time trend (*T*), and monthly dummies. The model was estimated with SAS Enterprise Guide 6.1 using the PROC AUTOREG procedure. The estimated steer ration cost was corrected for autocorrelation using Yule-Walker method of generalized least squares and is reported below with standard errors in parentheses.

$$
\begin{array}{lllllll}
(18) & RC & = 0.0499 & + \; 0.0123\,CORNP & + \; 0.0002\,T & + \; 0.0008\,OCT \\
 & & \;\;\;(0.0046) & \;\;\;(0.0010) & \;\;\;(0.0000) & \;\;\;(0.0008) \\
 & & & + \; 0.0012\,NOV & - \; 0.0010\,DEC & - \; 0.0002\,JAN \\
 & & & \;\;\;(0.0013) & \;\;\;(0.0016) & \;\;\;(0.0017) \\
 & & & - \; 0.0005\,FEB & - \; 0.0001\,MAR & + \; 0.0014\,APR \\
 & & & \;\;\;(0.0019) & \;\;\;(0.0019) & \;\;\;(0.0019) \\
 & & & + \; 0.0024\,MAY & + \; 0.0010\,JUN & - \; 0.0003\,JUL \\
 & & & \;\;\;(0.0017) & \;\;\;(0.0015) & \;\;\;(0.0012) \\
 & & & - \; 0.0003\,AUG & & \\
 & & & \;\;\;(0.0008) & & \\
 & \rho_1 & = -1.233 & & \rho_2 = 0.349 & \\
 & & \;\;\;(0.068) & & \;\;\;(0.068) &
\end{array}
$$

Other costs, including treatment cost, yard cost, and interest cost, are also defined as an identity equation. Treatment costs are calculated according to the following equation:

$$(4.19) \qquad TREATC_j = CPT_j \times PSIZE \times CT_j$$

where $TREATC_j$ is treatment cost and $j = 1$ is respiratory disease and $j = 2$ is digestive disorder, CPT_j is cost per treatment unit, $PSIZE$ is pen size, and CT_j is percentage of cattle treated (assumming only single treatment per head). Yardage cost of \$0.56 per day is taken from the mean of Kansas feedlots. Interest cost is computed based on an 8% interest rate on total cost of feeding cattle according to Ellis and Schulz (2018) and Lardy (2013).

Procedures and Scenarios

Expected net returns are calculated based on the relationship of variables in Figure 4.1. Choice variables including in-weight, pen size, cattle type (pen type), cattle source geographic location and market source type are predetermined. Only net returns for steers (cattle type) sourced from the Southern Plains (geographic location) are calculated in this study.

Random variables, specifically the percentage of cattle treated for respiratory disease and digestive disorders, are simulated as two dependent uniform standard variables. First, the variance-covariance matrix between these two variables was estimated using the pen-level observations from the private feedlot in Southern Plains. The variance-covariance was estimated with SAS Enterprise Guide 6.1 using the PROC CALIS procedure. Next, Cholesky decomposition of a two-by-two variance-covariance matrix between these two variables was calculated using the PROC IML (interactive matrix language) procedure. The Cholesky coefficients are calculated as below.

$$\begin{bmatrix} \Phi^{-1} & 0 \\ \rho\Phi^{-1} & \sqrt{1-\rho^2}\Phi^{-1} \end{bmatrix} = \begin{bmatrix} 10.22 & 0 \\ 7.42 & 10.30 \end{bmatrix} \tag{4.20}$$

where Φ^{-1} is the inverse of normal cumulative distribution function and ρ is the correlation coefficient. To simulate these two dependent random variables, two independent uniform standard variables (Z_1 and Z_2) are generated using a random real number generator. Then the Cholesky coefficients are used to calculate the two dependent random variables based on equations 4.21 and 4.22:

$$CTDIG = 10.22(Z_1) + 0 \tag{4.21}$$

$$CTRES = 7.42(Z_1) + 10.30(Z_2) \tag{4.22}$$

where $CTDIG$ is percentage of cattle treated digestive disorders and $CTRES$ is percentage of cattle treated for respiratory disease.

Corn prices are generated from \$2.20 to \$8.10 by \$0.10 given the range of corn prices during the period of January 2001 – December 2017. Expected net return per head are calculated for twelve scenarios. Table 4.2 describes scenarios 1 through 12.

The first eight scenarios calculate expected net returns for five in-weight categories including 450 pounds, 550 pounds, 650 pounds, 750 pounds, and 850 pounds across pen sizes of 75 or 150, cattle origin of sale barn or country, and July or January closeout. The selected pen sizes and cattle origins are common scenarios in a Southern Plains feedlot, while July and January closeout represent cold and warm weather, and different feeding periods.

Scenarios 9 and 10 represent light in-weight steers (450 pounds) versus heavy in-weight steers (850 pounds). Both scenarios are for pen size of 110 (mean pen size for a Southern Plains feedlot) and cattle sourced at sale barns. Expected net returns for each closeout month are calculated in these scenarios.

In scenario 11, expected net returns for twelve different pen sizes defined by 25 head intervals, from 25 head count to 300 head count, are calculated. This scenario assumes an in-weight of 650 pounds and cattle sourced at sale barns. The closeout month is September where death loss rate is typically lowest. Meanwhile, scenario 12 assumes cattle origin of sale barn or country and a closeout month of January, April, July, or October. In-weight and pen size are set at 650 pounds and 110 head, respectively.

Results

To illustrate expected net returns for each scenario, cumulative distribution function (CDF) graphs are created using SAS Enterprise Guide 6.1. Each scenario has 12000 simulated iterations comprised of 200 random variables of treatment percentages and 60 corn prices. CDFs for expected net return on the right are preferred to those on the left. The sensitivity of expected net return with respect to corn price is also analyzed using the sensitivity elasticity computed in the simulation.

Results for Scenarios 1 to 8

Scenarios 1 to 8 compare net returns for five in-weights differing by pen size, cattle origin, and closeout month. Figures 4.2 to 4.9 depict the CDF graphs of expected net returns for scenarios 1 to 8. Scenarios 1 to 4, July closeout, show that an in-weight of 850 pounds is preferred to lighter in-weights. However, in scenarios 5 to 8, January closeout, in-weights of 650 and 850 pounds are preferred to other in-weights. An in-weight of 450 pounds is the least preferred in all scenarios. In general, heavy weight feeder cattle are more profitable than light weight feeder cattle. Heavy weight feeder cattle take shorter feeding periods to reach sale weight as compared to light weight feeder cattle. Thus, less cost, especially feed cost, is attached to heavy weight feeder cattle.

Comparing pens size of 75 and 150 for the same cattle origin and closeout month, the smaller pen size of 75 is preferred to 150. For example, about 38 percent of feeder steers with 850 pound in-weights in scenario 1 make profit compared to 31 percent in scenario 2. Also, a comparison of scenario 2 and scenario 4, where 33 percent of 850 pound in-weight feeder steers make profit, suggests that country-sourced feeder cattle are preferred to sale barn-sourced feeder cattle.

For closeout month July, 450 pounds feeder steers in scenarios 1 to 4 do not make profit. However, feeder steers in-weights of 650, 750, and 850 pounds for July closeout make greater profits than for January closeout. Feeder steers of 650, 750, and 850 pounds generate closer net returns to each other. In scenarios 1 to 8, at least 15 percent of these feeder steers make profits.

Table 4.3 summarizes the sensitivity elasticities of net return with respect to corn price for scenarios 1 to 8. In all scenarios, net return sensitivity to corn price is increasing as in-weight of feeder steers increase. For example, in scenario 3, a one percent increase in corn price will decrease net return for 450 pound in-weight feeder steers by 1.86 percent and decrease net return for 850 pound in-weight feeder steers by 10.19 percent. This may be influenced by the sensitivity of feeder cattle price to corn price. Boete (2016) reports that feeder cattle price for cattle weighing 800 – 900 pounds was very sensitive to corn price changes from September 2013 to August 2016. However, for lighter placed feeder cattle of 600 – 800 pounds, the price is not significantly affected by corn price change.

Results for Scenarios 9 and 10

Net returns for each closeout month between light in-weight feeder steers (450 pounds) and heavy in-weight feeder steers (850 pounds) are compared in scenarios 9 and 10. The CDF of expected net returns for scenario 9 is shown in Figure 4.10. November closeout is preferred to other months with 15 percent of light weight feeder steers making profit. The highest possible profit is $77 per head. At least 95 percent of light weight feeder steers in January to August closeouts have negative net returns. June and July closeouts are the least preferred for light weight feeder steers, while late fall closeouts (September – December) are better options.

Figure 4.11 shows the CDF graph of the expected net returns for scenario 10. November closeout is still preferred to other months for heavy weight feeder steers. About 36 percent of feeder steers make profit at this closeout month. In contrast to light weight feeder steers, June and July closeouts for heavy weight feeder steers turn out to be preferable to other months besides November. About 33 percent and 35 percent of feeder steers make profit for both June and July closeout, respectively. The least preferred closeout month for heavy weight feeder steers is February with only 13 percent of the steers making profit. Feedlots may prefer heavy weight to light weight feeder steers for summer closeout months.

The sensitivity elasticities of net return with respect to corn price for scenarios 9 and 10 are summarized in Table 4.4. Overall, heavy weight feeder steers have more sensitive net returns to corn price than light weight feeder steers. This is aligned with findings in scenarios 1 to 8. Net return for November closeout is most sensitive to corn price in both scenario 9 and 10. A one percent increase in corn price will decrease net return for light weight feeder steers by 2.94 percent and decrease net return for heavy weight feeder steers by 7.66 percent. For light weight feeder steers, net return sensitivity to corn price in late fall closeout months (September – December) is at least 2.30 percent. A one percent increase in corn price will decrease net return by at least 2.30 percent. For heavy weight feeder steers, other than closeouts in June, July, and November, net return sensitivity to corn price is less than 6 percent. There are between 3.18 percent and 5.52 percent. In summer closeout months (June and July), net return for heavy weight feeder steers is very sensitive to corn price. The sensitivity elasticities are 6.63 percent and 7.15 percent for June and July closeouts, respectively.

Results for Scenarios 11

In scenario 11, expected net returns for twelve different pen sizes are compared. Recall that this scenario uses an in-weight of 650 pounds steers, origin of sale barn, and September closeout. Figure 4.12 shows the CDF graph of the expected net returns for scenario 11. Overall, smaller pen size is always preferred to larger pen size. About 34 percent of feeder steers in the smallest pen size of 25 head make profit. As the pen size increases, the percentages of feeder steers making profit are declining. Only 9 percent of feeder steers in the largest pen size of 300 head make profit. This outcomes confirm the findings in scenarios 1 to 8. Holding in-weight, cattle origin, and closeout month constant, small pen size is preferred to large pen size.

Table 4.5 summarize the sensitivity elasticities of net return with respect to corn price for scenarios 11. The net return sensitivity elasticities are between 2.98 percent and 5.96 percent. Sensitivity elasticities of net return with respect to corn price for pen size of 25 and 50 head are above 5 percent, which are very sensitive. Meanwhile, pen sizes of 150 head and greater have sensitivity elasticities less than 4 percent, indicate that the net return for large pen size is less sensitive to corn price compared to small pen size.

