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Retained Ownership Profitability of Beef Cattle Originating in Tennessee

Minfeng Tang
University of Tennessee, Knoxville, mtang2@vols.utk.edu

To the Graduate Council:

I am submitting herewith a thesis written by Minfeng Tang entitled "Retained Ownership Profitability of Beef Cattle Originating in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Karen E. Lewis, Major Professor

We have read this thesis and recommend its acceptance:

Dayton McGregor Lambert, Christopher N. Boyer, Andrew P. Griffith

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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ABSTRACT

Retained ownership is a marketing strategy that can be used by cow-calf operators to benefit from the potential increase in fed cattle prices. We analyze the profitability of retained cattle ownership from 2005 to 2015 for cow-calf producers in Tennessee. We also determine the impact of steer/heifer characteristics (e.g., average daily gain, feed conversion) and producer choice decisions (e.g., placement weight, placement season, days on feed) on retained ownership profitability. Data on 2,953 head of cattle originating in Tennessee and finished in Iowa using a retained ownership strategy were collected. A mixed regression model explaining profitability was estimated with fixed effects for animal characteristics and producer choice variables and random effects for feedlots, farm origin, and the year cattle were harvested. Retained ownership placement season decision alternatives were also distinguished using mean-variance and stochastic dominance methods. Mixed model results indicate that placement weight, placement season, days on feed, animal health and animal sex impacted retained ownership profitability. Winter was the most preferred placement season generating the highest expected retained ownership profits, while summer was the least preferred placement season generating the lowest expected retained ownership profits. These findings could be useful for cow-calf producers to develop more profitable production and marketing strategies.

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CHAPTER I: INTRODUCTION AND PROBLEM IDENTIFICATION

The beef cattle industry is Tennessee's largest agricultural enterprise (United Sates Department of Agriculture [USDA], 2012). The total cash receipts from the sale of cattle and calves during 2012 was $735.5 million, which was 20% of the state's total agricultural income (USDA, 2012). Like other southeastern states, cow-calf production is the major cattle enterprise in Tennessee (Sleigh, 1996). Tennessee annually markets more than 750,000 feeder calves to backgrounding operations and feedlots, primarily in the Midwest and High Plains areas of the United States (Neel, 2014). Net returns to feeder cattle have been highly variable over time due to variability in input costs, feeder cattle prices, fed cattle prices, feedlot performance (Langemeier, Schroeder, and Minert, 1992), and carcass characteristics (McDonald and Schroeder, 2003). An alternative method of marketing feeder cattle is to retain cattle after a traditional sale point, allowing Tennessee cow-calf producers to benefit from increased fed cattle prices and capture the potential benefits of an established breeding program (Lambert and Sands, 1984; Tassell et al., 1997; White et al., 2007a).

Researchers have summarized the advantages and disadvantages of retained ownership from the cow-calf producers' perspective. For the advantages, first, retained ownership can generate cow-calf producers valuable genetic information with which to evaluate feedlot performance of cattle (Gill Barnes and Peel, n.d.). Animal quality can be enhanced with retained ownership data by adjusting breeding programs (Wagner and Feuz, 1991; Lawrence, 2005). Second, retained ownership could be a risk efficient strategy to increase marketing flexibility by carrying some sales of cattle from one year to the next (Carlberg and Brown, 2001; Lawrence, 2005). The disadvantages of retained ownership include delayed income, increased risk of poor performance, and additional financing requirements (Davis, McGrann, and Mintert, n.d.; Wagner and Feuz, 1991; Lawrence, 2005).

Several studies analyzed and identified factors influencing the variability of feedlot cattle feeding profitability (e.g. Langemeier, Schroeder, and Minert, 1992; Lawrence, Wang, Joy, 1999; Mark et al., 2000; Forristall, May, and Lawrence, 2002; Stalker et al., 2006). Relatively few variables explained the variability of calf feedlot profitability (White et al., 2007a). Fed and feeder cattle price variability contributed most to cattle feeding profits over time, followed by corn prices and animal performance (Langemeier, Schroeder, and Mintert, 1992; Albright et al., 1993; Mark et al., 2000). Most studies analyzed data from Kansas feedlots (Simms, Maddux, and Mintert, 1991; Langemeier, Schroeder, and Minert, 1992; Schroeder et al., 1993; Mark et al., 2000) and other Midwestern feedlots (Lawrence, Wang, and Joy, 1999; Stalker et al., 2006).

Whether to retain calves after weaning or to sell at weaning is one of many complex questions faced by cow-calf producers. The decision to retain weaned calves depends on current market conditions, expected price, health performance, and the cow-calf producers’ propensity for risk (Schroeder et al., 1990; White, 2005). Given the cattle industry is characterized by highly variable returns (Wang et al., 2001), understanding how related factors contribute to profit variability may therefore help cattle feeders and cow-calf producers develop risk management strategies associated with feeding cattle.

Lewis et al. (2016) examined data from 2013-2014 and determined how animal characteristics and a supplemental prepartum feeding program for cows affected retained ownership profitability of 160 steers originating in Tennessee. Results indicated that retained ownership was profitable in that selected year. However, Lewis et al. (2016) only examined one year of retained ownership data.

This study extends Lewis et al.'s research by using individual cattle data covering 11-year. The main contribution of this study is the examination of multiple years of retained ownership data in the Southeastern United States.

Research Objectives

The objective of this thesis is to determine the profitability of retaining ownership and variability of profits for Tennessee cattle producers retaining ownership through the feedlot. I will also determine how animal characteristics (e.g., average daily gain and feed conversion) and producer choice decisions (e.g., cattle sex, placement weight, placement season, days on feed) affect retained ownership profitability.

CHAPTER II: LITERATURE REVIEW

An early study by Swanson and West (1963) concluded that aside from cattle price margins and feeding efficiency, other factors also played a role in affecting returns. Langemeier et al. (1992) analyzed data from a Kansas feedlot between 1980 and 1989 and found that feeder cattle price, fed cattle price, and corn prices explained most of the variation in cattle feeding net returns. Schroeder et al. (1993) examined closeout data from 7,292 pens of steers placed on feed between January 1980 and May 1991 in two Western Kansas feed yards and reached a similar conclusion. Lawrence, Wang, Joy (1999) analyzed data from 1,626 pens of cattle placed on feed between January 1987 and December 1996 in the upper Midwest and analyzed effects of animal sex, animal performance, and facility design on profits and found that all variables significantly affected profits. Fed cattle prices and feeder cattle prices had greater impacts on cattle feeding profitability than any other factors, such as corn prices, interest rates, and animal performance (Mark et al., 2000). Feeder cattle prices, corn prices, and interest rates negatively affected profits, and fed cattle prices and superior cattle performance positively affected profits.

Several studies focused on the profitability differences between steers and heifers (e.g. Williams et al. 1993; Mark et al., 2000). The impact of variability of corn prices, interest rates, and cattle performance was different for steers from heifers (Mark et al., 2000). Variations in fed and feeder cattle prices and animal performance explained most of the variability in profit differences between steers and heifers (Williams et al., 1993). Sale prices and performance affected profitability more for heifers than steers (Lawrence, Wag, and Loy, 1999).

With the adoption of a grid pricing system, carcass characteristics become an important factor affecting cattle feeding profitability (Feuz, 1999). Feeder cattle prices and grid based fed cattle prices exhibited the dominated effect on cattle feeding profits per head (Mark et al., 2000;

McDonald and Schroeder, 2003). Feedlot profitability was mostly determined by marbling, carcass weight, and feeding efficiency (Forristall, May, and Lawrence, 2002). Producers with high quality fed cattle could use value-based grid pricing to increase their net returns from cattle feeding operation (McDonald and Schroeder, 2003).

Although empirical evidence from previous studies indicates that retaining calves after weaning generally improves producers' cattle feeding profits in most years, retained ownership is not profitable every year (Wagner and Feuz, 1991; Fausti et al., 2003; Lawrence, 2005; White et al., 2007b; Randall and Watt, 2009). Thus, some producers view retained ownership of cattle as a risky decision (Fausti et al., 2003). A study by Gillespie et al. (2003) revealed that less than 10% of the Louisiana cattle producers used retained ownership in 2001 and about 14% of the producers who adopted retained ownership were members of a strategic alliance or cooperative (Gillespie, Basarir, and Schupp, 2004). Therefore, cow-calf producers have traditionally been slow to adopt retained ownership (Chroeder and Featherstone, 1990; Fausti et al., 2003; Kelsey, Schroeder, and Langemeier, 2011). It was suggested that cow-calf producers were generally risk-averse individuals and tend to sell cattle at weaning (Tassell et al., 1997; Kelsey, Schroeder, and Langemeier, 2011; Pope et al., 2011).

Agricultural policy analysts and agricultural economists are perennially interested in specifying factors that affect producers' decision about calf retention (Popp, Faminow, and Parsch, 1998). Age was found to be a factor affecting producers' cattle retained ownership decision. Young producers were more interested in adopting a retained ownership strategy (Gillespie, Basarir, and Schupp, 2004). Additionally, producers having greater contact with county extension agents and those interested in performance-based management using feedlot and carcass data were more likely to retain ownership of their cattle after weaning (Gillespie, Basarir, and Schupp, 2004; Franken et al., 2010).

Variation in retained ownership profits exist both on a year-to-year basis and within each year (Wagner and Feuz, 1991). Therefore, seasonality is also an important factor affecting cattle feeding profitability. Mark et al. (2002) studied seasonal variation in feeding performance, cattle prices, and corn prices in Western Kansas and detected a seasonal trend in steer feeding profitability. Feeder cattle prices had a greater impact on profit variability for spring and fall placement (Mark et al., 2000). Hardin and Saghaian (2014) examined data from a cattle marketing firm in Lexington, Kentucky and found that seasonality significantly impacted calf prices. Henry (2015) analyzed data from spring- and fall-calving cows originating in Tennessee and concluded that the fall-calving season was more profitable than the spring-calving season regardless of the feed ration and weaning month.

Most research analyzed retained ownership profitability using data before 2000 (e.g. Wagner and Feuz, 1991; Carlberg and Brown, 2001; Fausti et al., 2003). The most recent study on retained ownership profitability by Fausti et al. (2003) examined a three-year period on 845 steer calves originating in South Dakota. Continued research using updated long-term data that are representative of current management and production conditions are needed to provide cattle feeders more reliable implications for the future. Most research has also used average or aggregate data from pen or feedlot closeouts (e.g. Langemeier et al, 1992; Albright et al., 1993; Schroeder et al, 1993; Lawrence, Wang, and Joy, 1999; Mark et al., 2000), and research using individual cattle data to analyze factors affecting cattle feeding profit per head is less prevalent (e.g. McDonald and Schroeder, 2003). Few studies have examined differences in retained ownership profitability between steers and heifers. If information about the profitability of retained ownership for both steers and heifers over time were available, cow-calf producers could use it to develop more profitable production and marketing strategies. Therefore, I add to the literature by examining retained ownership profitability from 2005 through 2015 for Tennessee cattle producers.

CHAPTER III: CONCEPTUAL FRAMEWORK

Economic Framework

Net returns, or profit to retained ownership of steer/heifer per head were calculated by subtracting production cost for retaining the steer/heifer and opportunity cost of selling the steer/heifer at weaning from the total revenue received from finishing the steer/heifer (Lewis et al., 2016). This is expressed as:

(1) $\pi_i = [p_i y_i - PC_i - OC_i] \times Retain_i + OC_i \times [1 - Retain_i]$

where π_i is the net returns associated with animal i ($/head); p_i is the grid price received at harvesting ($/pound); y_i is the hot carcass weight of the steer/heifer; PC_i is the production cost for finishing the animal ($/head), which is the sum of total feed costs, health treatment costs, vaccine costs, yardage, trucking, data collection fee, checkoff fee, and miscellaneous costs such as ear tags and interest; $Retain_i$ is an indicator variable equal to one if the producer retained ownership of the animal (zero otherwise); OC_i is an opportunity cost ($/head) which equals the Iowa delivery weight of the feeder steer/heifer multiplied by the market value of the feeder steer/heifer ($/cwt) at the time of delivery to Iowa. The feeder steer/heifer market values were determined by weighing the animal and evaluating the frame size and muscling. This information was compared to the Tennessee USDA Agricultural Marketing Service weekly auction report and the feeder price for the associated class was used for the animal's market price.

