UTILIZING PRICE MARGINS TO

MAXIMIZE PROFITS FOR

STOCKER OPERATORS

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CHAPTER I

INTRODUCTION

The U. S. stocker cattle industry plays an important role within the beef industry in the process of transforming calves into a consistent supply of beef for consumers. The role of the stocker industry is to add forage-based weight gain to weaned calves prior to their placement in the feedlot. Stocker cattle are purchased weighing between 200 to 600 pounds and placed in the feedlot weighing between 600 to 900 pounds as yearlings (12-20 months of age). The stocker industry in the U. S. developed in the late 1800's and early 1900's when regional stockyards in Kansas City, Fort Worth, and St. Louis were built near packing facilities. During this period, cattle feeding was seasonal and restricted to the winter season when high quality forage was not available. As a result, some cattle were finished on grass while those not ready for slaughter were fed in local feedyards during the fall and winter to insure a more constant supply of slaughter cattle (Lalman, 2001). Prior to the development of the feedlot industry, weaned calves were grazed on forage until slaughter at maturity. Upon entering the feedlot, beef animals are fed high concentrate rations until they reach slaughter weights of 1100 to 1350 pounds. Many cow-calf producers retain ownership of weaned calves through the stocker and feedlot phases of the beef industry. Some heavier weaning calves bypass the stocker phase and are placed directly in the feedlot. When grain prices are low, the likelihood of weaned calves bypassing the stocker phase increases, but economics usually favors the use of forage to add cheap gain after weaning (CME).

Stocker operations exist in various forms throughout the U. S., and often serve as a complementary enterprise in a farm or ranch business. Stocker operations use summer grazing of native and improved pastures and winter grazing of wheat pasture or other cool season forages in the southern Great Plains to add gain to calves. The grazing of crop residues and dropped grain are used as well in certain areas. Weaned calves are often backgrounded through the winter until the spring and summer grazing season in regions where winter grazing does not exist. The largest number of stocker operations are located in the Great Plains. The stocker phase is the least understood and researched in the beef industry, and the majority of research has been conducted by animal science departments (Parsons, 1994).

The U. S. cattle industry continues to change resulting in new implications for stocker operators. Changes in the production and marketing of beef cattle have had an effect upon the structure of the stocker cattle industry. Factors which are changing in the beef industry and will affect the future of the stocker industry include increasing calf weaning weights, changing federal farm programs, changing patterns of cattle ownership, and increases in international trade in livestock and livestock products (Peel, 1991).

The marketing system in the cattle industry has the role of matching calf production, in which 70% to 80% of beef animals are born in the spring calving season, to consumer demand to provide a steady supply of beef to the retail market. Variations exist annually in grain, forage, and livestock production that make this objective more challenging. Additionally, lags in information from the retail level and the time lag that exists between the decision to retain replacement females and the production of beef from their offspring result in a cyclical pattern of beef production. The stocker industry plays the most significant role in smoothing the variability created by the factors of production and demand due to the flexibility in both the duration and rate of gain of the stocker industry.

The stocker industry is important in matching beef supply to retail demand in several different ways. First, the weight, age, and uniformity of feeder cattle that are too young or light to enter the feedlot are increased. Next, stocker operators play an important role in balancing cattle production with annual forage and grain supplies. The market will dictate how grain and forage supplies should be most profitably used by cow-calf, stocker, and feedlot industries, and the majority of short term adjustments are made within the stocker segment. Ranchers use stockers to manage variability in forage production. Stocker ownership allows cow-calf producers the flexibility of reducing stocking density if a drought or other situation results in a shortage of forage without selling breeding stock. Finally, the stocker industry is important in maintaining long run balance in the livestock, forage, and grain markets. A very strong connection exists between the three markets so that relative price changes result in the need for reallocation of resources within the different segments of the beef industry. Imbalance in the markets can be created by cyclical patterns of livestock production, changes in input and consumer demand, changes in farm policy, or weather related shocks. For example, an increase in the relative price of cattle in comparison to that of grain will result in allocation of grain from other livestock industries. The stocker industry makes a significant contribution to the beef industry by adding forage based gain to beef animals and allows the industry the flexibility adjust supply to retail demand (Peel, 1991).