Results for Scenarios 12

Scenario 12 compares expected net returns between cattle sourced from sale barns and country for closeout months of January, April, July, and October. Recall that this scenario uses in weight of 650 pounds and pen size of 110 head. The CDF graph of the expected net returns for scenario 12 is shown in Figure 4.13. For all closeout months, country-sourced feeder steers is always preferred to sale barn-sourced feeder steers. For specific comparison, only the least and most preferred closeout months (April and July) are explained. In April closeouts, about 20 percent of country-sourced feeder steers make profit compared to about 17 percent for sale barn-sourced feeder steers. July closeout also shows that more country-sourced feeder steers make profit compared to sale barn-sourced feeder steers, with about 30 percent for country-sourced and about 27 percent for sale barn-sourced.

The sensitivity elasticities for scenario 12 is summarized in Table 4.6. Overall, net return for country-sourced feeder steers is more sensitive to corn price than sale barn-sourced feeder steers. Sensitivity elasticities of net return with respect to corn price for country-sourced feeder steers are between 3.57 percent and 5.28 percent. For sale barn-sourced feeder steers, sensitivity elasticities are from 3.29 percent to 4.76 percent.

Conclusions

Cattle placement and market source have significant effects on feedlot profitability. The effects may depend on closeout month that implies a placement month based on feeding period. Generally, heavy weight feeder steers are more profitable than lightweight feeder steers. However, feedlots may not always be able to purchase heavy weight feeder cattle.

Findings in scenario 9 imply that purchasing light weight feeder cattle for late spring closeout may yield a better probability of making profit. Sensitivity of heavy weight feeder cattle net return to corn price suggest that purchasing light weight feeder cattle may reduce risk when corn price variability is high.

Decisions on pen size and cattle origin may improve net return and help manage death loss at the same time. From scenario 11, it may imply that optimum pen size is between 75 and 125 head. Net return for other pen sizes is either very sensitive or less sensitive to corn price. Scenario 12 indicates that feedlots should (if possible) source feeder cattle from country ranches directly rather than sale barn.

For future improvement, it may be interesting if one could use a random growth and carcass characteristics function to determine fed cattle prices as in the study by Thompson, et al. (2016) simultaneously with the death loss model in this study. Combining the fed cattle price and death loss models may improve the accuracy of simulated net returns.

Table 4.1. Mean Values of Feed Intake (FI), Days on Feed (DOF), Sick Head Days (SHD), and Shrinkage (SHRINK), Private Feedlot in Southern Plains, May 2009 – January 2017

Steers (lbs.)	FI (lbs.)	DOF (days)	SHD (%)	SHRINK (%)
400 - 500	16.97	247	0.94	3.85
500 - 600	17.94	204	1.06	3.68
600 - 700	19.35	177	0.94	3.45
700 - 800	21.03	159	0.66	2.86
800 - 900	22.69	141	0.42	2.39

Table 4.2. Summary of Scenarios 1 to 12

Scenario	In Weight	Pen Size	Origin	Closeout Month
1	450, 550, 650, 750, 850	75	Sale barn	Jul
2	450, 550, 650, 750, 850	150	Sale barn	Jul
3	450, 550, 650, 750, 850	75	Country	Jul
4	450, 550, 650, 750, 850	150	Country	Jul
5	450, 550, 650, 750, 850	75	Sale barn	Jan
6	450, 550, 650, 750, 850	150	Sale barn	Jan
7	450, 550, 650, 750, 850	75	Country	Jan
8	450, 550, 650, 750, 850	150	Country	Jan
9	450	110	Sale barn	Jan - Dec
10	850	110	Sale barn	Jan - Dec
11	650	25 - 300	Sale barn	Sep
12	650	110	Sale barn vs Country	Jan, Apr, Jul, Oct

Table 4.3. Sensitivity Elasticities of Net Return w.r.t. Corn Price for Scenarios 1 to 8

Steer (lbs.)	Sensitivity Elasticities Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
450	-1.80	-1.73	-1.86	-1.79	-2.21	-2.09	-2.31	-2.17
550	-2.84	-2.57	-3.01	-2.71	-3.36	-2.95	-3.63	-3.15
650	-5.40	-4.22	-6.02	-4.66	-4.24	-3.51	-4.64	-3.83
750	-5.93	-4.54	-6.58	-4.99	-3.77	-3.22	-4.01	-3.44
850	-8.84	-5.93	-10.19	-6.63	-4.16	-3.50	-4.40	-3.72

Table 4.4. Sensitivity Elasticities of Net Return w.r.t. Corn Price for Scenarios 9 and 10

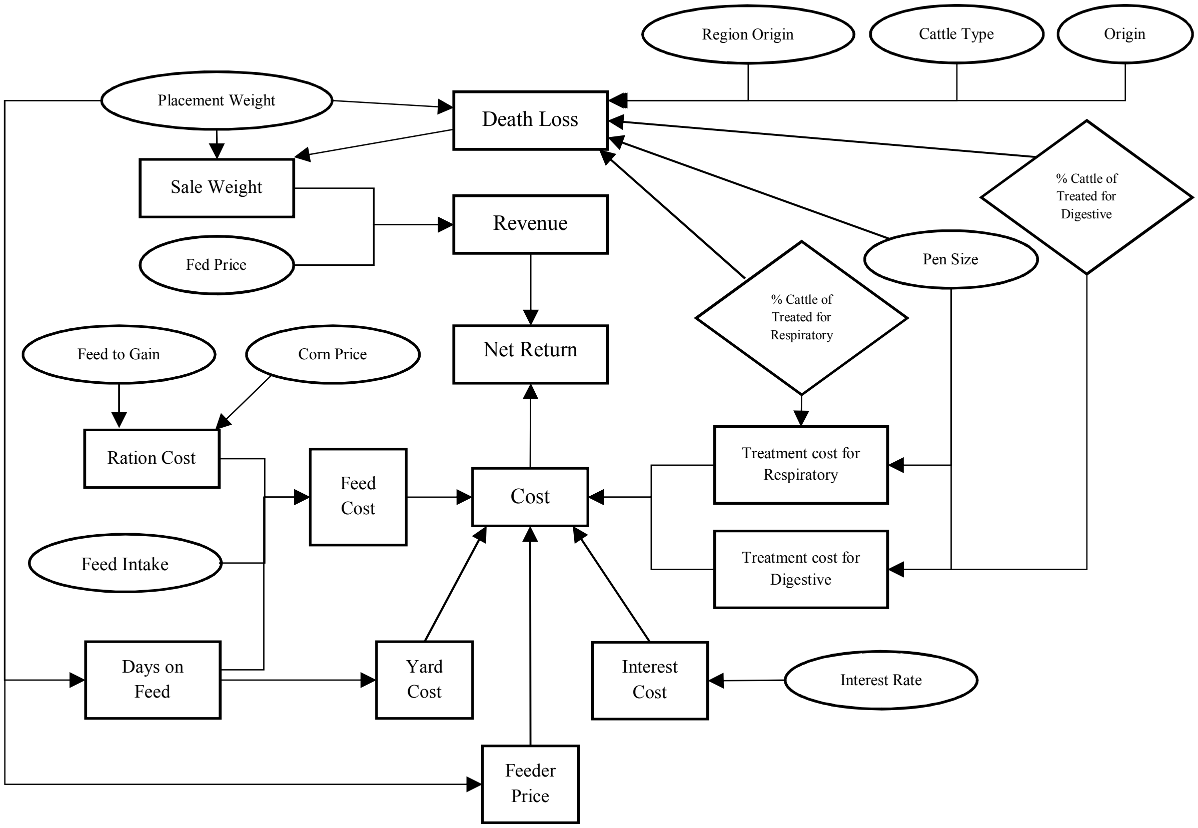
Closeout Month	Sensitivity Elasticities	
	Scenario 9 (Light Weight)	Scenario 10 (Heavy Weight)
Jan	-2.15	-3.82
Feb	-1.82	-3.18
Mar	-2.00	-5.52
Apr	-1.76	-3.59
May	-1.90	-5.35
Jun	-1.76	-6.63
Jul	-1.76	-7.15
Aug	-1.95	-4.68
Sep	-2.30	-4.06
Oct	-2.53	-4.42
Nov	-2.94	-7.66
Dec	-2.39	-4.62

Table 4.5. Sensitivity Elasticities of Net Return w.r.t. Corn Price for Scenario 11

Pen Size	Sensitivity Elasticities
25	-5.96
50	-5.38
75	-4.93
100	-4.55
125	-4.23
150	-3.96
175	-3.73
200	-3.53
225	-3.37
250	-3.22
275	-3.09
300	-2.98

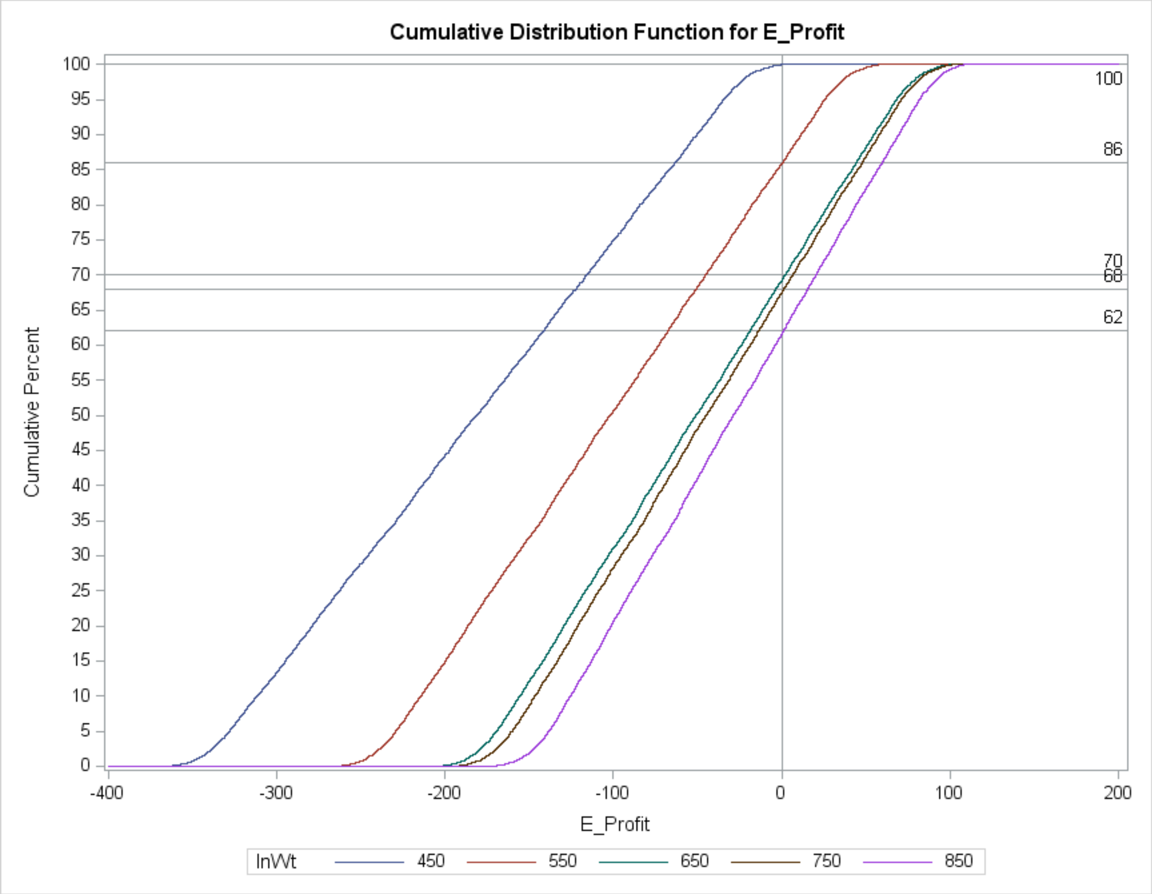
Table 4.6. Sensitivity Elasticities of Net Return w.r.t. Corn Price for Scenario 12