Retained ownership of cattle is a risky investment alternative for cow-calf producers (Fausti et al., 2003). Production risk and economic risk are two major types of risk faced by cow-calf producers (Mark et al., 2002; Belasco et al., 2009). Production risks associated with retaining ownership of a calf include cattle sex, placement weight, placement date, and days on feed. Economic risks include fed and feeder steer/heifer prices, feed costs, and miscellaneous costs incurred during the cattle retaining ownership (Fausti et al., 2003). Cattle producers are typically risk-averse (Tassell et al., 1997). Risk aversion is the preference to choose alternatives with a considerable probability of high value results, or at least being profitable (Hien, et al., 1997). A cow-calf producer will retain cattle through slaughter if the decision yields a higher expected net return relative to selling calves at weaning: $\mathrm{E}[\pi_i|Retain_i = 1] > \mathrm{E}[\pi_i|Retain_i = 0]$. Conversely, a cow-calf producer will sell calves at weaning if the expected net return from retaining ownership is lower relative to selling calves at weaning: $\mathrm{E}[\pi_i|Retain_i = 1] < \mathrm{E}[\pi_i|Retain_i = 0]$

Consider the case where market prices are given and producers have no control over to affect economic risks. The production decisions of cattle sex, placement weight, placement season, and days on feed are identified risk resources associated with expected profit and variability (Lawrence, Wang, and Loy, 1999; Mark et al., 2000; Mark et al., 2002). A producer can select the sex of cattle to be retained, days on feed, weight of cattle at the time of delivery (placement weight), and the season in which cattle would be sent into the feedlot (placement season) in order to obtain the highest expected net returns.

Many factors such as prices, lot conditions, and cattle performance are closely related to seasonal feeding conditions (Lawrence, Wang, and Loy, 1999). The optimal placement season is a function of expected net returns and variability of net returns. A cow-calf producer will select the optimal season to place calves on feed to achieve the highest expected net return ($\max_{d=j} E[\pi_i]$), where $d = j$ denotes the placement season decision with j = 1 to 4 indicating spring, summer, fall, and winter placement decisions, respectively. Likewise, a cow-calf producer will retain heifers instead of steers if retaining steers is more profitable is more profitable than retaining heifers: $\mathrm{E}[\pi_i|Steer_i = 1] > \mathrm{E}[\pi_i|Steer_i = 0]$, where $Steer_i$ is a binary (1=steer, 0 otherwise).

CHAPTER IV: MATERIALS AND METHODS

Data

Tri-County Steer Carcass Futurity Cooperative (TCSCFC) collected the data used in this study. It includes feedlot information and carcass cutout data from November 2004 through February 2015 on 2,297 steers and 689 heifers from the Tennessee Beef Evaluation Program. The 2,986 cattle originated from 39 Tennessee producers, who consigned cattle to the program. The cattle originated on farms in Tennessee and were finished in feedlots participating in the TCSCFC in Lewis, Iowa on a retained ownership contract. Cattle from eleven different feedlots participating in TCSCF were harvested from 2005 to 2015. The feedlot data for individual cattle include cattle sex, placement weight, placement date, days on feed, feed to gain ratio, average daily gain, feed costs, final weight, and harvest date. Data on feeder cattle price on delivery ($/cwt), carcass quality, dressing percentage, and carcass price ($/cwt) were collected. The finished steers/heifers were sold on a grid- pricing marketing system. The prices and costs reported in this study were indexed for inflation to 2015 dollars by using the Bureau of Labor Statistics Consumer Price index (United States Bureau of Labor Statistics, 2015). For cattle placed on feed and harvested in two consecutive years, an average value of the consumer price index was assigned to all the costs and prices associated with that animal.

Thirty-three cattle consisting of one heifer and thirty-two steers died during the feeding phase, leading to a total loss of $27,917 with an average loss of $846/head. This indicates a death loss of 1.4% for steers and 0.1% for heifers. Thus, complete feedlot summary statistics were available for 2,265 steers and 688 heifers (Table 1). Specifically, Table 1 displays the summary statistics of placement weight, days on feed, animal performance statistics, the number of health treatments, and dressing percentage for steers, heifers, and all of the cattle combined. Placement weight is the weight of the cattle (lb.) at the time of its placement into the feedlot. Days on feed is the interval between the delivery date when the cattle entered the feedlot and the harvest date of the cattle. Feed-to-gain ratio is the total pounds of feed dry matter divided by pounds of weight gain during the placement period. Average daily gain is the ratio of feedlot gain and days on feed. Dressing percentage is as the ratio of hot carcass weight and final live weight of the cattle. The number of health treatments is the number of individual health treatments for the animal during the feedlot stage.

Table 1 displays the summary statistics of placement weight, days on feed, animal performance statistics, the number of health treatments, and dressing percentage for steers, heifers, and all of the cattle combined. The average placement weight for all the cattle was 716.27 lbs. /head. Steer placement weight was 728.12 lbs. /head, which was almost 51 lbs. heavier than heifer placement weight on average. Heifers stayed in the feedlot for 148.33 days on average, which was 0.55 days longer than steers. Heifers exhibited higher feed to gain ration than steers. The lowest feed to gain ratio was observed from steers and the maximum feed to gain ratio was observed from heifers. Steers exhibited better average daily gain than heifers. The lowest and highest average daily gains were both observed from steers though. The average number of health treatments was 0.31 for all the cattle combined. The average dressing percentage was 61.45% for steers and 61.77% for heifers.

The Two Sample t-test was performed to identify if statistically significant differences exist for the summary statistics between steers and heifers. Two assumptions of equal variance and normal distribution of the compared variables were tested before performing the t-test. The null hypothesis of the test is the means of the compared variable from two independent groups are equal: $\mu_A = \mu_B$. The null hypothesis is rejected if the two-sided P value is lower than 0.05.

According to the test results, the placement weight of steers was statistically different from the placement weight of heifers. There existed statistical feedlot performance differences between steers and heifers. No statistical differences were detected for the days on feed, number of health treatment, and dressing percentage between steers and heifers ($p > 0.05$).

[Place Table 1 Approximately Here]

Table 2 displays the summary statistics of placement weight, days on feed, animal performance, the number of health treatments, and dressing percentage for steers, heifers, and all of the cattle combined by placement season. Spring, summer, fall, and winter were defined as March-May, June-August, September-November, and December-February, respectively, which follows from Lawrence, Wang, and Loy (1999).

Steers and heifers placed in the fall were in the feedlot for the longest amount of time with an average of 155.86 and 156.40 days, respectively. Steers and heifers placed in the spring were the heaviest on the placement date. Steers placed in the fall and heifers placed in the winter were the lightest on placement date. Steers placed in the spring had the best feed to gain ratio and the highest average daily gain. Heifers placed in the spring had the best feed to gain ratio and the highest average daily gain when placed in winter. Steers and heifers placed in the fall had the highest dressing percentage when slaughtered. Overall, cattle placed in the winter received the most number of health treatments among the four seasons of placement probably because of induced health problems caused by cold conditions (Langemeier, Schroeder, and Mintert, 1992).

Mean difference comparison using t-tests indicated that placement weight and average daily gain were statistically different between steers and heifers placed in four seasons. Steers normally enter feedlot at a higher weight and put on weight on a faster pace than heifers (Belasco et al., 2009). Statistical differences existed for feed to gain ratio between steers and heifers placed in the spring, summer, and fall. Statistical differences also existed for dressing percentage between steers and heifers placed in the summer and fall. No statistical difference was found for days on feed between steers and heifers placed in four seasons ($P > 0.05$).

[Place Table 2 Approximately Here]

Table 3 displays summary statistics of feed cost, corn prices, total feedlot cost, and specific feedlot costs for steers, heifers, and all of the cattle combined. Feed cost was computed as total feed dry matter (lb.) times the cost of ration dry matter ($/lb.). Corn price was the monthly price received by U.S. corn producers from USDA's Agricultural Marketing Service (AMS) from marketing year 2004 to 2015. Total feedlot cost was the sum of the individual cattle costs generated in the feedlot plus trucking costs. Health treatments were the individual treatment costs (as recorded by the TCSCF Steer and Heifer Test Evaluation Formulas). Yardage was calculated as the number of days on feed times the feedlot's yardage charge (as recorded by the TCSCF Steer and Heifer Test Evaluation Formulas).

Average health treatment costs were $1.49/head higher for steers than heifers. Average feed costs were $46/head higher for steers than heifers. All the other specific feedlot costs except "miscellaneous" were higher for steers than heifers. Consequently, total feedlot cost for steers was higher than heifers, with a difference of about $54/head. Comparison t-tests indicated that feed cost, total feedlot costs, yardage fee, trucking for steers were statistically different from heifers. Corn price was also statistically different between steers and heifers at the 1% level, which could be the result of different months of placement. No statistical differences for the mean health treatment payments and "miscellaneous" between steers and heifers were detected according to t-test results ($P > 0.05$).

[Place Table 3 Approximately Here]

Table 4 displays summary statistics of feedlot cost, corn price, feeder cattle price, and fed cattle price for steers, heifers, and all the cattle combined by placement season. Feedlot cost, corn price, and fed cattle price were the highest for all the cattle placed in winter. Average feeder cattle price was the lowest for steers and heifers placed in the spring. Feedlot cost and feeder cattle price were higher for steers than heifers in four placement seasons. Steers and heifers placed in the winter received the highest fed prices. Fed prices were the lowest for steers placed in the spring and the lowest for heifers placed in the fall. Pairwise comparison tests indicated that feedlot cost and feeder cattle price were statistically different for steers from heifers in four placement seasons. Corn price was statistically different between steers and heifers placed in the spring, fall, and winter. Fed cattle price was statistically different between steers and heifers placed in the summer, fall, and winter.

[Place Table 4 Approximately Here]

Methods and Procedure

Net Returns mixed regression Model

To identify factors affecting retained ownership profits, I estimate the factors explaining variation in net returns of cattle with linear mixed regression model:

$$(2)\ NR_i = \beta_0 + \sum_{j=1}^{3} \beta_j PS_{ji} + \beta_4 S_i + \beta_5 DoF_i + \beta_6 W_i + \beta_7 FG_i + \beta_8 ADG_i + \beta_9 D_i + \beta_{10} T_i + \beta_{11} C_i + \mu_{year} + \mu_{feedlot} + \mu_{producer} + \varepsilon_i$$

where NR_i is the net return of animal i through retained ownership. The effects of placement season were examined by including indicator variables of three placement seasons ($PS_{ji}, j = 1,2,3$) with summer as the reference group. The variable S_i identifies cattle sex (1 = steers, 0 = heifers). The variables associated with animal characteristics and performance were also included into the model. The variable DoF_i is days on feed, which is the number of days the animal was fed in the feedlot. *DOF* was calculated as the interval between harvest date and Iowa delivery date. The variable W_i is placement weight, the weight of feeder steer/heifer at the time being delivered into the feedlot. The variable FG_i is the feed to gain ratio, which was calculated as the total pounds of feed on a dry matter basis divided by pounds of feedlot gain. ADG_i is the overall average daily gain, which was calculated as total weight gain in the feedlot divided by total days on feed. D_i is dressing percentage, which was calculated as hot carcass weight divided by final live weight. T_i is the number of independent health treatments received by an individual animal during the feeding period. C_i is average monthly U.S. corn price during the time the animal was fed, which was obtained from USDA Statistics Service (2004-2015).