The grazing of stockers on summer pasture has long had prominence in Oklahoma, but the winter grazing of wheat pasture continues to remain important in the state. The wheat pasture industry provides pasture for calves at the time when the majority of calves are weaned helping to decrease the volatility of calf prices in the fall. The importance of wheat pasture grazing is illustrated by the estimate that on January 1 the number of feeder cattle in Oklahoma is 22.7% greater than the state annual calf crop while the national average across states of feeder cattle inventories on January 1 is 23.7% below the estimated calf crop for all states (Peel, 2000). This indicates a strong movement of stockers to Oklahoma for the winter wheat grazing season with stocker cattle grazing half of Oklahoma's 4.5 million wheat acres in years favorable to wheat pasture growth (Tweeton, 1982). Also, approximately 10 to 20% of wheat acres planted will be grazed out within a given year. Often the industry is not well recognized outside of the region as the majority of wheat pasture grazing takes place in the Southern Plains. (Peel, 1991).

Stocker operators face numerous production and marketing decisions in their operations. Decisions must be made regarding the purchase and selling weights, sex, quality, and type of stocker animals used to market the forage produced in their operations. The goal of stocker operators whose intent is profit maximization should be to maximize returns per acre.

Problem Statement

Much of research previously conducted by agricultural economists has focused on predicting prices and the development of marketing strategies. This research has not been widely used by producers in the industry (Brorsen and Irwin, 1996). Now, the focus of research is beginning to shift to analyzing the signals that are sent by the market. Producers should be able to profit by adapting production and marketing decisions based on price signals.

The most important factor affecting the profitability of stocker operators are the margin values that are derived from the purchase and selling price of the stocker animal. Margin values are determined by subtracting purchase price times purchase weight from selling price times selling weight. The value of each pound of added gain, which is determined by dividing the margin value by the weight gain of a stocker animal, is commonly used in the industry to determine production decisions. Value of gain determines the value of forage that is marketed through the use of stockers. These market signals indicate which purchase and selling weights will be most profitable and the length of time that a beef animal should remain in the stocker phase.

The greatest opportunity for stocker operators exists when the relationship between purchase and selling price results in value of gain above $.50 per pound, a general long run average (Peel, 2000). When the value of gain for a stocker animal is high, opportunities to take advantage of this development exist by increasing the length of time that stockers are grazed. Rotational grazing can also be used to increase stocking density, and lower quality forage can be grazed with supplementation. Wheat pasture can be grazed out instead of being harvested, and crop residues can be grazed by stockers or a cow-calf herd. The use of crop residues by cow calf operations frees high quality forage for stocker grazing. The market dictates whether forage is more valuable when marketed through stockers or a cow-calf operation or that profitability can be maximized by increasing the length of the stocker phase.

The purchase weight of stockers is an input of production in which different weights become more profitable as price margins change. This research will focus upon determining the most profitable historical purchase weights based upon market prices. The market is dictating the use of resources and timing of when livestock should be marketed. Producers with the flexibility to take advantage of this development should adjust purchase weights to maximize profitability as price margins change.

Objectives

General Objective

Utilize information derived from price margins in cattle markets to increase profits for stocker operators.

Specific Objective

Determine the purchase weights that maximize returns per acre for winter wheat stocker grazing operations.

Procedure

This research will determine the most profitable purchase weight of stocker steers grazing winter wheat pasture on a per acre basis. Price data from the years 1992 to 2000 from the Oklahoma National Stockyards will be used to determine the purchase weights each grazing season that were the most profitable on a per acre basis. The winter grazing of wheat pasture will be used as the production method because gains and costs associated with grazing wheat pasture are fairly constant across the state, and more data are available on the subject. Profit will be adjusted to a per acre basis to more accurately measure profitability through the use of a linear programming model. Regressions that represent price as a function of weight at the purchase and selling date of each grazing season will be utilized in the linear programming model along with historical input price data. This research will not explain the supply and demand factors that create margin values, but will focus upon how producers can respond to prices and maximize profit.