Month	Sensitivity Elasticities	
	Sale Barn	Country
Jan	-3.85	-4.21
Apr	-3.29	-3.57
Jul	-4.76	-5.28
Oct	-4.20	-4.62



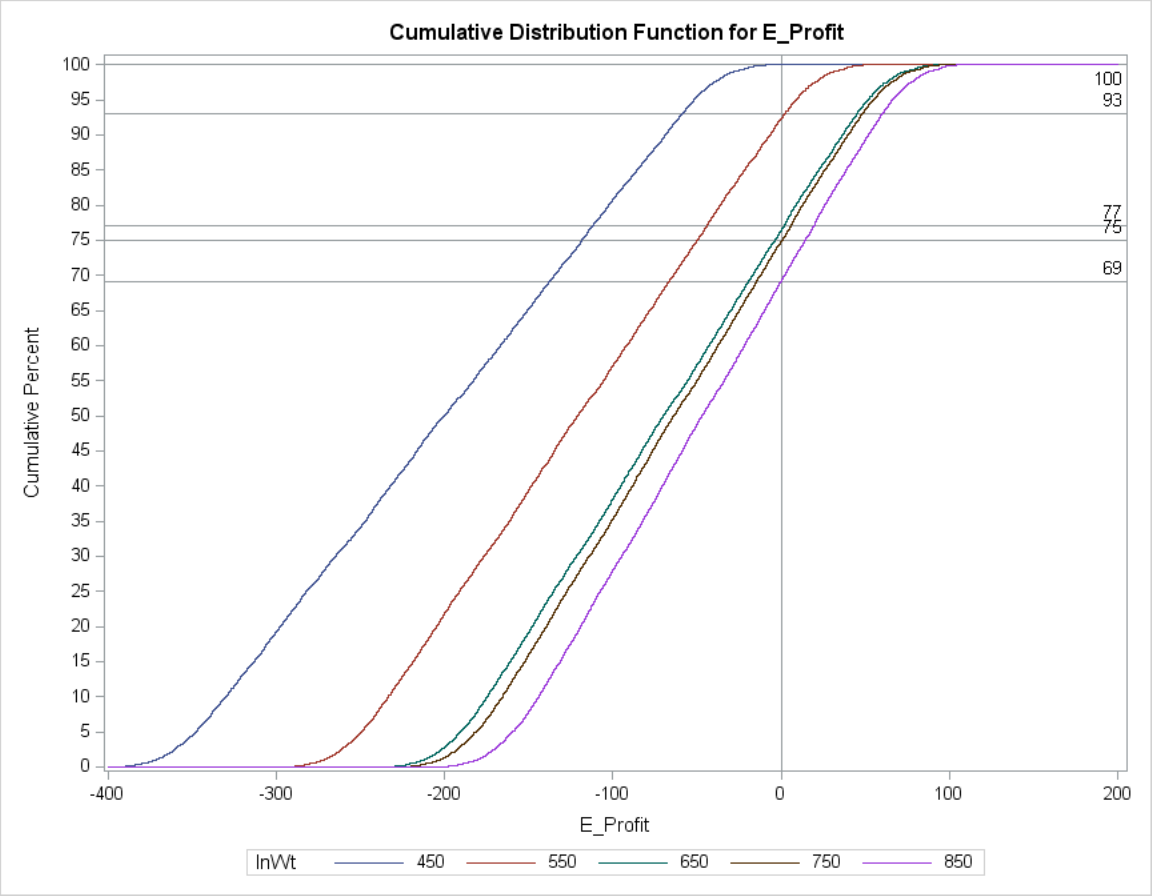
Note: Variables in ovals are exogenous, variables in rectangles are calculated, and variables in diamond are randomly simulated.

Figure 4.1. Conceptual Model of Recursive System for Feedlot Net Return



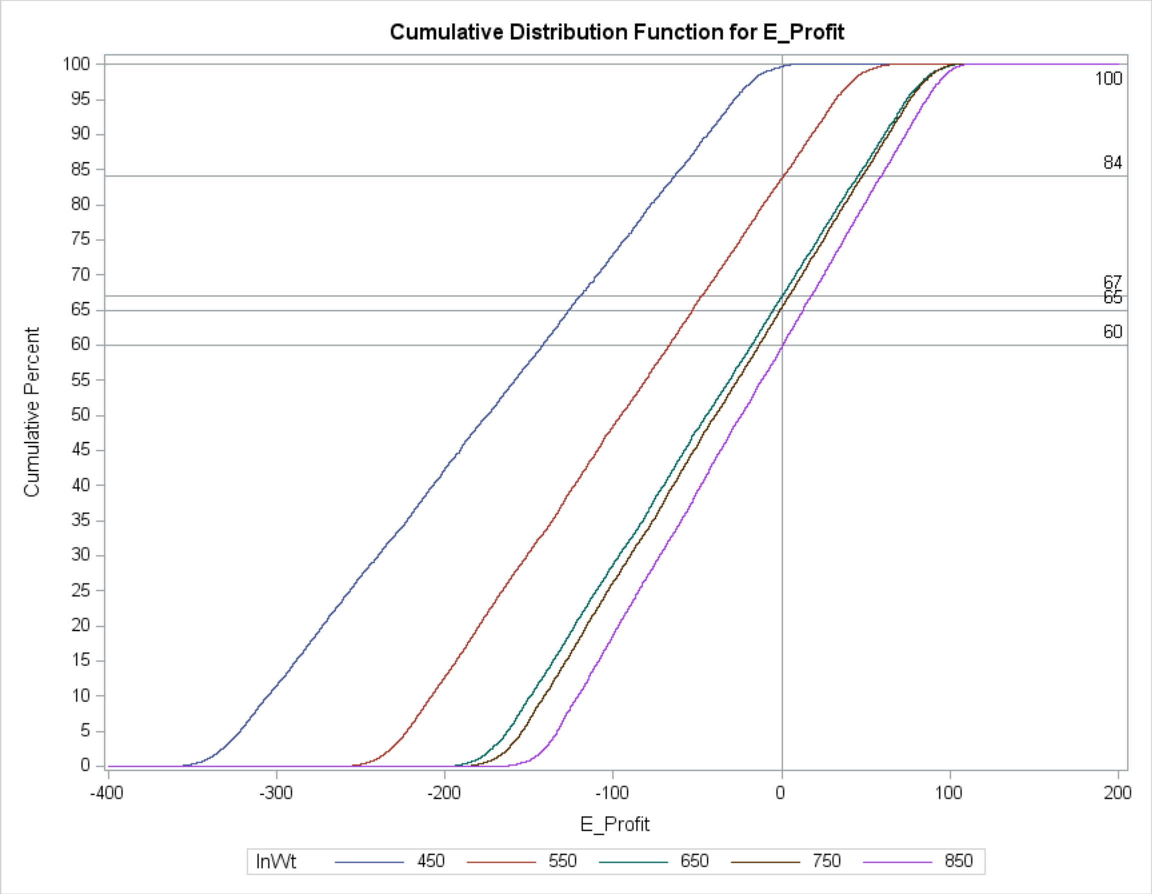
Note: About 38 percent (100 – 62) of 850 pounds feeder steers make profit

Figure 4.2. Scenario 1 Cumulative Distribution Function (CDF) of Expected Profit, $/head (Pen Size = 75; Origin = Sale barn; Closeout Month = July)



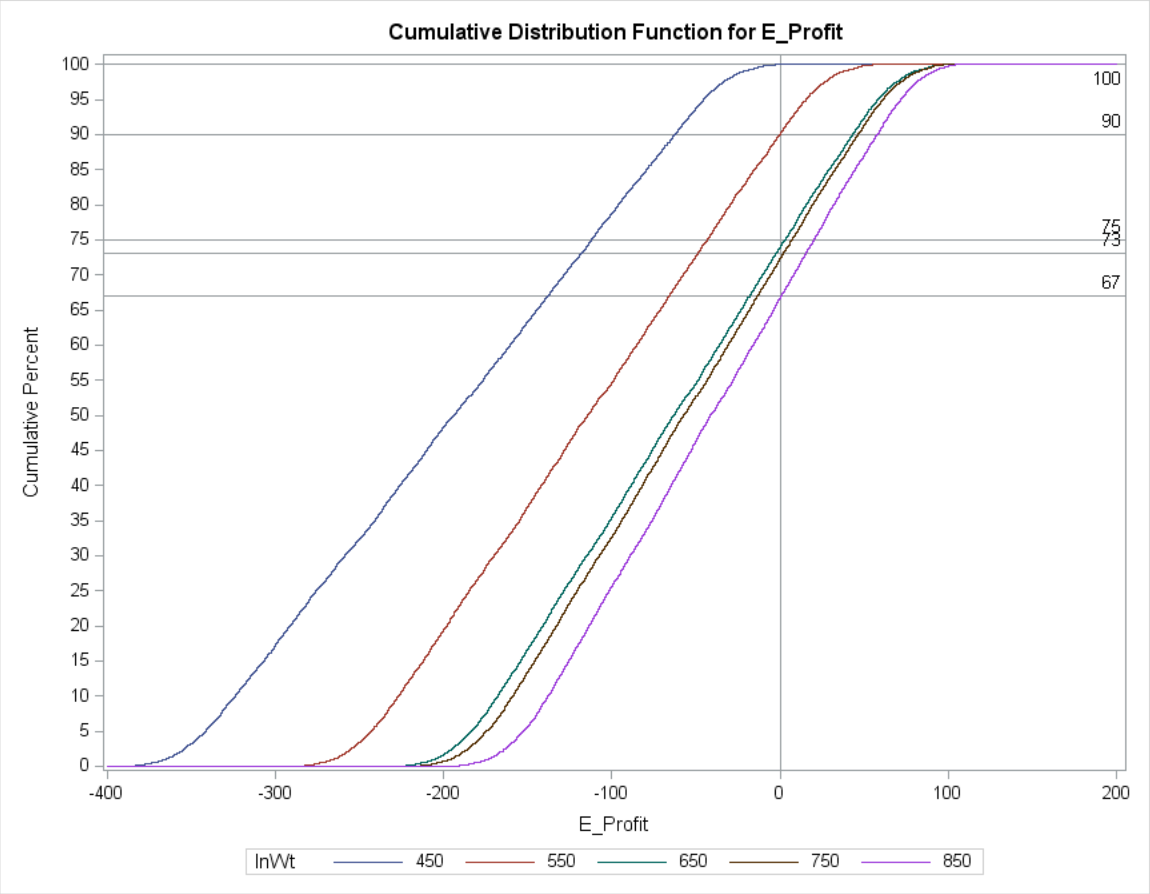
Note: About 31 percent (100 – 69) of 850 pounds feeder steers make profit