The parameter μ_{year} is the random effect of the harvest year, $\mu_{feedlot}$ is the random effect of feedlot, and $\mu_{producer}$ is the random effect associated with producers. The parameter ε_i is the residual error term and is independently and identically distributed. The random effects of harvest year, feedlot, and producer were assumed to affect cattle retained ownership profitability. The alternative hypothesis is the opposite, H_0: $\sigma^2_{year} = \sigma^2_{feedlot} = \sigma^2_{producer} = 0$. The likelihood ratio test was used to test the need for including random effects into the model (Verbeke and Molenberghs, 1997). The likelihood ratio test compares the -2 Res Log likelihood of the full model and the restricted model. The log likelihood ratio statistics were calculated sequentially by adding the three random effects one by one to the null model omitting all random intercept effects. The likelihood ratio tests indicated that random effects should be included into the model. The linear mixed regression model was estimated using the Minimum Variance Quadratic Unbiased Estimation (MIVQUE0) method in SAS 9.4, which does not require the normality assumptions of the error term and random effects (SAS Institute, Cary NC).

I hypothesized superior cattle performance (i.e. lower feed-to-gain ratio and higher average daily gain) to have a positive effect on cattle retained ownership profits (Schroeder, et al, 1993; Jones, et al., 1996; Mark et al., 2000). Dressing percentage is hypothesized to positively relate to profits (Fausti et al., 2003; Lewis et al., 2016). An increase in corn price will decrease retained ownership profits corn corn prices directly affect feeding cost (Miller et al., 2001). Independent health treatments in the feedlot will incur extra costs and negatively affect cattle retained ownership profits. It has been shown that untreated calves and calves only treated once were more profitable than calves treated multiple times, and calves that recovered after a single treatment had improved average daily gain compared to calves treated multiple times (Hardin and Saghaian, 2014). It is generally believed that steers perform better in the feedlot, and thus yield more profits than heifers (Belasco et al., 2009). The effects of placement season on retained ownership profit was examined because many factors (i.e., prices, weather, and feedlot conditions) are closely related to seasoning feeding conditions (Lawrence, Wang, Joy, 1999). It is difficult to predict which placement season is the most profitable and which one is the least profitable. It is generally known that the number of days cattle are kept on fed affects cattle feedlot performance and beef quality grade thus affects retained ownership profits (McDonald and Schroeder, 2003). It is not known how days on feed and placement weight affect profits in our dataset.

Risk Analysis Methods

Empirical distributions of net returns of cattle placed in five placement seasons (i.e., spring, summer, fall, winter, and mixed) were compared using the mean-variance criterion and the stochastic dominance method. The mean-variance criterion assumes that the dominant alternative must have either a higher mean for a give variance or a lower variance for a given mean (Lambert and Lowenberg-Deboer, 2003). For example, given two placement season alternatives spring and summer with different cattle retained ownership net return distributions, the mean-variance criterion determines that spring placement season is preferred to summer if the net returns of cattle placed in the spring are higher than net returns of cattle placed in the summer and the variance of net returns of cattle placed in the spring is lower. However, if the net returns of cattle placed in the spring have both a higher mean value and variance, then the mean-variance criterion cannot be used to rank the two placement season alternatives (Hardaker, Huirne, and Anderson, 2015). In this case, stochastic dominance should be used to rank risky alternatives. The coefficient of variation measuring the dispersion of net returns was used to supplement the mean-variance criterion.

The stochastic dominance uses two observations on human beings (Hien, et al., 1997): (i) most people prefer more to less; (ii) Human beings prefer to avoid low value outcomes. Two decision rules are used to quantify these corresponding observations in terms of empirical distributions: first degree stochastic dominance (FDSD) and second degree stochastic dominance (SDSD). FDSD states that an alternative is preferred over others if it has the greatest cumulative probability at every level of outcome (Lambert and Lowenberg-Deboer, 2003). Expressed graphically, the dominant distribution always lies below and to the right of other distributions. If the cumulative probability distribution (CDFs) of net returns of cattle placed in the spring lies below and to the right of CDFs of net returns of cattle placed in the summer, then spring dominates summer in FDSD sense. SDSD assumes risk averse. SDSD states most people prefer to avoid low value outcome and prefer more to less. The dominant alternative is selected if the area under its cumulative probability curve is the smallest at any given outcome level (Hien, et al., 1997). Comparisons of the five placement season distributions were made pairwise. The Kolmogorov-Simirnov (K-S) test was used to supplement stochastic dominance results (Lambert and Lowenberg-Deboer, 2003). The K-S test is non-parametric and is used to determine if two compared distributions were identical. The K-S statistic is applied to the maximum vertical distance between two compared distributions. If the distance exceeds the critical level at the 95 significance level, then it concludes that the two distributions are significantly different (Lambert and Lowenberg-Deboer, 2003). The null hypothesis in this context was empirical distributions of net returns of cattle placed in five placement seasons are identical.

Estimation of Cumulative Distribution

In order to compare the riskiness of the placement season alternatives, empirical distributions of cattle net returns must be estimated. The cumulative probabilities of observed, predicted, and simulated net returns of cattle placed in different seasons were plotted and compared. The linear regression model omitting random effects were used to estimate the predicted net returns. The predicted net returns were a linear combination of the unbiased parameter estimates (β^*) from Model (2) and the observed independent variables of cattle (X). The predicted net returns of cattle placed in a specific season were obtained by fixing the corresponding season indicator variable as 1 and other indicators as 0, *ceteris paribus*.

The empirical distributions of predicted net returns and observed net returns were compared to check how well they match each other and ultimately to validate the linear mixed model results associated with placement season alternatives. Monte Carlo simulation generates sample average estimators of the population mean by sampling from the distribution of estimated model parameters. Model results regarding the placement season alternatives were analyzed by examining CDFs of simulated net returns of cattle placed in different seasons. The sole effect of placement season on net returns can be compared and analyzed, all else being equal. Sensitivity analysis was implemented to examine how net returns change with the variation of cattle performance and corn prices.

The distribution of model parameters $(\beta_0, \beta_1, \beta_2, \ldots \beta_{11})$ were simulated as multivariate normal (MVN) random variables.

$$(3) \qquad \begin{bmatrix} \beta_0^* \\ \beta_1^* \\ \vdots \\ \beta_{11}^* \end{bmatrix} \sim MVN\left(\begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_{11} \end{bmatrix}, \begin{bmatrix} \sigma_{\beta_0}^2 & \rho_1 \sigma_{\beta_0} \sigma_{\beta_1} & \cdots & \rho_{11} \sigma_{\beta_0} \sigma_{\beta_{11}} \\ \rho_1 \sigma_{\beta_0} \sigma_{\beta_1} & \sigma_{\beta_1}^2 & \cdots & \rho_{12} \sigma_{\beta_1} \sigma_{\beta_{11}} \\ \vdots & \vdots & \vdots & \vdots \\ \rho_{11} \sigma_{\beta_0} \sigma_{\beta_{11}} & \rho_{12} \sigma_{\beta_1} \sigma_{\beta_{11}} & \cdots & \sigma_{\beta_{11}}^2 \end{bmatrix} \right)$$

where the mean vector was the parameter coefficients of Equation (2). The 12 by 12 variance-covariance matrix was the robust covariance estimator of the model, where ρ is the correlation coefficient, and the "*" indicates a random draw from the distribution (Lambert, Boyer, and He, 2015; Cuvaca et al., 2015). At each iteration, a new vector, $\beta^* = (\beta_0^*,\ \beta_1^*, \beta_2^*, \ldots \beta_{11}^*)$, was created to calculate an *ex ante* net return value. Ten thousand iterations were generated using Matlab r2016a (The MathWorks, Inc., 2016). Therefore, a 10000 × p matrix was generated consisting of 10000 simulations of β^*, represented as *B*.

The model parameter estimates and mean observed independent variables $(\hat{X})$ for the 2,953 cattle were substituted into a simulation model to calculate the ex-ante net returns:

$$(4) \qquad \hat{Y} = \hat{B}\bar{X}$$

Where $\hat{Y}$ is a 10000 ×1 column vector representing the simulated net returns of cattle placed in each season. $\hat{B}$ is a 10000 × p matrix containing the marginal effects of each independent variable, and $\bar{X}$ is a p × 1 column vector containing the following mean values of independent variables for the 2,953 cattle that include a constant term, binary variables indicating sex (*steer*) and placement seasons (*spring*, *summer*, *winter*), days on feed (*dof*), placement weight (*placewt*), feed to gain ratio(*conv*), average daily gain (*adg*), dressing percentage (*dress*), number of health treatment (*treat*), and corn prices (*corn*):

$$\bar{X}^T = [1\ steer\ spring\ fall\ winter\ dof\ placewt\ conv\ adg\ dress\ treat\ corn]^T$$

The simulated net returns of cattle placed in a specific season were obtained by fixing the corresponding season indicator variable as 1 and other indicators as 0.

Sensitivity analyses were made to understand the effects of corn prices and cattle performance on retained ownership profitability in each placement season. Four scenarios were simulated. For the convenience of comparison, scenario 1 was when all the independent variables were at the mean ($\bar{X}$). Scenario 2 is when corn price at the 75th level ($5.22/bu.) were used to proxy the mean ($4.52/bu.), *ceteris paribus.* Scenario 2 simulated the condition when corn prices were higher than the average.

Scenario 3 was simulated when dressing percentage at the 75th percentile (62.64%) was used to proxy the mean (61.53%), average daily gain at the 75th percentile (3.83 lbs.) was used to proxy the mean (3.42 lbs.), health treatment at the 25th percentile (0) was used to proxy the mean (0.31), and feed to gain ratio at the 25th percentile (6.14) was used to proxy the mean (6.63), *ceteris paribus.* Scenario 3 simulated the condition when healthy cattle exhibited superior feedlot performance and a higher dressing percentage than the average. Based on scenario 3, scenario 4 is when corn prices were set at the 75th percentile, *ceteris paribus.*

CHAPTER V: RESULTS AND DISCUSSION

Empirical Results

Net Returns

Retained ownership profits per head were calculated following Equation (1). Summary statistics of average annual net returns from retained ownership of cattle are presented in Table 5. Net returns both including and excluding death loss are shown in Table 5. Returns to retained ownership including death loss were positive in 8 of the 11 years analyzed, with an average return of $37.92/head (Table 5). Returns to retained ownership excluding death loss were positive in 9 of the 11 years analyzed, with an average return of $47.80/head. In both scenarios, average retained ownership profits of heifers were higher than steers in most of the years. Specifically, average net returns of steers excluding death loss were positive in 8 of 11 years with an average return of $43.62/head; average net returns of heifers excluding death loss were positive in 9 of 10 years with an average return of $61.56/head.

[Place Table 5 Approximately Here]

Retained ownership including death loss was the most profitable in year 2005 and year 2014 with an average profit of $206/head, and was the least profitable in year 2013 with an average profit of -$82/head (Figure 1). Retained ownership including death loss was the most profitable for cattle placed in the spring with an average profit of $75/head. Cattle placed in the summer were the least profitable with an average profit of -$15/head (Figure 3). The average feeder price of cattle placed in the summer was the highest ($116.30/cwt) among the four seasons. Profits varied seasonally and exhibited different patterns for steers and heifers. Profits for heifers placed in the spring were the highest, and profits for steers placed in the summer were the lowest. Steers placed in summer and fall months were generally less profitable than steers placed in spring and winter. Heifers placed in the spring and winter were more profitable than summer and fall. Figure 2 and Figure 4 display the retained ownership profits excluding death loss.

[Place Figure 1 to 4 Approximately Here]

Empirical Distributions of Observed Net Returns

Figure 5, Figure 6, and Figure 7 display all pairwise comparisons of empirical distributions of observed net returns of each sex group by placement season. Figure 5 displays pairwise comparisons of empirical distributions of observed net returns of steers, heifers, and the mixed cattle. Empirical distributions of observed net returns of steers and mixed cattle are almost identical. The distribution of net returns of heifers lies below and to the right of steers until 70 percentile ($113/head) and is dominated by the latter for the rest of the comparison. The distribution of net returns of heifers lies below and to the right of the mixed distribution and crosses each other at the 70^{th} percentile ($113/head).