Certain assumptions and constraints are made to simplify the analysis. First, stocker steers will be grazed on winter wheat pasture from November 15 to the first week of March which results in a constant grazing period of 110 days. The stocker steers will be purchased during October and preconditioned for one month. Preconditioning will consist of appropriate vaccinations, and stockers will be fed a supplement containing 20% protein and non-legume hay. Stocking rates will be determined by matching wheat pasture forage production with stocker forage intake in pounds of dry matter, and a 3% shrink resulting from stress associated with transport will be subtracted from the selling weight. The linear programming model will be developed based upon the profit maximization function represented by equation 1.

$$\Pi = S \cdot P(X_t)X_t - P(X_{t-1})X_{t-1} - \sum_{i=1}^{I} C_i Z_i^c \tag{1}$$

where:

Π = profit per acre

S = stocking rate expressed in head per acre (pounds of dry matter forage produced per acre/ pounds of dry matter forage intake per stocker steer)

P = price as a function of weight in a given time period

X_t = selling weight as a function of purchase weight

X_{t-1} = the purchase weight of the stocker animal.

C_i = cost of inputs, i = 1 to I

Z_i^c = inputs of production, I = 1 to I

The sum of production costs apart from the expense of purchasing the stocker steer will first be calculated. Some costs will be fixed on a per head basis while other expenses will be a function of purchase weight. Recommended vaccinations will be a fixed expense per head, while the expense of wormer and antibiotics will be a function of purchase weight. The freight and commission charges will also be a function of weight and will increase with heavier purchase weights. Death loss will be subtracted from selling weight, and a higher percent death loss will result from lighter purchase weights. Also, equipment fees will be assessed as a fixed cost on a per head basis. A survey (True et al., 1995.) of producers grazing wheat pasture in western Oklahoma along with stocker cattle budgets developed by the Agricultural Economics Department at Oklahoma State University will be used to estimate input costs and usage of production inputs. The selling weight of the stockers will be a function of the purchase weight and the amount of energy that wheat pasture provides for gain. The length of the grazing period will be set at 110 days by estimating a placement date of November 15 and a removal date of March 5. Intake will be estimated by a function developed by the National Research Council on Animal Nutrition, and a formula developed by Brorsen and others will be utilized to estimate average daily gain. Forage production of wheat pasture is estimated based on trials by the Plant and Soil Sciences department at Oklahoma State University.

The purpose of this research is to utilize price margins to determine the profit maximizing purchase weight of various weight classes of stocker steers grazing winter wheat pasture. Margin values change over time and represent the value of forage that is marketed through the stocker industry. These signals could reflect smoothing of seasonal supplies and variation of supply due to changes in cattle numbers at different points in the cattle cycle. Producers with management flexibility should be able to increase profitability by utilizing price signals.

Chapter II

LITERATURE REVIEW

The stocker phase is not strictly defined as many variations exist across the country. As a result, most of the agricultural economics research conducted in the beef cattle industry has focused upon the feedlot and packer segments of the industry. A portion of the research conducted refers to the stocker phase as backgrounding or refers to the stocker operation as retained ownership for cow-calf producers. Backgrounding is the retention of calves by producers for the purpose of adding gain before marketing or the maintenance of stockers before a grazing season begins and forage is available. The research reviewed in this chapter describes practices used by producers in grazing winter wheat pasture, profit maximization studies involving the stocker industry, and the effects of the cattle cycle upon production and marketing decision.

Production Practices

The first section of the literature review will examine the production practices of wheat pasture grazing. Due to the economic importance of wheat pasture grazing in Oklahoma, considerable extension work and institutional research have been conducted in the state. The practice of grazing stocker calves on winter wheat pasture from late fall to early spring is unique to the Southern Plains, and allows wheat producers to have an alternative to grain production. Producers are able to graze wheat until the early joint stage and still harvest the crop for grain, pasture wheat for the full season from November to June (graze-out), or pasture wheat beyond early the joint stage and harvest wheat forage for hay or silage. Although rotational grazing can increase spring stocking rates by up to 20%, the practice has shown no significant improvement in carrying capacity in the fall (Krenzer, 1991). Dry matter consumption for stocker cattle in pounds on a daily basis increases as the live weight of the stocker animal increases.