Figure 4.3. Scenario 2 Cumulative Distribution Function (CDF) of Expected Profit (Pen Size = 150; Origin = Sale barn; Closeout Month = July)



Note: About 40 percent (100 – 60) of 850 pounds feeder steers make profit

Figure 4.4. Scenario 3 Cumulative Distribution Function (CDF) of Expected Profit (Pen Size = 75; Origin = Country; Closeout Month = July)



Note: About 33 percent (100 – 67) of 850 pounds feeder steers make profit

Figure 4.5. Scenario 4 Cumulative Distribution Function (CDF) of Expected Profit (Pen Size = 150; Origin = Country; Closeout Month = July)

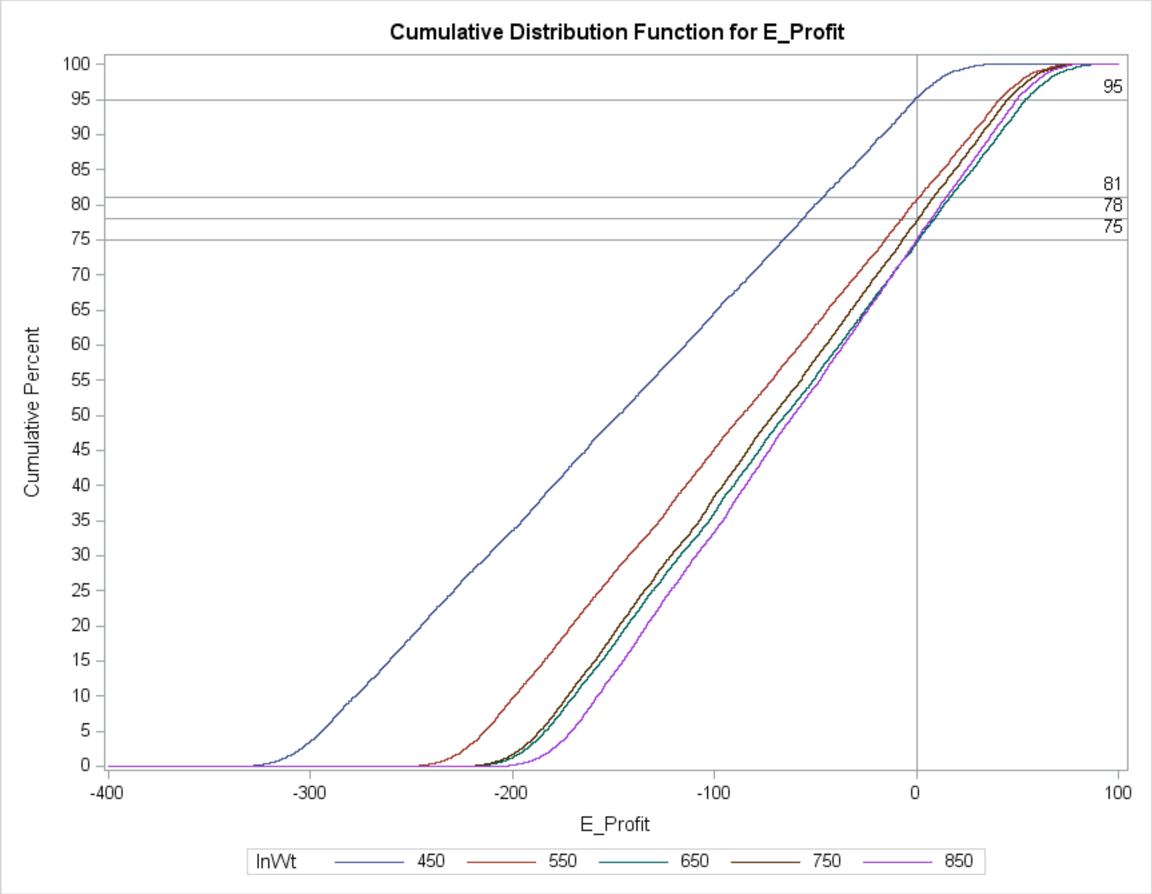


Figure 4.6. Scenario 5 Cumulative Distribution Function (CDF) of Expected Profit (Pen Size = 75; Origin = Sale barn; Closeout Month = January)

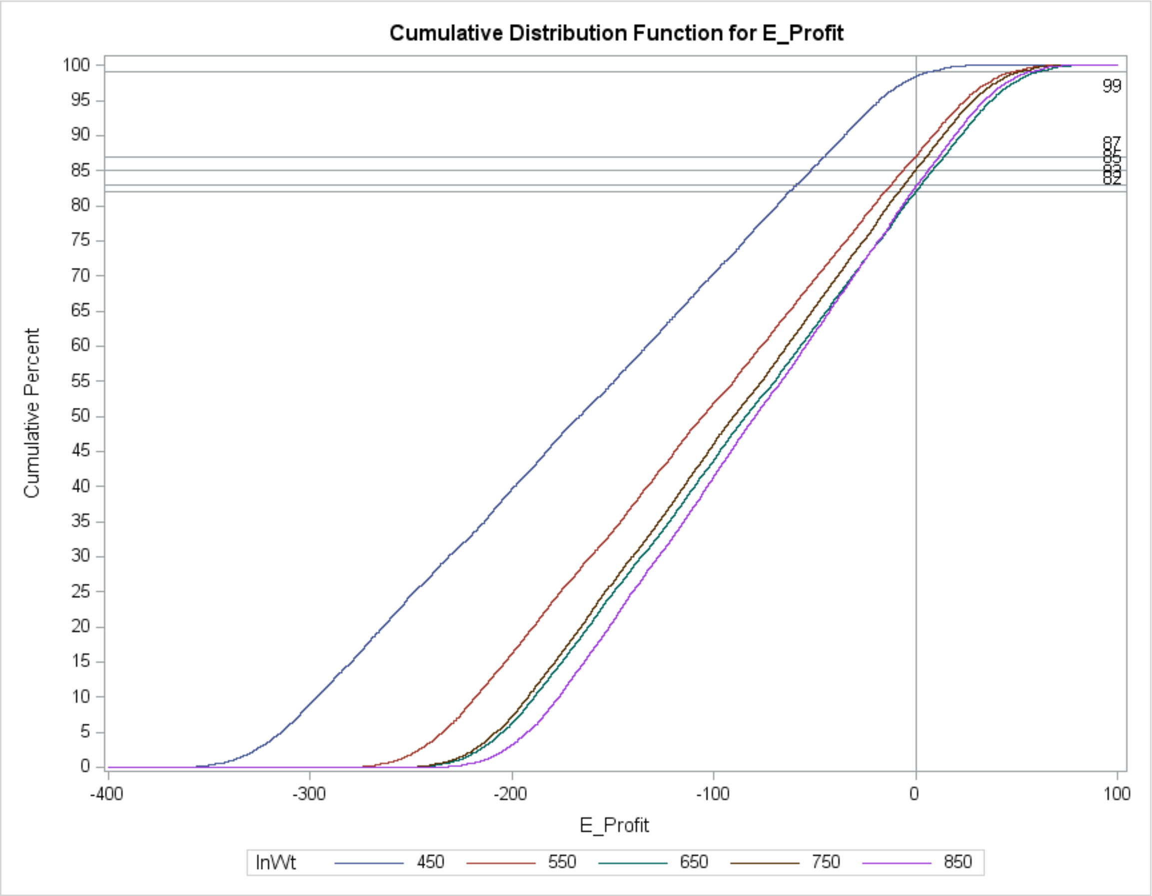


Figure 4.7. Scenario 6 Cumulative Distribution Function (CDF) of Expected Profit (Pen Size = 150; Origin = Sale barn; Closeout Month = January)

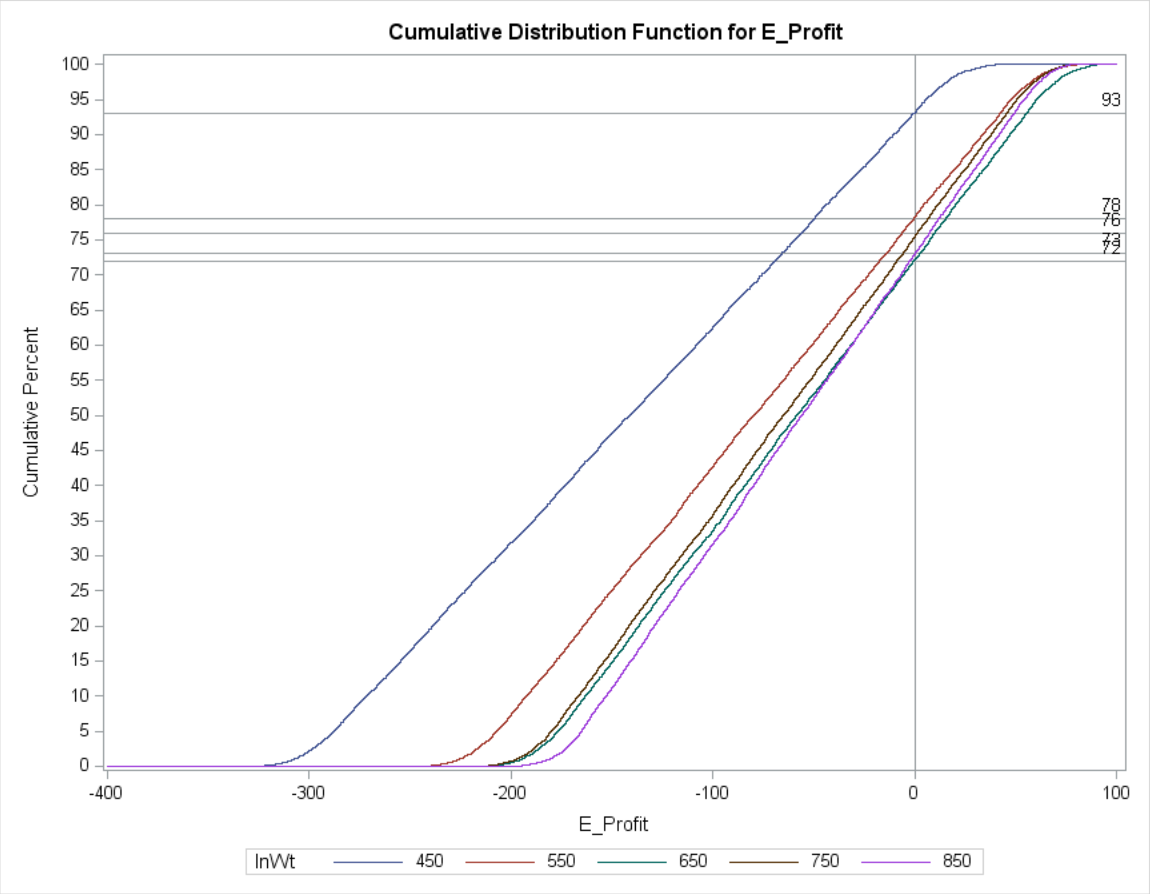


Figure 4.8. Scenario 7 Cumulative Distribution Function (CDF) of Expected Profit (Pen Size = 75; Origin = Country; Closeout Month = January)