[Place Figure 5 Approximately Here]

Figure 6 displays pairwise comparisons of empirical distributions of the observed net returns between the mixed and each of the four placement seasons. Net returns of the cattle placed in the mixed season exceed returns of cattle placed in the spring at the 65 percentile ($96/head) and are to the right throughout the rest of the comparison. Except for the lower tail (0-5^{th} percentile) and the upper tail (99.7^{th}-100^{th} percentile), the distribution of net returns of cattle placed in the mixed season lies below and to the right of summer distribution, and the winter distribution lies below and to the right of the mixed distribution. Net returns of cattle placed in the mixed season surpass net returns of cattle placed in the fall at the 88.6th percentile ($213.4/head).

[Place Figure 6 Approximately Here]

Figure 7 displays pairwise comparisons of empirical distributions of observed net returns of cattle placed in the spring, summer, fall, and winter. The distributions of net returns of cattle placed in the spring, fall, and winter are always below and to the right of distribution of net returns of cattle placed in the summer. Net returns of cattle placed in the fall exceed net returns of cattle placed in the spring at the 62th percentile ($91/head) and remains superior for the rest of the comparison. Net returns of cattle placed in the winter are lower than net returns of cattle placed in the spring before 37th percentile ($46/head) and exceed the latter throughout the rest of the comparisons. Net returns of cattle placed in the winter are higher than net returns of cattle placed in the fall at every probability level.

[Place Figure 7 Approximately Here]

Model Results

Estimated coefficients of the linear mixed model are presented in Table 6. Cattle performance significantly affected retained ownership profits. Higher average daily gain and lower feed-to-gain ratio increased cattle feeding profits. The number of individual health treatments received by the cattle was negatively related to profits, as expected. Higher corn prices significantly reduced retained ownership profits. Retaining heifers was more profitable than retaining steers. A higher dressing percentage would lead to a heavier carcass weight and result in a higher net return, *ceteris paribus*.

Components of profit variability between steers and heifers can be attributed to differences in feeder cattle prices (William et al., 1993; Lawrence, Wang, and Loy, 1999; McDonald and Schroeder, 2003). A higher feeder cattle price for steers relative to heifers lead to a higher opportunity cost of retaining steers and thus a lower retained ownership profit. The results presented in Table 4 also confirms this finding. Feeder cattle price for steers averaged, at least $9.67/cwt, more than feeder cattle price for heifers. However, differences in fed cattle prices were much smaller between steers and heifers.

[Place Table 6 Approximately Here]

Previous research by Mark et al. (1997) indicated that steers placed on feed in late spring to early summer were generally more profitable than steers placed on feed in late winter and early spring at the same weight. This analysis on combined steers and heifers indicates that cattle placed on feed in summer were the least profitable, while cattle placed on feed in winter were the most profitable (Table 6). Placement weight positively affected profits to cattle retained ownership. One possible explanation for this positive effect is that heavier weight at the time of placement indicates a faster growth rate in the feedlot thus reduces the number of days to reach harvest weight (Williams and Stockton, 2001). Days on feed had a positive effect on profits. The possible explanation is cattle fed for a longer period result in a higher probability of good quality grade and thus lead to a higher net return (McDonald and Schroeder, 2003).

The random effects for harvest year, feedlot and producer were all significant at the 1% level.

Risk Analysis Results

Figure 8. displays the probability distributions of observed and predicted net returns of cattle placed in five placement seasons. For the observed net return distributions, winter FDSD dominated fall, mixed, and summer with 75.78% of cattle being profitable. Fall was preferred over mixed and summer by FDSD with 47.43% cattle being profitable. Summer was the least preferred placement season alternative with the lowest percentage of cattle being profitable (47.43%). Spring distribution crossed with winter, fall, and mixed at the 37^{th}, 62^{nd}, and 65^{th} percentile, respectively, with the highest probability of cattle being profitable (83.83%). Spring dominated summer by FDSD. When comparisons between the observed and predicted distributions were made, the predicted distributions of net returns are more clearly differentiated than the observed distributions as the predicted spring distribution does not cross with other distributions. This is because the predicted net returns were estimated from a linear regression model omitting random effects. The random effects were included into the linear mixed model to avoid omitted variable bias in order to get the unbiased parameter estimates (Rabe-Hesketh and Skrondal, 2008). For the predicted distributions, winter was the most preferred placement season with the highest percentage of cattle being profitable (78.09%) followed by fall (76.74%) and spring (69.01%). Summer was the least preferred season to place cattle on feed with the lowest percentage (33.56%) of cattle being profitable. The model predictions agreed reasonably well with the observations in the placement season ranking. The Kolmogorov-Smirnoff (K-S) tests were conducted to supplement the stochastic dominance results. The K-S tests indicated that distributions compared pairwise by stochastic dominance above were statistically different from each other. The mean-variance criterion cannot be used to rank the five placement season alternatives. Although winter placement exhibited the highest mean ($86.50/head), the lowest

standard deviation (109.34) was from the mixed placement season (Table 7). The coefficient variation could not be used because the lowest value (-0.26) was from summer, which made little sense since the mean net returns of cattle placed in the summer was negative ($-44.58/head).

[Place Table 7 Approximately Here]

[Place Figure 8 Approximately Here]

Figure 9 displays CDFs of the simulated net returns of cattle placed on feed in different seasons under four scenarios. Overall, the standard deviations for the simulated net returns (33.64$\leq \text{Std. Dev} \leq 34.91$) (Table 8) were much smaller than the observed (86.71$\leq \text{Std. Dev} \leq 140.53$) and the predicted (109.34 or 110.68). The simulated distributions looked more compact compared with the observed and predicted when plotted on the same x-axis scale. This is because the simulated net returns were estimated using the mean value of the independent variables ($\bar{X}$) rather than the observed independent variables (X). The former takes the average of the observed independent variables and has a lower standard deviation than the latter.

[Place Table 8 Approximately Here]

[Place Figure 9 Approximately Here]

a. Mean-variance analysis and stochastic dominance results: scenario 1

The cattle placed in the winter exhibited the highest mean ($86.62/head) (Table 7) with a standard deviation of 33.97. The cattle placed in the fall had the second highest mean ($81.67/head). Cattle placed in the summer exhibited a loss of $40.39/head with the second highest standard deviation (33.98). The placement season alternatives cannot be ranked by mean-variance criterion. FDSD results indicated that winter was the dominant placement season with the highest mean net return ($86.62/head) and the most number of cattle being profitable (94.67%) followed by fall ($81.67/head, 99.22%) and spring ($56.04/head, 94.67%). Summer was FDSD dominated by the mixed with a loss of $40.93/head and with the lowest probability of cattle being profitable (9.61%). The K-S comparison tests rejected the null and concluded that all the distributions were different from each other.

b. Mean-variance analysis and stochastic dominance results: scenario 2

When corn price increased form the mean ($4.52/bu.) to the 75th level ($5.22/bu.), *ceteris paribus*, the overall mean net returns and number of cattle being profitable decreased considerably. Winter was still the most profitable placement season ($43.28/head) with the highest probability of cattle being profitable (89.82%) followed by fall ($38.33/head, 87.09%) and spring ($12.70/head, 63.50%). Summer was FDSD dominated by the mixed with a net loss of $87.72/head. The ranking of placement season alternative keep the same as scenario1 by FDSD. The K-S test rejected the null hypothesis of distribution equality.

c. Mean-variance analysis and stochastic dominance results: scenario 3

Opposite to scenario 2, scenario 3 witnessed a good production condition when healthy cattle performance was above the average level, i.e., high dressing percentage (62.64%) and average daily gain (3.83 lbs.), and a desirable feed to gain ratio (6.14), *ceteris paribus*. Cattle placed in the spring, fall, winter, and mixed were 100% profitable. Mean net returns of cattle placed in the winter were the highest ($168.47/head) followed by the fall ($163.52/head) and spring ($137.89/head). 86.38% of the cattle placed on feed in the summer were profitable with a mean net return of $37.47/head. Comparison of the coefficient of variation led to the same preference ranking as by FDSD. Summer exhibited the highest coefficient of variation (0.91) followed by mixed (0.27) and spring (0.25). Winter had the lowest coefficient variation (0.20). The K-S tests made pairwise comparisons of the distributions and led to the rejection of the null hypothesis.

d. Mean-variance analysis and stochastic dominance results: scenario 4

The corn price at the 75th level was used to proxy the mean based on scenario 3. Superior cattle performance exhibited a positive effect on the profitability of cattle retained ownership, corn price negatively affected retained ownership net returns. Mean net returns of cattle placed in the winter decreased from $168.47/head to $125.13/head but all the cattle placed on feed were profitable. Winter was still the dominant placement season by FDSD. Fall ranked the second with a mean net return of $120.18/head and 99.99% of the cattle were profitable. Spring ranked the third with a mean net return of $94.55/head and 99.70% of the cattle were profitable. Summer suffered a net loss of $5.87 in this scenario and only 43.17% of the cattle were profitable. The K-S tests supplemented the stochastic dominance results and indicated that all the distributions were statistically different from each other.

Overall, a comparison of scenario 1 and other scenarios exhibited how feed cost and cattle feedlot performance played a role in affecting retained ownership net returns both individually and collectively. Superior cattle performance positively affected net returns. Higher corn prices reduced net returns because corn prices are closely linked to feed costs. Scenario 4 displayed a combined effect of high corn prices and superior cattle performance on net returns. The negative effects of high corn prices were counteracted by the positive effects of superior cattle performance on net returns. Winter was the dominant placement season with the highest profitable percentage throughout the four scenarios followed by fall and spring. Summer was the least preferred placement season with the lowest probability of cattle being profitable. The ranking list of placement season alternative by simulation was consistent with the model results.

CHAPTER VI: CONCLUSION AND IMPLICATIONS

Conclusion

Two common questions constantly raised by cow-calf producers are, "what kind of beef animal is most profitable" and "can profits be increased by cattle retention post weaning" (Stokes, Farris, and Cartwright, 1981). My findings provide insight into these questions. Understanding how cattle performance and producer choice variables affect profitability is important for cow-calf producers in making strategic marketing decisions. Retained ownership data for steers and heifers harvested from 2005 to 2015 were analyzed. A mixed regression model was estimated with fixed effects for the factors mentioned previously and related random effects (i.e., feedlot, producer, and harvest year). Net return distributions under the four scenarios when corn prices and cattle performance at lower and higher percentile levels were simulated and compared. Risk analyses using the mean-variance criterion and stochastic dominance methods were used to distinguish among the alternatives of retained ownership decisions with respect to placement season. Results indicated that placement weight, placement season, days on feed, animal health and animal sex impacted retained ownership profitability.

Overall, retained ownership profits to heifers were higher than steers on average. Cattle placed on feed in winter were the most profitable, while cattle placed on feed in summer were the least profitable. Days on feed had a positive effect on retained ownership profits. Desirable cattle feedlot performance (i.e. lower feed-to-gain ratio and higher average daily gain) increased retained ownership profits. Dressing percentage and placement weight positively affected retained ownership profits, while the number of individual health treatments and corn prices negatively affected retained ownership profits. Overall, returns to retained ownership were positive in 9 of the 11 years analyzed, indicating that retained ownership could be a beneficial marketing strategy. Retained ownership were profitable in 8 of the 11 years even when death loss were accounted for.

Implications

Useful implications can be drawn from the empirical evidence presented above. Cow-calf producers can improve retained ownership profitability by selecting calves and dates based on the model results. Overall, the linear mixed regression model suggests that retaining young heifers with potential superior feedlot performance and a heavier weaning weight in the winter placement season is the best strategy.