300 lb..........12 lbs.
400 lb..........14 lbs.
500 lb..........17 lbs.
600 lb..........19 lbs.

These guidelines for stocking rate take into account growth of the stocker animal and the increased consumption that results (Krenzer, 1991).

Doye and Kletke found that rental agreements and rates were dependent upon factors such as landowner cost and expected earnings, previous rates, competition for leasing rights, and government programs. The three most common methods of leasing winter wheat pasture were:

1. a rate per acre
2. a fixed rate per hundredweight per month
3. a rate per pound of gain

In 1995, winter wheat grazing was leased for an average of $8.92 per acre per year or a price of $2.48 per hundredweight was paid per month, while a previous study conducted in 1989 determined prices were $17 dollars per acre or $2 per hundredweight. Rates were the highest in north central Oklahoma and the lowest in eastern Oklahoma. The tenant was generally responsible for checking livestock and providing salt, mineral, and supplemental feed. The landlord was usually responsible for fencing supplies, water, and fertilizer. Approximately 4/5 of the leases were annual while 1/5 of the leases were greater than one year in length. Also, electric fencing was generally used to contain livestock if permanent fencing did not exist.

Epplin et al., (2000) studied the effects of plantings dates upon forage and grain yield, and concluded that although previous research determined that grazing did not decrease the yield of winter wheat, the results could be misleading. Dual purpose wheat has generally been planted earlier than wheat varieties intended for grain only in order to increase forage production. While both fall and winter forage production has not been significant in explaining grain yield, crop yields for wheat planted prior to October were reduced. Because planting prior to October is required for winter wheat to produce adequate forage to be grazed, yields of dual-pupose wheat are generally lower. The study estimates that moving the planting date from September 1 to September 21 results in a 44% increase in grain yield, but the forage yield is decreased by 32% by delaying the planting date. As a result of the research, an important tradeoff between grain and forage yield was determined to exist.

Several surveys of wheat pasture grazers have been conducted in Oklahoma that are useful in determining the production practices statewide for winter wheat grazing. A survey of wheat production and grazing practices was completed by True in the 1995-96 growing season. The survey results were affected by drought during the growing season. The research focused upon wheat production, wheat pasture, and livestock production practices separately.

The first section of the survey studied the differences in production practices of producers based upon the intended use of the wheat. 25% of the planted wheat was intended for grain-only, 9% for forage only, and 66% was for both forage and grain. One third of the wheat planted for forage-only had a crop such as rye or ryegrass included. Also, higher seeding and nitrogen rates were applied to wheat that producers expected to be used only for forage. The targeted planting dates for producers of September 10, September 17, and September 27 were dependent upon whether the crop was intended for forage-only, forage and grain, or grain-only.

The second part of the survey focused upon the practices used in grazing wheat pasture. Livestock grazed 50% of Oklahoma's wheat acres. Steers and heifers grazed 2/3 of these acres while cows and replacement heifers grazed the rest along with sheep, dairy cattle, horses and other livestock. The average placement weight was 466 for steers and 459 for heifers with ADG of 1.9 and 1.8. The stocking rate was dependent upon the availability of forage and climate conditions with an average stocking rate of 2.7 acres per steer and 2.6 acres per heifer. Stocking density would be higher with normal rainfall during the growing season. The regions in the South Central and Eastern regions have a higher annual rainfall than the Panhandle and normally produce more forage.

A great deal of variation was found to exist in the conditioning programs producers used. The respondents used either their own conditioning programs, used commercials programs, purchased livestock that were pre-conditioned or used no program at all. Producers' conditioning programs consisted of 24 days at $22 dollars per head while commercial programs lasted 24 days at a cost of $23 dollars per head. The most common program utilized grass hay plus a hay energy supplement. Also used were grass hay with high protein supplement and grass hay alone. On wheat, 57% fed a mineral supplement, hay was fed by 55%, wheat straw was used by 22%, and 39% used a bloat preventative. March 3 was the average termination date.