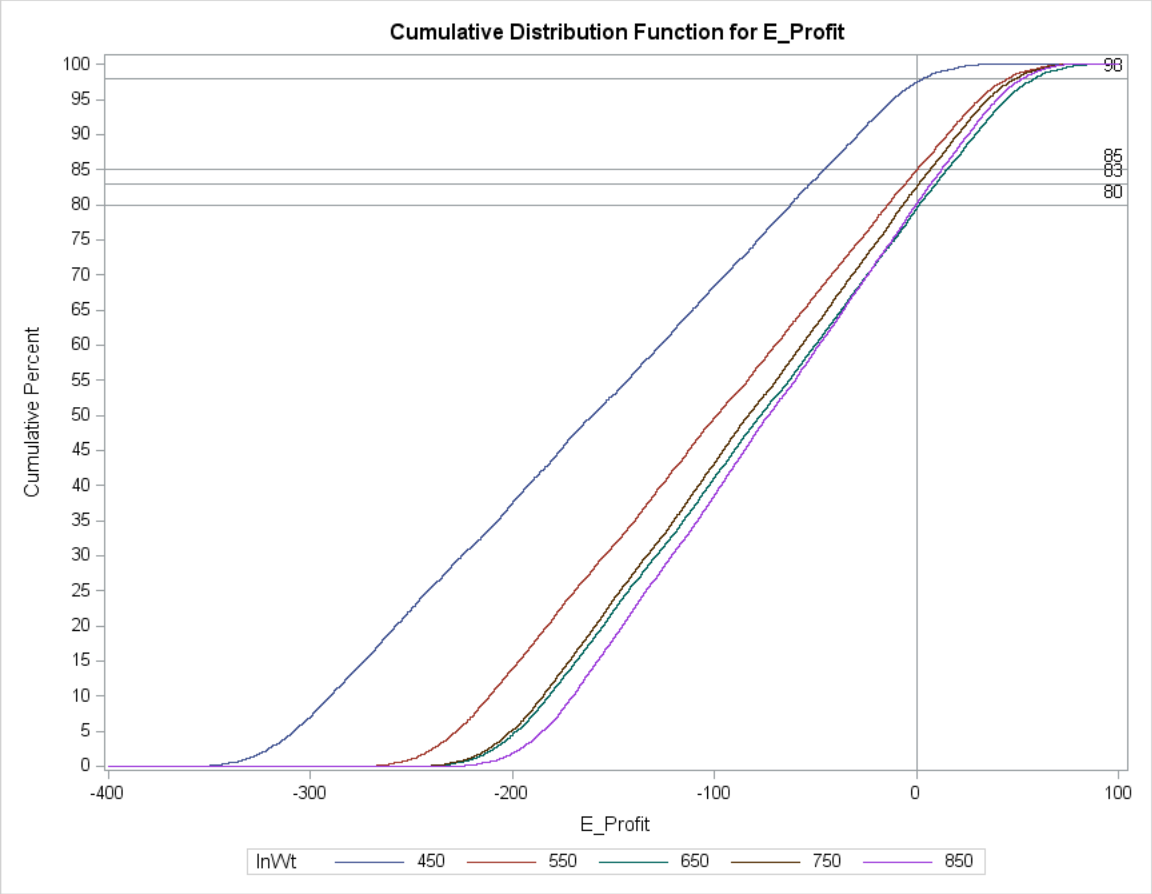


Figure 4.9. Scenario 8 Cumulative Distribution Function (CDF) of Expected Profit (Pen Size = 150; Origin = Country; Closeout Month = January)

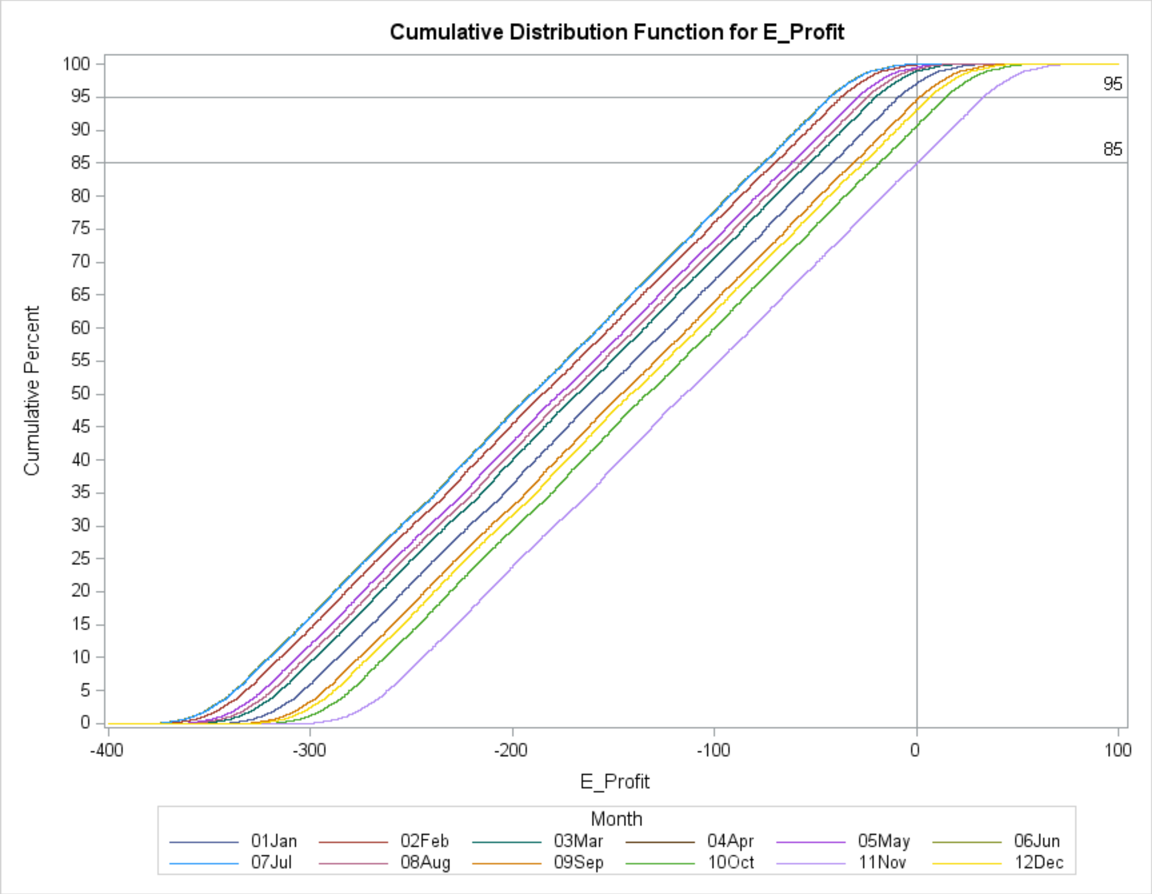


Figure 4.10. Scenario 9 Cumulative Distribution Function (CDF) of Expected Profit (In-Weight = 450; Pen Size = 110; Origin = Sale barn)

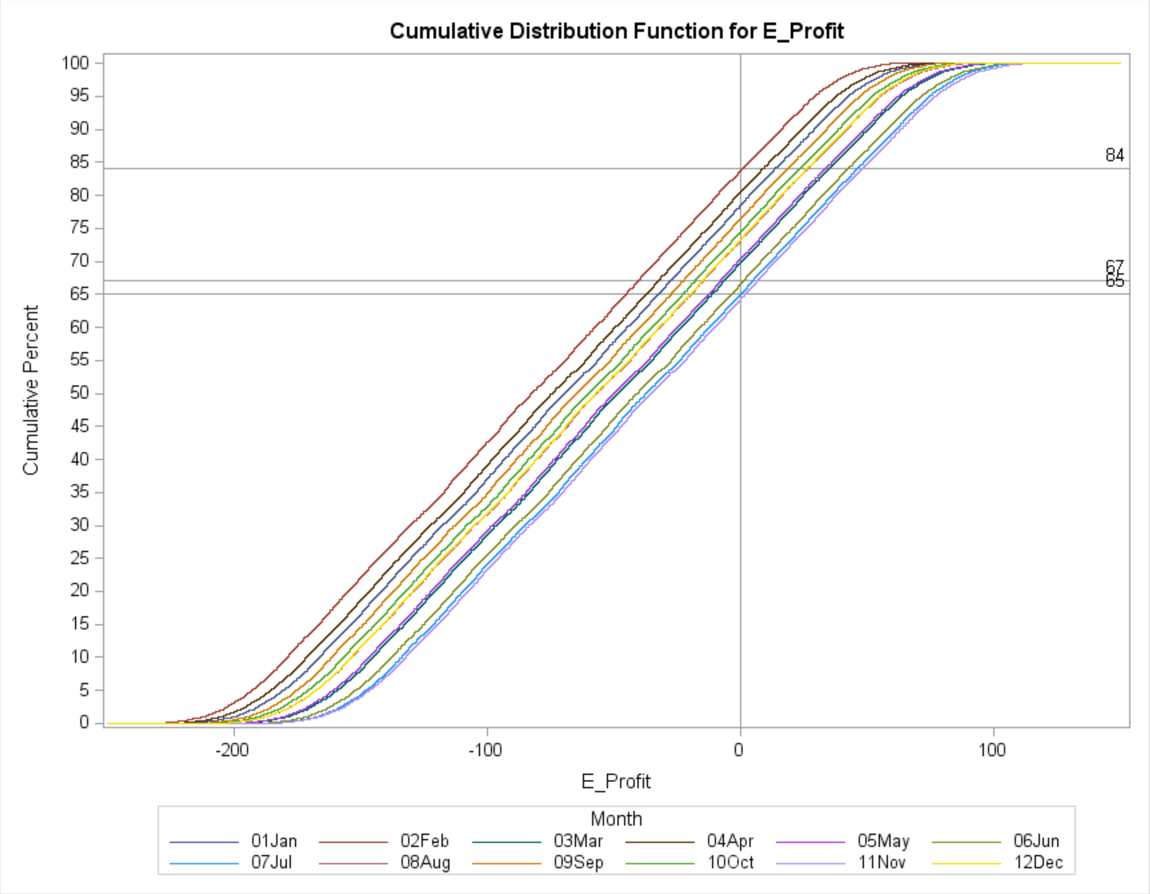


Figure 4.11. Scenario 10 Cumulative Distribution Function (CDF) of Expected Profit (In-Weight = 850; Pen Size = 110; Origin = Sale barn)