The results that placement season and days on feed impacted profits provide cow-calf producers a unique opportunity to determine the optimal days and season for the cattle to be placed on feed. Cattle quality grade increases with days on feed. Meanwhile, cattle average daily gain decreases and feed to gain ratio increases, which generated extra feed costs for the producers (McDonald and Schroeder, 2003). Joint consideration of cattle performance factors and quality grade are required regarding the days on feed. Cattle producers can meet the seasonal demand of beef quality by adjusting the number of days for the cattle to be placed on feed in the feedlot. For example, cattle placed in the late winter (February) can be fed for an extended period to be slaughtered in the summer (June-August) to satisfy the high quality need for “grilling” (Hogan, Robert, and Ward, 2005).

An improvement in cattle performance would increase the likelihood of positive net returns to retained ownership. Cow-calf producers have direct access to the cattle performance information and can improve profitability by selecting superior cattle to place on feed. However, cattle performance factors are not the solely contributors to net returns, factors such as fed cattle price and feeder cattle price should also be taken into consideration when making retained ownership decisions (Williams et al., 1993).

Model results also yielded useful implications for placement weight adjustment when corn prices are high. High corn price increases the optimal placement weight (Hardin and Saghian, 2014). Tennessee cow-calf producers can use cool-season grass pasture to feed calves to the optimal placement weight. Cool-season grasses grow primarily in the spring (March to May) and fall (September to November) (Keyser et al., 2011). This provides the cow-calf producers a rare opportunity to adjust the calving season to optimize their profits. For example, cow-calf producers can select the fall calving season when cool-season grass grows at the peak and feed the calves until the winter placement season.

Whether to retain steers or heifers can be a hard decision faced by many cow-calf producers (Williams et al., 1993). Based on model developed in this research, retaining heifers is more profitable than retaining steers, all else being equal. Higher feedlot feed costs offset the premiums generated from the better feedlot performance for steers. A higher heifer retention rate implies a higher probability of positive net returns. Cow-calf producers can therefore adjust the cow-calf ration to optimize the retained ownership net returns.

Future Research

This study extends earlier research (e.g. Lewis et al., 2016) by including other placement decisions that may affect cattle feeding profitability and by analyzing multiple years of retained ownership data. Future research could include sensitivity analysis of our results by examining the relationship between feeder and fed prices and examining retained ownership profitability in different regions of the country.

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APPENDIX

APPENDIX I

Tables

Table 1. Summary Statistics for Steers and Heifers Finished and Harvested in Iowa and Originating in Tennessee for 2005-2015

	All			Steer			Heifer		
Variable	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Placement Weight(lb.)	716.27 (108.89)	410	1110	728.12*** (105.75)	425	1110	677.25*** (110.03)	410	1070
Days on Feed	147.91 (25.26)	101	206	147.78 (25.70)	101	206	148.33 (23.76)	101	206
Feed-to-Gain Ratio	6.63 (0.77)	4.20	13.08	6.54*** (0.70)	4.20	10.76	6.91*** (0.90)	4.56	13.08
Average Daily Gain	3.42 (0.62)	1.05	5.66	3.53*** (0.60)	1.05	5.66	3.06*** (0.54)	1.20	5.13
#Number of Health Treatments	0.31 (0.69)	0	5	0.31 (0.71)	0	5	0.30 (0.66)	0	4
Dressing %	61.53% (0.02)	53.61%	69.68%	61.45% (0.02)	53.61%	69.68%	61.77% (0.02)	56.23%	67.16%
Number of Observations	2,953			2,265			688		

Note: Standard deviations are in parenthesis.

*,**, *** denotes pairwise differences between steers and heifers at the 10%, 5% and 1% levels.

Table 2. Summary Statistics of Cattle Performance by Cattle Sex and Placement Season for 2005-2015

Placement Season[a]	Cattle Group	Variables: Placement Weight	Days on Feed	Feed-to-Gain Ratio	Average Daily Gain	Number of Health Treatments	Dressing %	Number of Observations
Spring	All	787.62 (109.49)	131.33 (16.51)	6.38 (0.73)	3.52 (0.65)	0.30 (0.68)	61.44% (0.02)	266
	Steer	800.02*** (112.63)	131.77 (17.52)	6.29*** (0.70)	3.67*** (0.62)	0.23*** (0.56)	61.44% (0.02)	185
	Heifer	759.32*** (96.78)	130.32 (14.00)	6.57*** (0.74)	3.18*** (0.57)	0.48*** (0.87)	61.45% (0.01)	81
Summer	All	746.82 (122.86)	144.77 (26.71)	6.54 (0.77)	3.53 (0.70)	0.27 (0.66)	61.52% (0.02)	877
	Steer	763.76*** (119.98)	143.79 (27.28)	6.40*** (0.72)	3.68*** (0.67)	0.28 (0.68)	61.43%*** (0.02)	668
	Heifer	692.67*** (116.37)	147.92 (24.60)	6.97*** (0.78)	3.05*** (0.56)	0.22 (0.58)	61.81%*** (0.02)	209
Fall	All	694.78 (94.13)	155.98 (26.52)	6.78 (0.85)	3.25 (0.58)	0.24 (0.56)	61.57% (0.02)	749
	Steer	701.10*** (87.48)	155.86 (25.91)	6.66*** (0.71)	3.38*** (0.55)	0.26 (0.59)	61.47%*** (0.02)	574
	Heifer	674.05*** (111.02)	156.40 (28.50)	7.19*** (1.13)	2.80*** (0.45)	0.18 (0.43)	61.91%*** (0.02)	175
Winter	All	688.29 (90.22)	148.96 (22.32)	6.66 (0.69)	3.43 (0.53)	0.38 (0.80)	61.52% (0.02)	1,061
	Steer	702.34*** (86.20)	148.97 (23.48)	6.63 (0.66)	3.49*** (0.53)	0.37 (0.81)	61.46% (0.02)	838
	Heifer	635.49*** (85.46)	148.91 (17.38)	6.76 (0.79)	3.22*** (0.50)	0.40 (0.75)	61.75% (0.02)	223

Note: Standard deviations are in parenthesis.

[a] Placement season: Spring = March-May, Summer = June-August, Fall = September-November, Winter = December-February.

*,**, *** denotes pairwise differences between steers and heifers at the 10%, 5% and 1% levels.

Table 3. Summary Statistics of Feedlot Feed Costs ($/head) by Cattle Sex for 2005-2015

Variable	All			Steer			Heifer		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Feed Cost	328.29	126.06	786.56	339.01***	135.54	786.56	293.01***	126.06	711.96
	(102.25)			(105.77)			(80.19)		
Corn Price[c] $/bu.	4.52	2.38	7.32	4.55***	2.38	7.32	4.40***	2.38	7.32
	(1.27)			(1.32)			(1.04)		
Health Treatments	9.24	0	162.81	9.59	0	162.81	8.10	0	128.08
	(22.08)			(22.87)			(19.19)		
Vaccines	16.66	4.43	38.40	16.91	4.43	38.39	15.84	4.43	37.15
	(7.42)			(7.69)			(6.37)		
Yardage	54.74	36.46	74.73	55.08***	36.46	74.73	53.61***	36.46	74.73
	(8.80)			(8.81)			(8.67)		
Trucking[a] & Checkoff	62.73	29.29	107.89	63.69***	29.29	106.62	59.58***	37.02	107.89
	(12.26)			(11.51)			(13.98)		
Miscellaneous[b]	23.13	17.22	29.92	23.11	17.22	29.92	23.19	18.55	29.92
	(2.86)			(2.97)			(2.46)		
Total Feedlot Cost	494.79	277.59	1018.10	507.38***	283.80	1018.1	453.34***	277.59	906.11
	(114.65)			(119.10)			(86.52)		
Number of Observations	2,953			2,265			688		

Note: Standard deviations are in parenthesis.

[a] Trucking costs consist of the cost of transportation for the cattle from home to Iowa and the cost of transportation for the cattle from the feedlot in Iowa to the packing plant to be slaughtered.

[b] Miscellaneous expenses include data collection fee, interest paid less interest received, tags, peril insurance, labor, scale charge and meals for weaning cattle, GA health inspections and electrolytes if used.

[c] Corn price differences between steers and heifers were caused by differentials of placement time.

*,**, *** denotes pairwise differences between steers and heifers at the 10%, 5%and 1% levels.

Table 4. Summary Statistics of Feedlot Feed Cost ($/head) by Placement Season for 2005-2015

Placement Season	Cattle Group	Variables: Feedlot Cost $/HD	Corn Price $/bu.	Feeder Cattle Price $/cwt	Fed Cattle Price[b] $/cwt	Number of Observations
Spring	All	438.52 (57.50)	4.37 (0.69)	97.73 (10.55)	163.59 (10.89)	266
	Steer	454.05*** (56.57)	4.43** (0.72)	100.68*** (9.97)	163.22 (11.31)	185
	Heifer	403.06*** (41.96)	4.23** (0.58)	91.01*** (8.63)	164.43 (9.87)	81
Summer	All	463.62 (97.58)	4.09 (1.14)	116.30 (12.34)	167.33 (19.72)	877
	Steer	476.03*** (105.37)	4.07 (1.24)	119.83*** (10.53)	169.54*** (21.33)	688
	Heifer	423.98*** (49.52)	4.15 (0.73)	105.02*** (10.83)	160.26*** (10.60)	209
Fall	All	480.18 (123.73)	4.29 (1.35)	114.88 (18.60)	174.37 (22.37)	749
	Steer	500.92*** (129.70)	4.40*** (1.42)	118.57*** (16.74)	178.64*** (22.53)	574
	Heifer	412.16*** (65.91)	3.94*** (1.01)	102.78*** (19.30)	160.94*** (15.58)	175
Winter	All	544.97 (113.29)	5.06 (1.22)	106.82 (31.63)	178.60 (28.59)	1,061
	Steer	548.58*** (119.01)	5.06*** (1.24)	108.91*** (30.83)	179.64*** (27.52)	838
	Heifer	531.44*** (87.51)	5.07*** (1.13)	98.95*** (33.41)	174.68*** (32.08)	223

Note: Standard deviations are in parenthesis.

[a] Placement season: Spring = March-May, Summer = June-August, Fall = September-November, Winter = December-February.

[b] Fed cattle price is represented by the actual carcass price ($/cwt).

*,**, *** denotes pairwise differences between steers and heifers at the 10%, 5% and 1% levels.

Table 5. Summary Statistics for Net Returns of Cattle by Harvest Year

Year	Observations	All[1]	All[2]	Steer[1]	Steer[2]	Heifer[1]	Herifer[2]
2005	26(0)	205.71	205.71	230.71	230.71	171.63	171.63
		(85.28)	(85.28)	(72.83)	(72.83)	(92.41)	(92.41)
2006	301(2)	-56.03	-63.59	-67.53	-76.43	4.11	4.11
		(107.89)	(141.89)	(104.70)	(144.43)	(105.31)	(105.31)
2007	490(1)	9.86	7.76	-9.93	-12.72	65.69	65.69
		(137.48)	(145.00)	(145.69)	(154.87)	(90.57)	(90.57)
2008	422(4)	27.80	20.11	25.62	14.06	32.04	32.04
		(91.31)	(120.35)	(94.14)	(134.29)	(85.71)	(85.71)
2009	489(5)	32.25	27.58	29.04	19.03	37.31	33.08
		(85.36)	(115.47)	(85.56)	(123.70)	(85.03)	(102.82)
2010	499(11)	159.60	140.95	154.19	132.18	187.59	187.59
		(111.52)	(168.26)	(112.72)	(176.79)	(101.22)	(101.22)
2011	196(3)	196.87	185.12	193.30	180.28	227.77	227.77
		(107.63)	(149.01)	(107.49)	(152.57)	(106.53)	(106.53)
2012	284(5)	0.83	-21.63	-7.72	-33.68	51.91	51.91
		(89.11)	(190.42)	(88.71)	(200.79)	(73.79)	(73.79)
2013	178(2)	-70.73	-70.73	-67.12	-79.53	-98.88	-98.88
		(161.58)	(161.58)	(158.81)	(192.70)	(183.75)	(183.75)
2014	48(0)	205.82	205.82	205.82	205.82	n.a.[3]	n.a.
		(158.74)	(158.74)	(158.74)	(158.74)		
2015	53(0)	131.49	131.49	149.84	149.84	68.82	68.82
		(124.70)	(124.70)	(108.14)	(108.14)	(159.51)	(159.51)
Average		47.80	37.92	43.62	31.19	61.56	60.36
		(138.74)	(169.50)	(145.02)	(181.45)	(114.71)	(118.84)
Observations	2986(33)[4]	2953	2986	2265	2297	688	689

Note: Numbers in parentheses are standard errors;
[1]Net returns of live cattle; [2] Net returns of both live and dead cattle; [3] No heifers were slaughtered in 2014; [4]data in the parenthesis are the number of dead cattle.

Table 6. Parameter Estimates of Retained Ownership Net Returns of Cattle Originating from Tennessee and Shipped to Iowa Feedlot (n=2953). Dependent Variable=Net Returns ($/head)

Independent Variables	Parameter Estimates	Standard Error	t Value
Fixed Effects			
Steer (yes=1; no=0)	-73.94***	4.28	-17.26
Spring	100.46***	10.73	9.37
Fall	126.06***	6.59	19.14
Winter	131.0***	8.16	16.06
Days on feed	0.54***	0.54	6.02
Placement weight	0.26***	0.26	11.41
Feed to gain ratio	-54.91***	3.38	16.26
Average daily gain	49.39***	3.87	12.77
Dressing percentage %	24.00***	0.92	26.08
No. of health treatments	-26.03***	2.57	-10.15
Corn Price, $/bu.	-61.42***	6.07	-10.12
Constant	-1250.27***	78.66	-15.89
Random Effects Variance			Z Value
Year effects, σ_y^2	7415.17***	2737.64	2.71
Feedlot effects, σ_f^2	4307.09***	4307.09	4.24
Producer effects, σ_p^2	501.25***	53.67	9.34
Residual, σ_ε^2	6471.26***	6471.26	37.34

Note: Numbers in parentheses are standard errors; *** denotes significance at the 99% level. McFadden's Pseudo $R^2 = 1 - \frac{\ln L(M_{full})}{\ln L(M_{intercept})} = 1 - \frac{33807.2}{35588.8} = 5$

Table 7. Summary Statistics of Observed and Predicted Net Returns of Cattle Placed on Feed in Different Seasons

Observed Season	Mean	Std. Dev[1]	C.V.[2]	L05[3]	Median	U95[4]	Minimum	Maximum
Spring	75.02	86.71	1.16	-63.93	70.29	231.54	-150.68	393.28
Summer	-9.81	139.47	-14.22	-233.68	-7.93	221.00	-440.85	673.78
Fall	56.58	128.87	2.28	-164.94	55.07	269.53	-358.17	463.06
Winter	82.40	140.53	1.71	-164.11	85.89	302.30	-521.35	532.23
Mixed	47.80	138.74	2.90	-188.56	48.44	278.32	-521.35	673.38
Predicted Season	Mean	Std. Dev	C.V.	L05	Median	U95	Minimum	Maximum
Spring	55.88	110.68	1.98	-121.11	55.16	243.62	-531.86	351.43
Summer	-44.58	110.68	-0.26	-221.57	-45.30	143.16	-632.32	250.97
Fall	81.48	110.68	1.36	-95.51	80.76	269.22	-506.26	377.03
Winter	86.50	110.68	1.28	-90.49	85.78	274.24	-501.24	382.05
Mixed	43.54	109.34	2.51	-138.74	45.09	225.98	-501.24	377.03

Note: [1]Std. Dev=Standard deviation; [2]C.V. = Std. Dev/ Mean; [3]L05=5th percentile; [4]U95=95th percentile

Table 8. Summary Statistics of Simulated Net Returns of Cattle Placed in different Seasons under Four Scenarios

[1]Scenario 1								
Season	Mean	Std. Dev[5]	C.V.[6]	L05[7]	Median	U95[8]	Minimum	Maximum
Spring	56.04	34.91	0.63	-1.20	55.69	113.43	-74.47	205.95
Summer	-40.39	33.98	-0.84	-99.91	-44.77	11.34	-167.10	112.97
Fall	81.67	33.68	0.41	26.86	80.99	137.20	-37.93	229.72
Winter	86.62	33.97	0.39	31.11	86.23	142.41	-35.69	235.01
Mixed	43.70	33.64	0.77	-11.32	43.26	99.43	-76.74	194.81
[2]Scenario 2								
Season	Mean	Std. Dev	C.V.	L05	Median	U95	Minimum	Maximum
Spring	12.70	34.98	2.75	-44.60	12.51	70.30	-113.43	164.23
Summer	-87.72	34.48	-0.39	-144.40	-87.95	-31.09	-208.31	71.25
Fall	38.33	33.92	0.88	-16.93	37.89	94.14	-80.74	188.00
Winter	43.28	34.03	0.79	-12.49	43.05	99.07	-71.79	193.29
Mixed	0.36	33.88	94.11	-55.13	-0.07	56.26	-117.95	153.08
[3]Scenario 3								
Season	Mean	Std. Dev	C.V.	L05	Median	U95	Minimum	Maximum
Spring	137.89	34.89	0.25	80.62	93.39	195.44	6.56	288.75
Summer	37.47	33.99	0.91	-17.65	37.09	92.75	-82.33	195.78
Fall	163.52	33.75	0.21	108.60	162.93	219.01	46.67	312.53
Winter	168.47	34.00	0.20	113.14	168.11	224.28	45.34	317.81
Mixed	125.55	33.67	0.27	70.89	125.08	180.90	5.55	256.62
[4]Scenario 4								
Season	Mean	Std. Dev	C.V.	L05	Median	U95	Minimum	Maximum
Spring	94.55	34.95	0.37	37.31	94.27	151.84	-28.66	247.03
Summer	-5.87	34.50	-5.88	-62.08	-6.07	50.47	-126.89	154.05
Fall	120.18	33.99	0.28	65.00	119.72	175.50	-1.89	270.80
Winter	125.13	34.05	0.27	69.53	124.88	180.84	10.24	276.09
Mixed	82.21	33.91	0.41	26.97	82.01	137.80	-35.89	235.89

Note: [1]Scenario 1: simulated net returns ($/head) when all independent variables are at the mean; [2]scenario 2: simulated net returns ($/head) when corn price is at the 75th percentile, *ceteris paribus*; [3]scenario 3: simulated net returns ($/head) when ADG and dressing percentage are at the 75th percentile, and number of health treatment and feed to gain ratio are at the 25th percentile, *ceteris paribus*; [4]scenario 4: simulated net returns ($/head) when corn price is at the 75th percentile based on scenario 3, *ceteris paribus.* [5]Std Dev=Standard deviation; [6]C.V.=Std. Dev/ Mean; [7]L05=5th percentile; [8]U95=95th percentile.

Figures

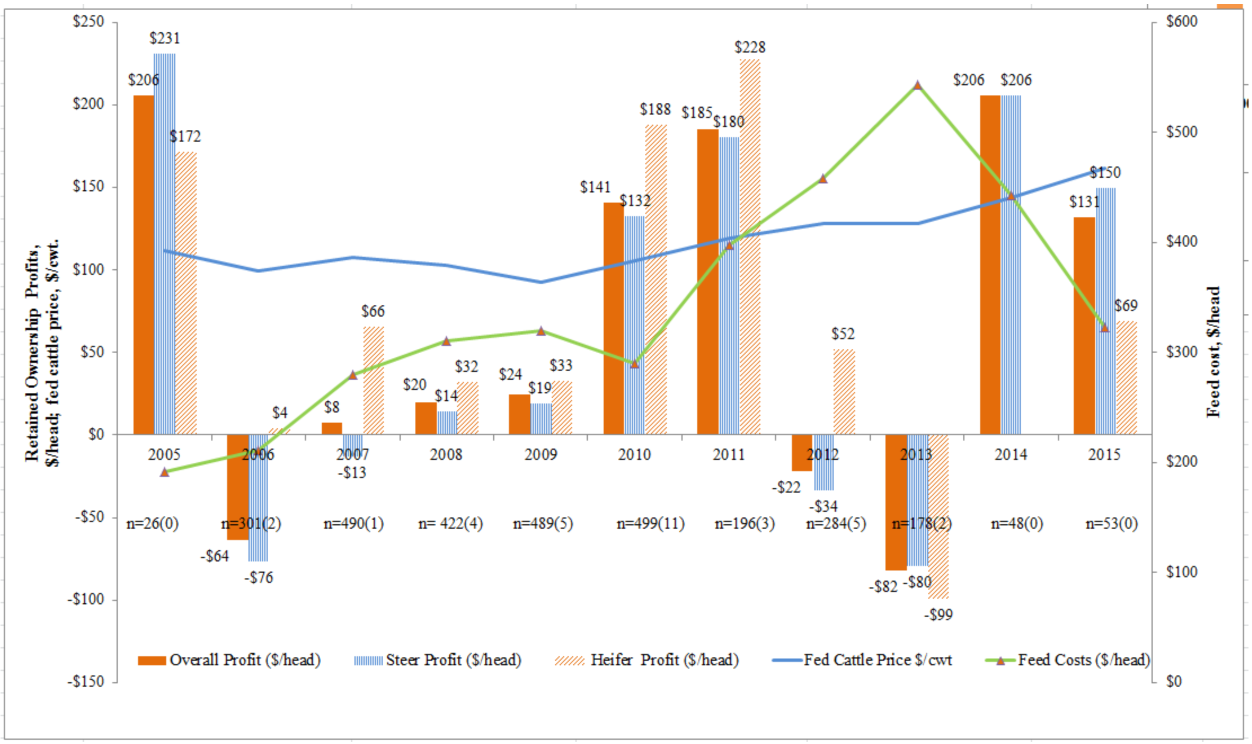

Figure 1. Retained Ownership Net Returns of Cattle by Harvest Year (including dead cattle)

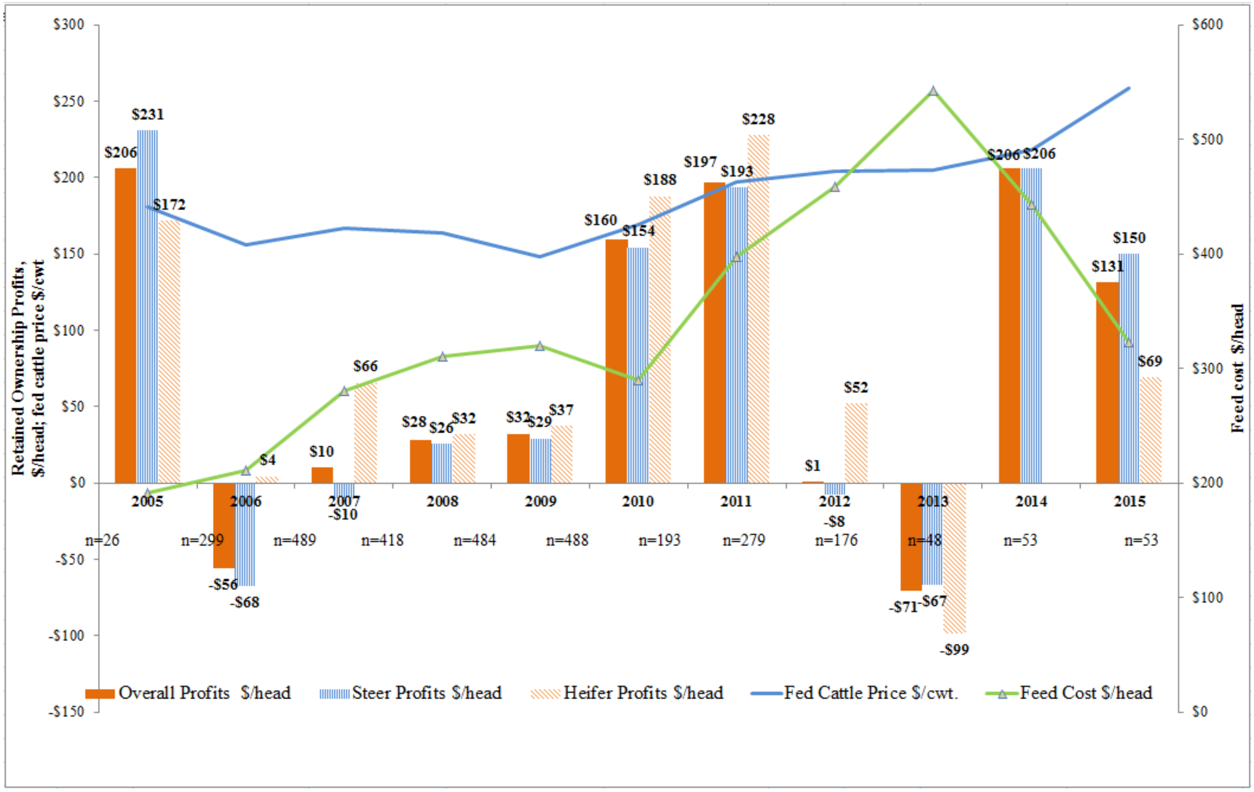

Figure 2. Retained Ownership Net Returns of Cattle by Harvest Year (excluding dead cattle)