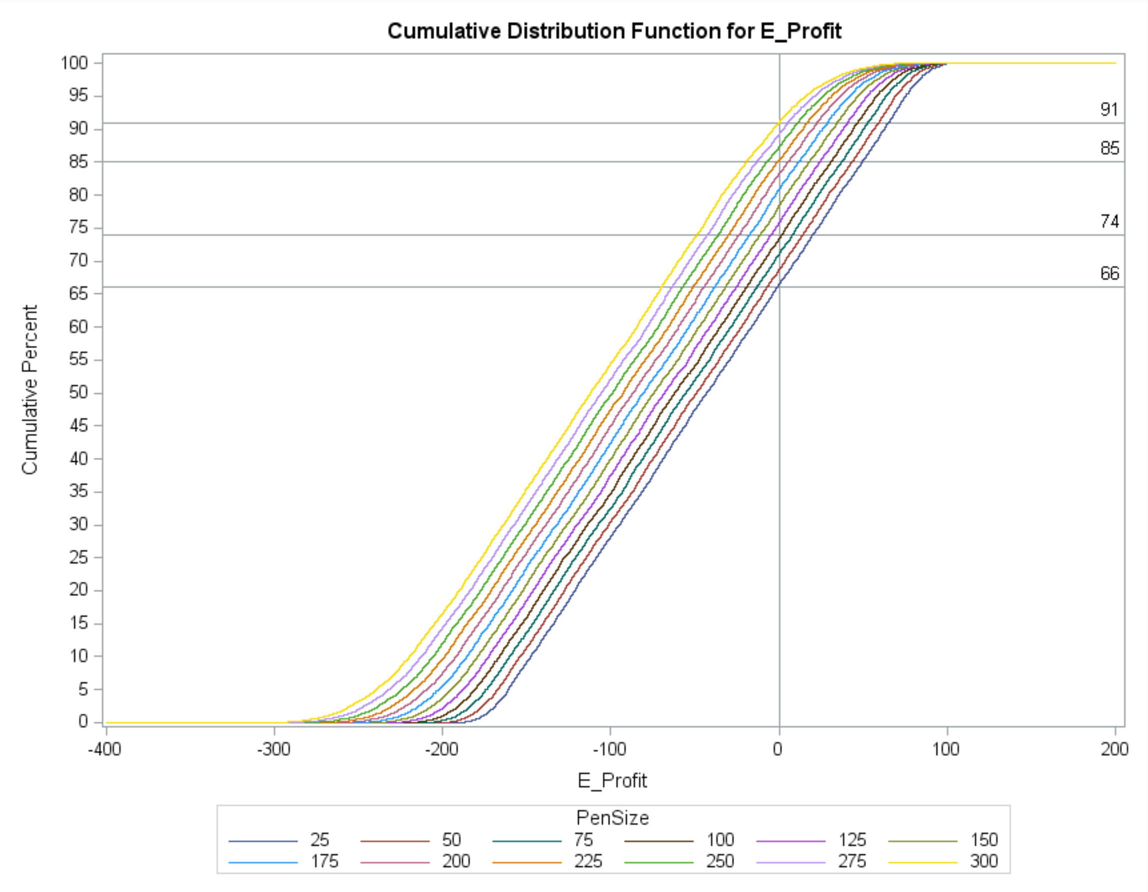


Figure 4.12. Scenario 11 Cumulative Distribution Function (CDF) of Expected Profit (In-Weight = 650; Origin = Sale barn; Closeout Month = September)

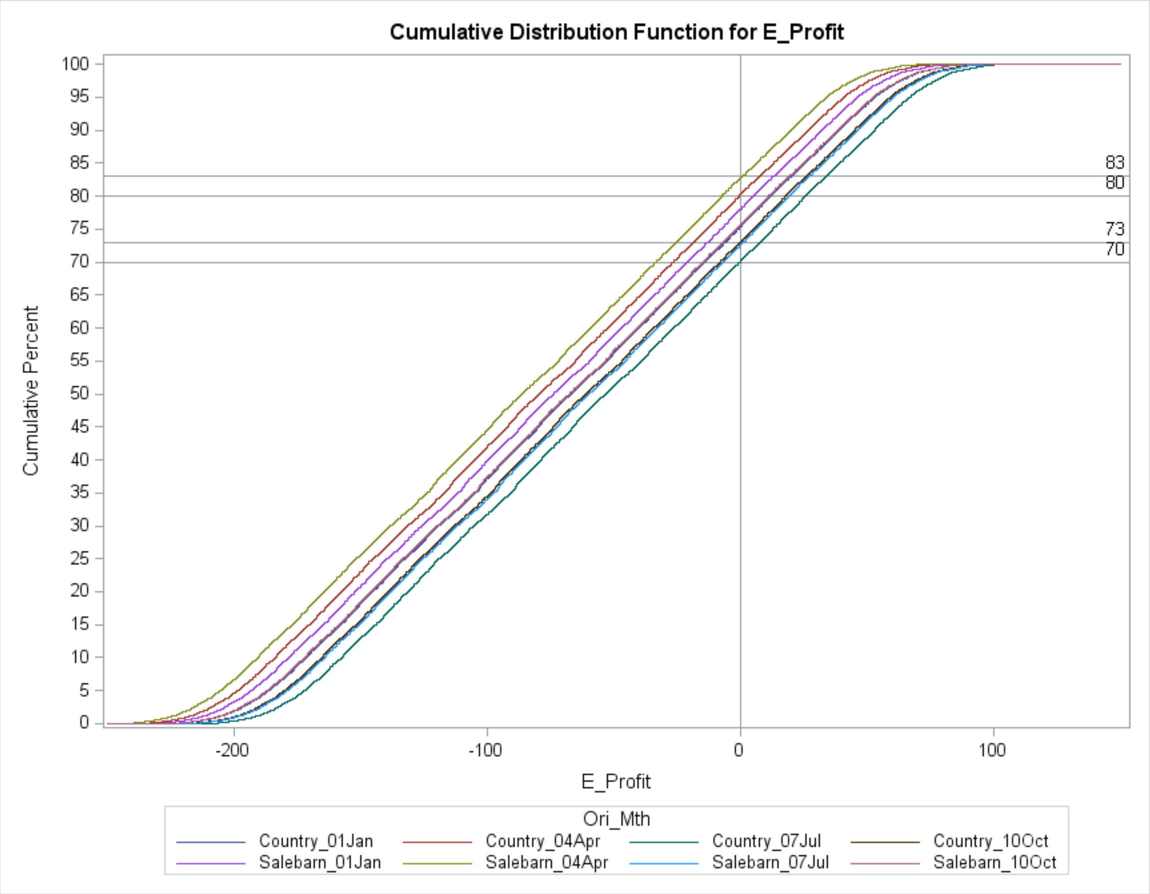


Figure 4.13. Scenario 12 Cumulative Distribution Function (CDF) of Expected Profit (In-Weight = 650; Pen Size = 110)

CHAPTER V

CONCLUSIONS

Anecdotally, evidence suggests that feedlot death loss is increasing over time. As such, the aim of this dissertation is to contribute to the understanding of changes in death loss rates (mortality), choices that influence that rate, and how profitability is impacted. In the first study (Chapter II), the cumulative sum (CUSUM) test, CUSUM of squares test, and Bai and Perron tests are implemented using monthly observations to examine whether death loss rates have changed. The anecdotal evidence of change is supported by these structural change tests and reinforced by test of unequal means and variances. Results indicate a gradual increase in death loss rates over time, as well as a structural shift upward during the period of December 2000 – September 2010.

The second study (Chapter III) explores factors that may influence death loss rates to using a pen-level observations for a more in-depth analysis. Expected death loss percentage is estimated using a Tobit model. The study found that cattle sourcing, including geographic location and market source type, are important determinants for death loss in addition to in-weight, pen size, sick head days, and medical treatments.

In the third study (Chapter IV), expected net returns are simulated to account for expected death loss rate using the death loss model from Chapter III. Choice variables for the simulation include in-weights, pen sizes, closeout months, and market origins. Findings in this study suggest that heavier in-weights and country-sourced (directly sourced from ranches) cattle not only reduce death loss rate, but also generate greater net returns, depend on the closeout months.

Given that death loss rate management is vital in feedlots, future research may benefit by further examination of the factors considered here. At a minimum, there is evidence of increasing industry death loss rates over the period considered in this dissertation. There is also evidence from pen-level data analysis that details the influence of choice variables on feedlot death loss. The study uses both aggregate and disaggregate data as well as time series and cross sectional data to examine death loss. Future research may benefit by incorporating these death loss determinants into modelling efforts.

Future research may also consider incorporating death loss through cost rather than revenue to account for early timing of death, instead of discounting revenue to incorporate death loss, presuming a late timing of death. If available, actual pencil shrink agreed upon sale may be included in computing the revenue. Furthermore, estimating death loss by exact timing of death should be considered with a comparison of net returns across timing scenarios.

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APPENDICES

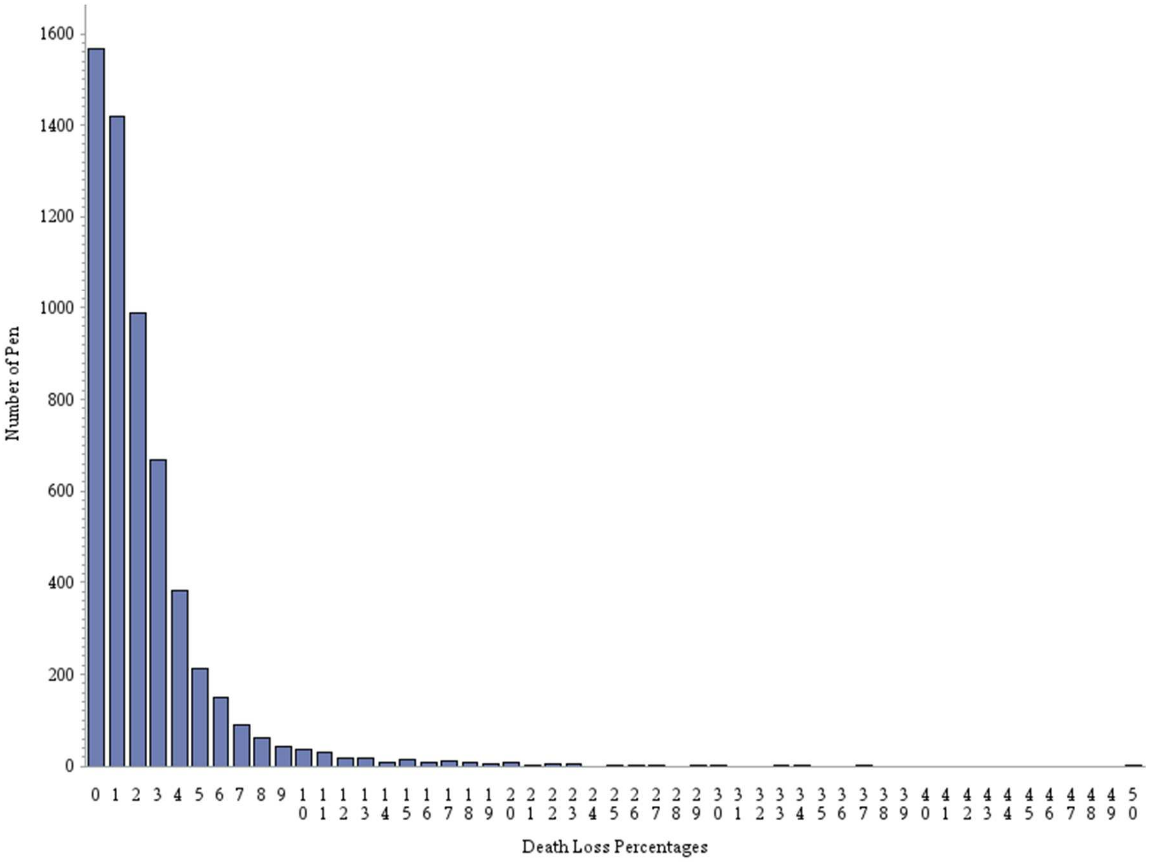

Figure 2.1A. Distribution of Death Loss, Private Feedlot in Southern Great Plains