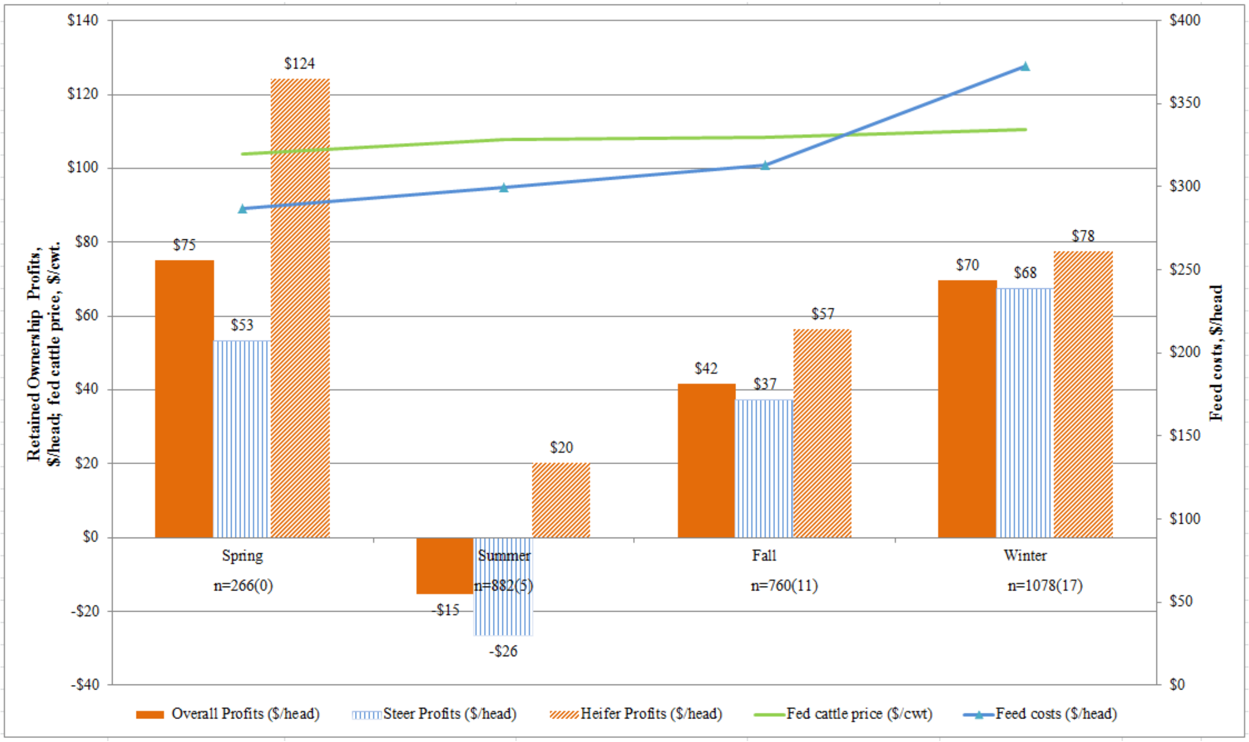

Figure 3. Retained Ownership Net Returns of Cattle by Placement Season (including dead cattle)

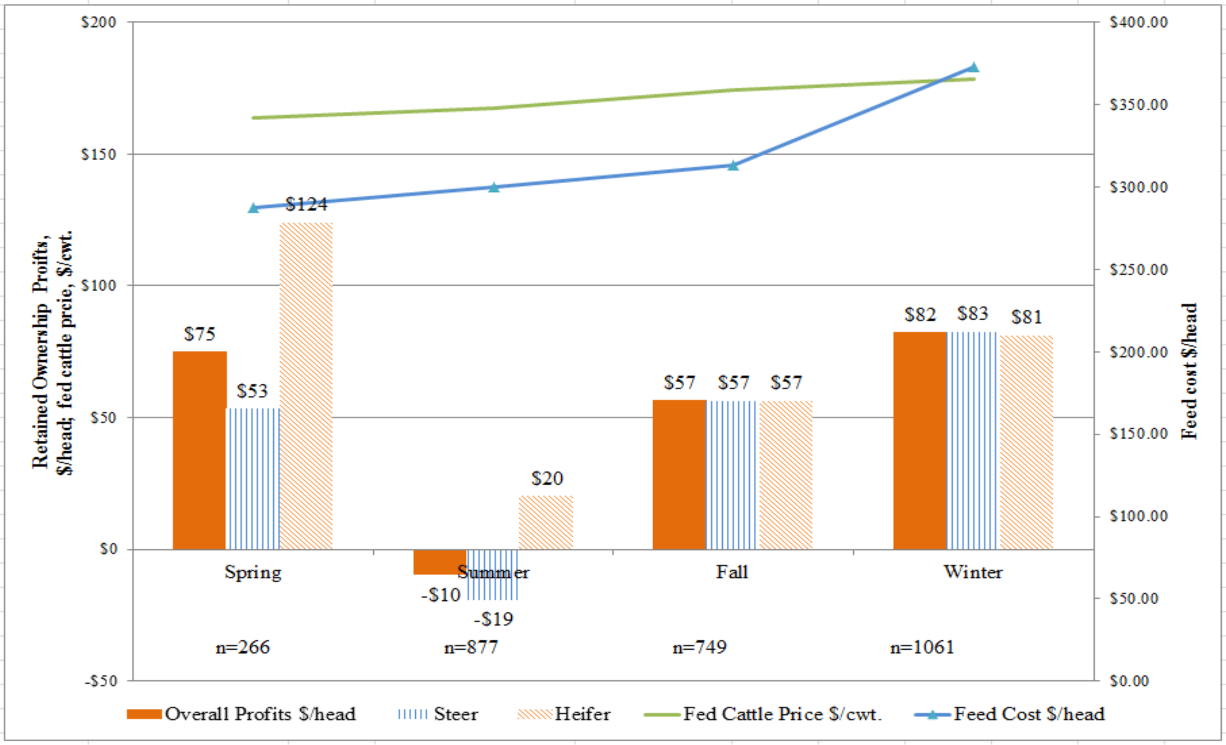

Figure 4. Retained Ownership Net Returns of Cattle by Placement Season (excluding dead cattle)

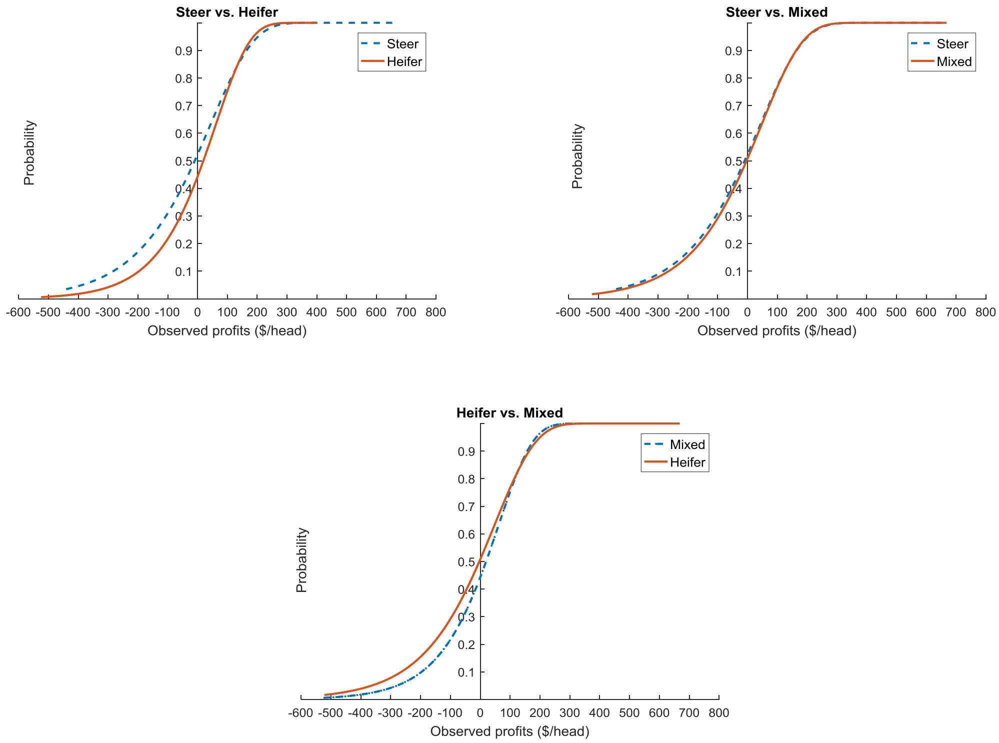

Figure 5. Pairwise Comparison of Empirical Distributions of the Observed Net Returns of Steers, Hiefers, and the Mixed Cattle

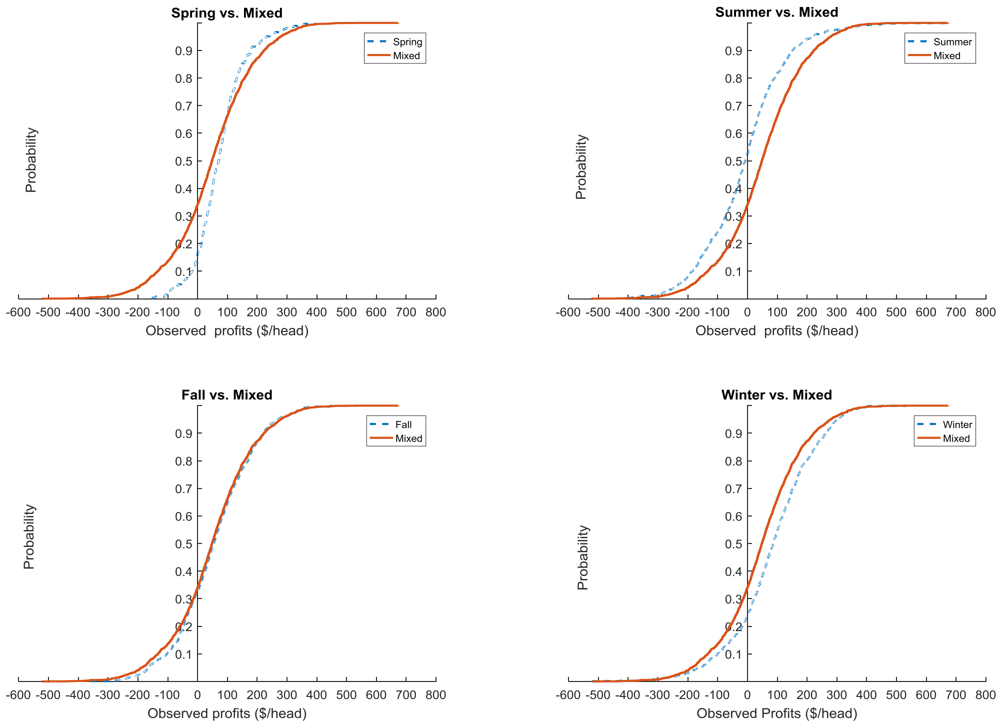

Figure 6. Pairwise Comparison of Empirical Distributions of the Observed Net Returns of Cattle Placed in the Mixed Season and the Other Four Seasons

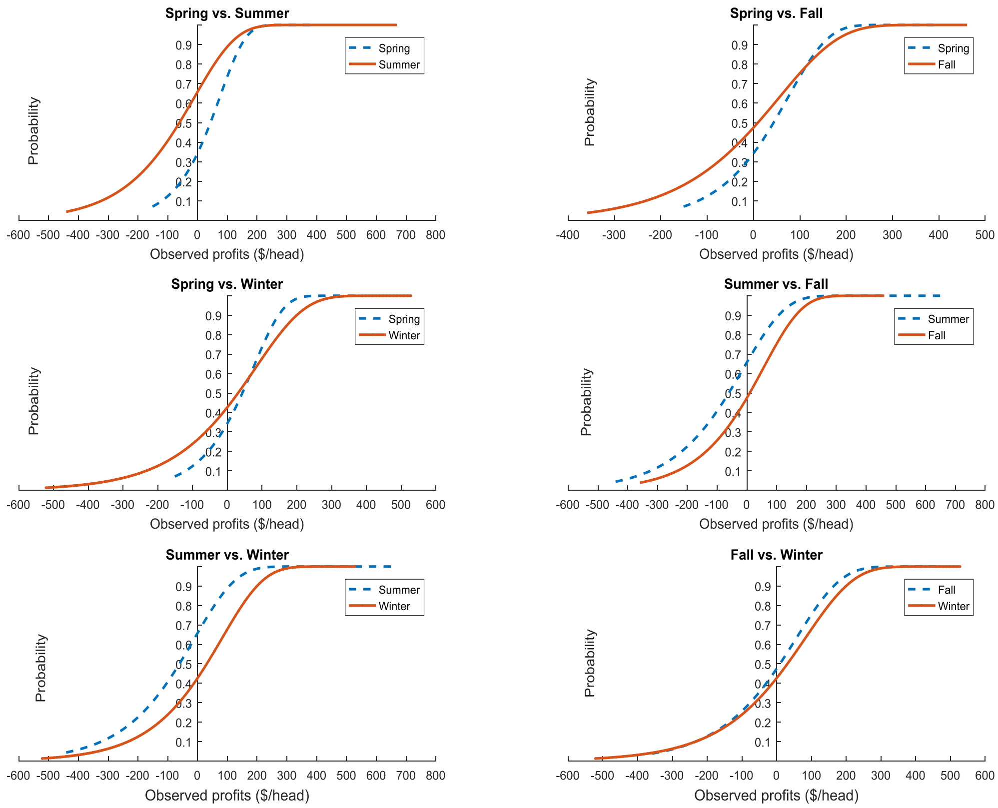

Figure 7. Pairwise Comparison of Empirical Distributions of the Observed Net Returns of Cattle Placed in the Spring, Summer, Fall, and Winter

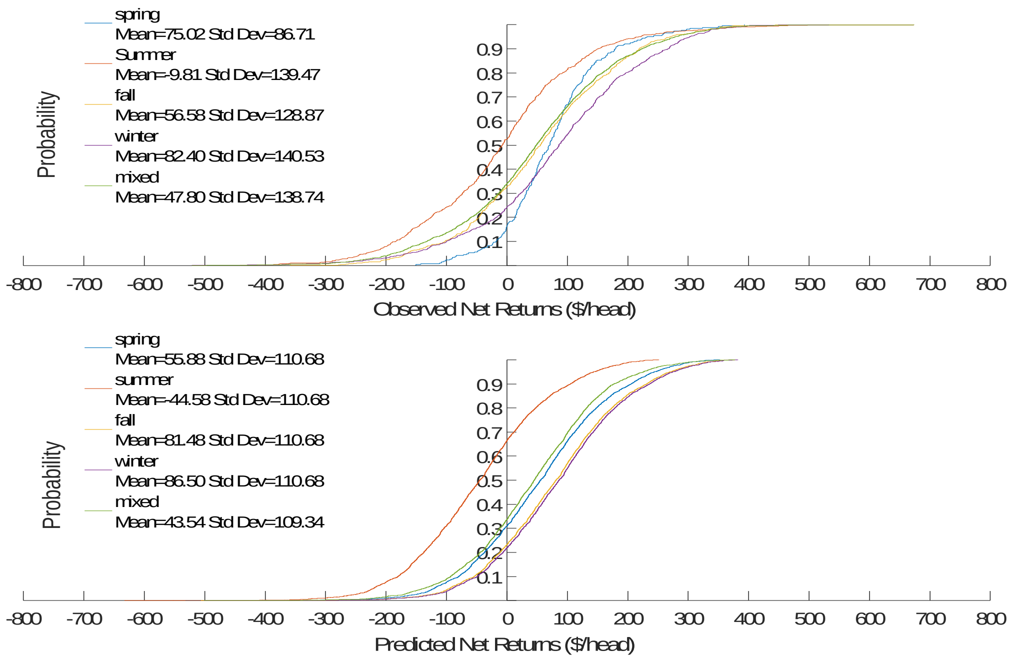

Figure 8. Cumulative Distributions of the Observed and Predicted Net Returns of Cattle Placed in Different Seasons

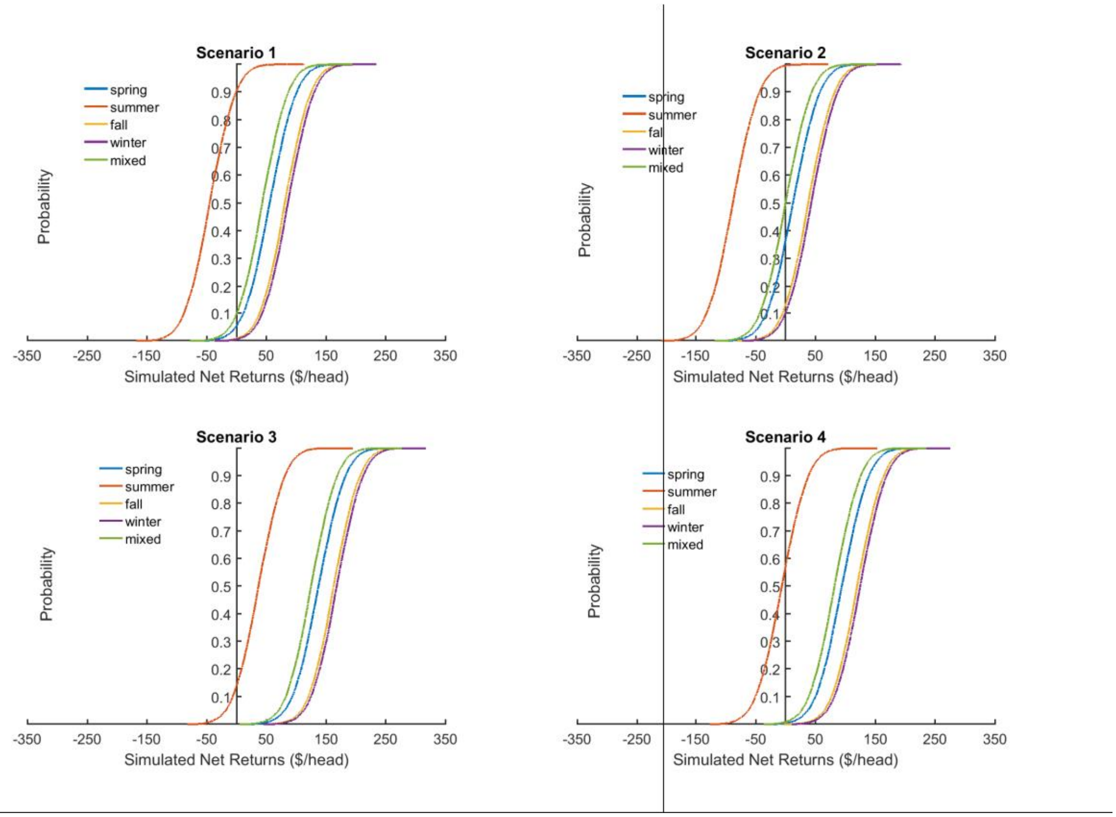

Figure 9. Cumulative Distributions of the Simulated Net Returns of Cattle Placed in Four Seasons under Four Scenarios

APPENDIX II

Covariance Matrices for the Net Returns Model Estimates

$$cov(\beta_0,\ \beta_1, \ldots \beta_{11}\ ) = \begin{bmatrix} 6187.64 & -5.6925 & 46.1595 & 20.5032 & 59.5236 & -2.2281 & -0.03398 & -64.9284 & -116.8 & -50..9298 & -23.4616 & -170.11 \\ -5.6925 & 18.3428 & -3.781 & -3.5007 & -2.8951 & -0.0705 & -0.02446 & 1.6776 & -2.9932 & 0.2039 & -0.2199 & 1.7226 \\ 46.1595 & -3.781 & 115.05 & 29.984 & 39.6615 & 0.06744 & -0.01299 & 3.542 & 1.964 & -0.02336 & 0.2865 & -22.3169 \\ 20.5032 & -3.5007 & 29.984 & 43.3878 & 32.3.98 & 0.02088 & 0.01612 & -2.0861 & 2.5137 & 0.02496 & 0.8573 & -12.6364 \\ 59.5236 & -2.8951 & 39.6615 & 32.3098 & 66.6305 & -0.0688 & 0.02464 & -0.3238 & 0.9235 & 0.004336 & 0.2478 & -22.2306 \\ -2.2281 & -0.0705 & 0.06744 & 0.02088 & -0.0688 & 0.008158 & 0.0007 & -0.01063 & 0.06337 & -0.00262 & -0.0118 & 0.1267 \\ -0.03398 & -0.02446 & -0.01299 & 0.01612 & 0.02464 & 0.0007 & 0.000532 & -0.03933 & -0.02023 & -0.00101 & 0.002352 & -0.01185 \\ -64.9284 & 1.6776 & 3.542 & -2.0861 & -0.3238 & -0.01063 & -0.03933 & 11.4052 & 7.3016 & -0.1808 & 0.2224 & 0.9717 \\ -116.8 & -2.9932 & 1.964 & 2.5137 & -0.9235 & 0.06337 & -0.02023 & 7.3016 & 14.9699 & 0.3033 & 1.5523 & 0.538 \\ -50.9289 & 0.2039 & -0.02336 & 0.02496 & 0.004336 & -0.00262 & -0.00101 & -0.1808 & 0.3033 & 0.847 & 0.2486 & -0.05063 \\ -23.4616 & -0.2199 & 0.2865 & 0.8573 & 0.2478 & -0.0118 & 0.002352 & 0.2224 & 1.5523 & 0.2486 & 6.5808 & -0.3637 \\ -170.11 & 1.7226 & -22.3169 & -12.6364 & -22.2306 & 0.1267 & -0.01185 & 0.9717 & 0.538 & -0.05063 & -0.3637 & 37.8709 \end{bmatrix}$$

VITA

Minfeng Tang was born in 1987 in Zhoushan Archipelago, China. He has a bachelor's degree in Forestry from Zhejiang A & F University. He also holds a Master of Science degree in Management from Sichuan Agricultural University. He began the M.S. Program in the Department of Agricultural and Resource Economics at the University of Tennessee, Knoxville in 2014. He will be conferred a Master of Science degree in Agricultural Economics in 2016.