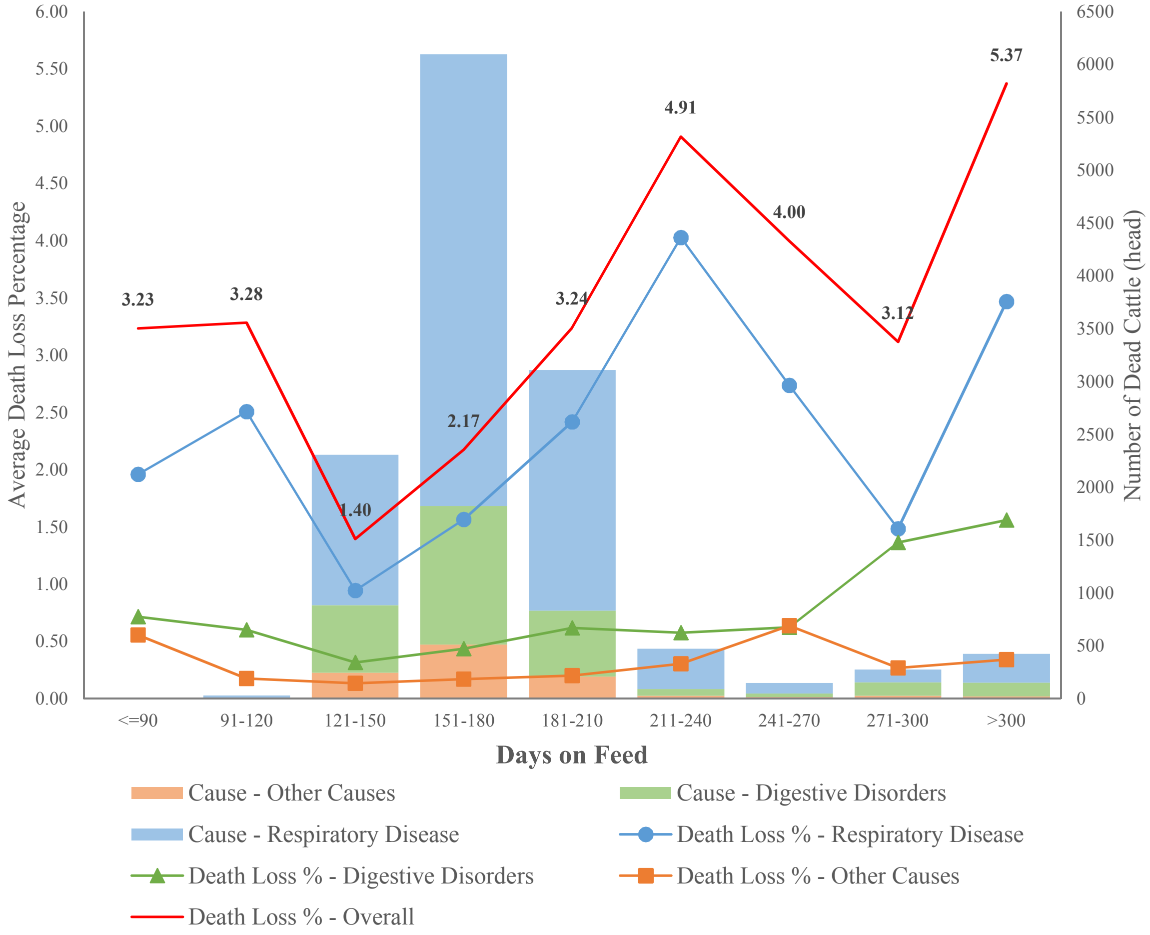

Figure 3.1A. Feedlot Death Loss by Days on Feed

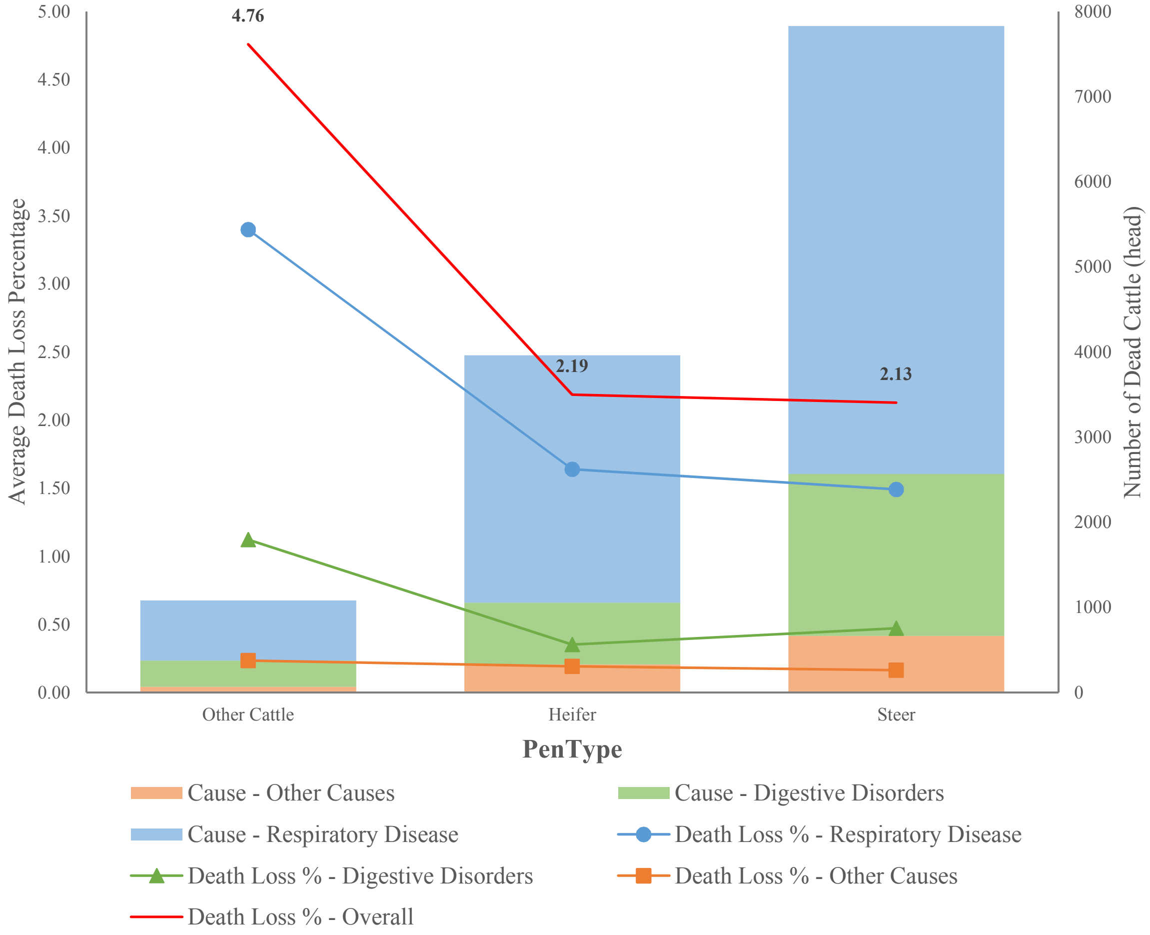

Figure 3.2A. Feedlot Death Loss by Pen Type

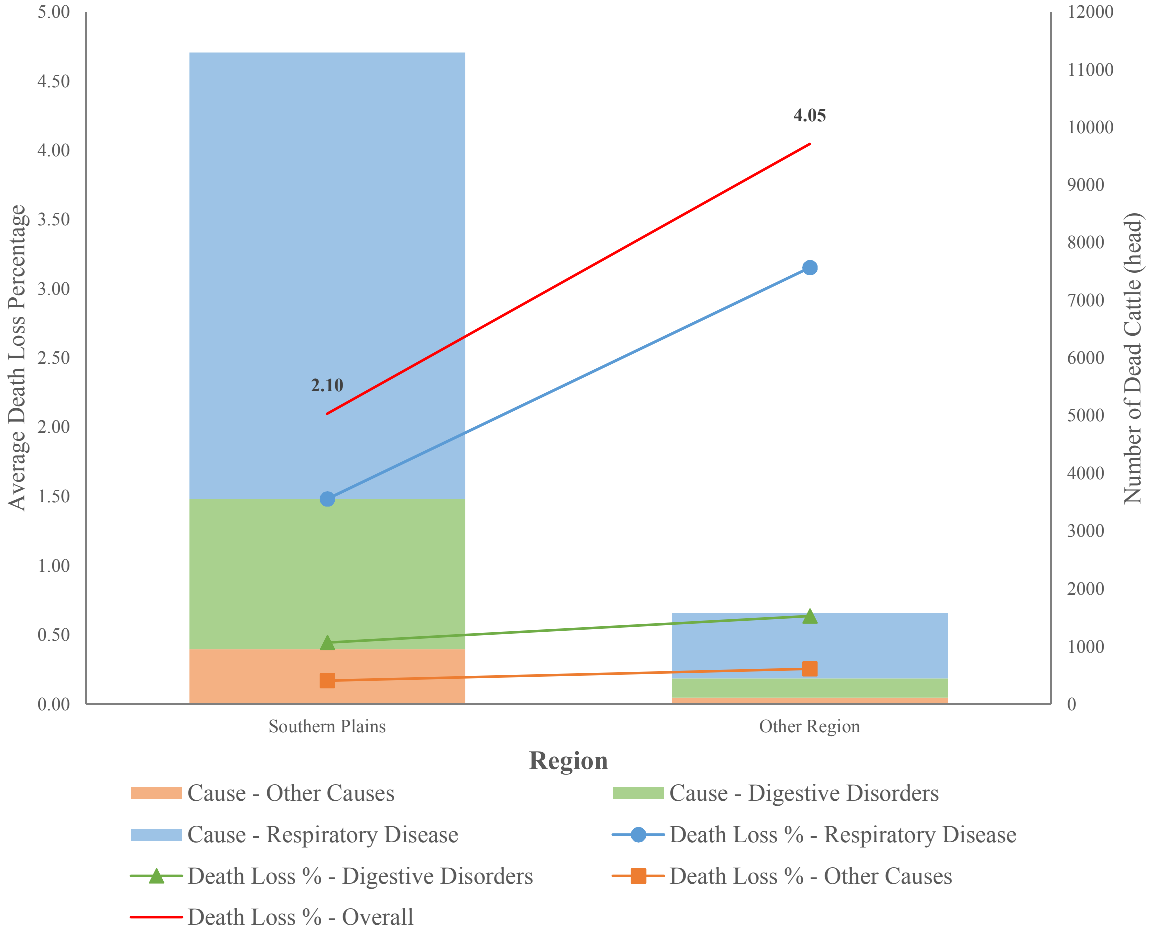

Figure 3.3A. Feedlot Death Loss by Region Origin

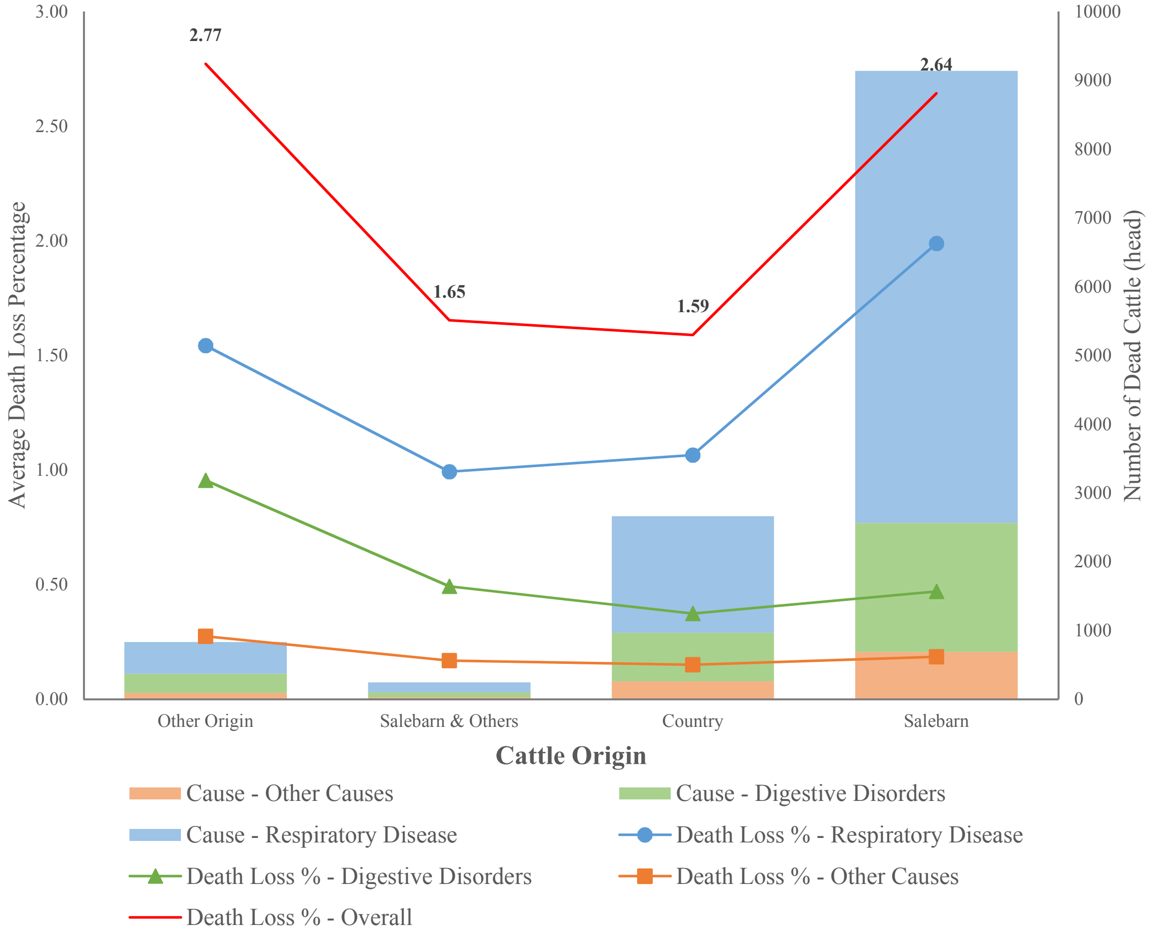

Figure 3.4A. Feedlot Death Loss by Cattle Origin

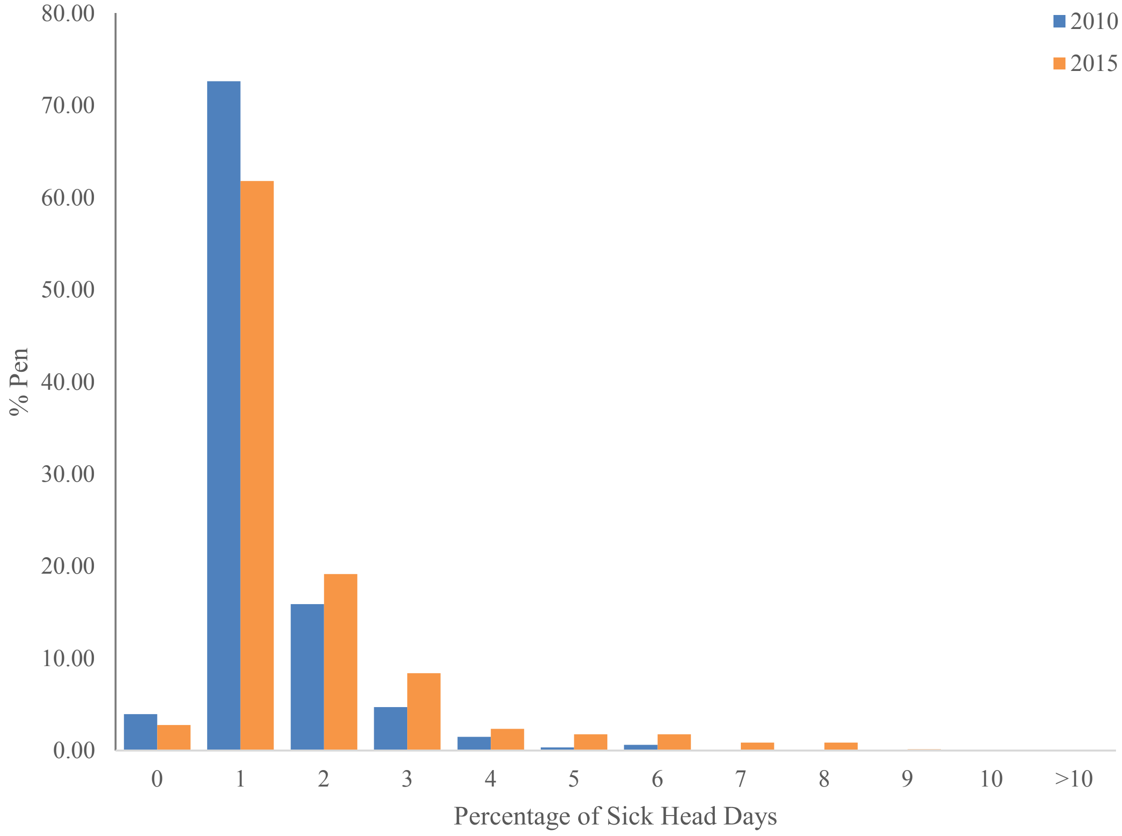

Figure 3.5A. Distribution of Percentage of Sick Head Days in 2010 and 2015

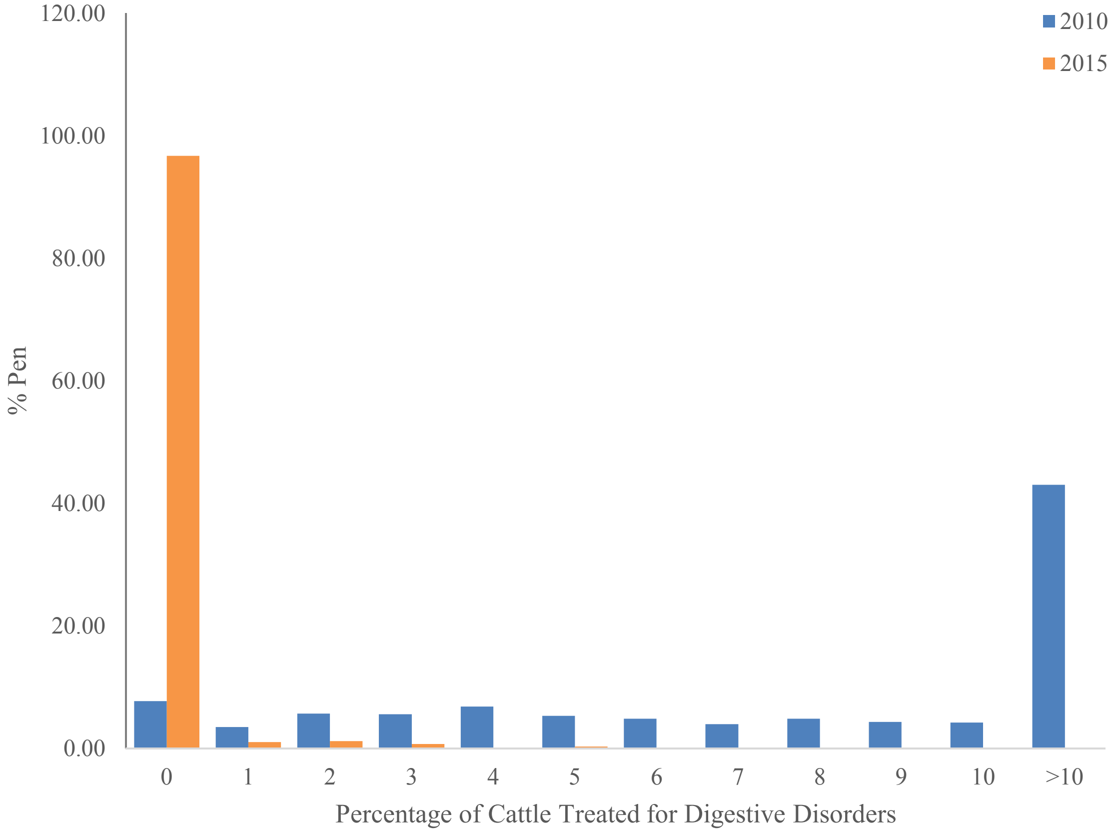

Figure 3.6A. Distribution of Percentage of Cattle Treated for Digestive Disorders in 2010 and 2015

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