Producers either grazed winter wheat with their own cattle or entered into a contract with a tenant to pasture the wheat. 60% of respondents to the survey were landlords while 40% were tenants. 82% entered into oral contracts while 18% of the contracts were written. 81% of the contracts were annual while 19% were determined to exist for a time period of greater than one year. The average rental price was \$.31 per pound for the growing season (True, 1995).

Walker et al., (1998) conducted a wheat pasture survey in 1988 to determine which production practices for grazing wheat pasture were changing. The average purchase date of stocker cattle was determined to be September 12. The purchase weights of stockers were in the range of 400 to 425 pounds for normal purchase dates. Cattle below 350 and above 550 pounds were identified as potentially poor performers. 85% of the stockers operators surveyed placed cattle on wheat between November 1-18, and March 8 was the average date for removal. Grazing programs ranged in length from 85 to 135 days with an average length of 115 days. The average length of receiving programs was 13 days, and veterinary medicine costs averaged \$7 for receiving and \$9 for the total program. An average stocking density of 2.07 acres per steer existed, and the expected average daily gain was 1.75. The average rental rate was \$2 per hundredweight per month with the land owner providing the watering facilities. Some stocker operators rented land for \$31 per acre while the average price paid on a gain basis was \$ .28 per pound.

Brorsen et al., (1983) developed a model to predict the growth of stocker cattle under different production environments that is used in this research to estimate wheat pasture gain and intake. The model provides a basis for the methodology of this research by providing the framework to calculate average daily gain and forage as a function of purchase weight. The California Net Energy System (CNES) was used as a base for their study. This framework was developed using medium framed British cattle that were given a growth stimulant in a controlled environment. Different formulas exist for steers and heifers, and adjustments were used to account for the shrinkage resulting from shipping and marketing stocker cattle as well as the reduced initial performance that exists when stockers are transferred to a new production environment. The first adjustment made to the CNES accounts for voluntary intake. The intake of forage with low digestibility was controlled by rumen capacity and rate of passage. The intake of highly digestible forage was controlled by the energy requirements of the animal. Adjustments were also made for compensatory growth and the protein requirements of the animal. An adjustment was made for differences in mature size by dividing an animal's average market weight by expected market weight and multiplying this figure by the actual body weight. This calculation was then taken to the power of .75 as shown in formula 1 which represents the relationship between energy requirements and metabolic weight.

Due to the fact that the CNES was developed using diethylstilbestrol (DES) which is now illegal, an adjustment must be made for different growth promotants. A multiplier was developed for four different implants. Additionally, an adjustment can be made for Rumensin which was found to increase the digestibility of forage by 5 percent. Brorsen et al. developed a gain function that accounts for the different production alternatives available to stocker operators. Using this model, projections of weight gains were estimated and compared to experiments that were conducted using nine different forage situations. The differences in average daily gain were not found to be significant when a paired differences test was used.

The average daily gain model developed can estimate average daily gain under a wide variety of production situations. It can predict gain for a specific operation, and also analyze general situations. The model could be used to predict gain where the plain of nutrition is not an input that could be changed easily, or it could help to optimize the level of nutrition where a stocker operator has management flexibility. Some producers currently feed their cattle at a level of nutrition that is uneconomical. The model is well suited to be used in a production maximization model that would determine the optimum level of nutrition.

Profitability in the Stocker Industry

The second section of the literature review examines the factors that affect profitability in the stocker industry. The majority of research on the stocker industry has been conducted by animal science departments and has focused on maximizing production instead of profit.

An article on value of gain (Lalman, 1999) details the importance of determining the value of gain in the stocker industry. Value of gain is the price that a producer will receive for putting on an additional pound of gain. It is calculated by subtracting purchase price times purchase weight from selling price times selling weight dividing this figure by the pounds of gain added. The value of gain has typically ranged from $45 to

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$65 per hundredweight, although it can occasionally vary from this range. The value per hundredweight of a stocker animal usually decreases as weight is added, but conditions such as high grain prices can result in different weight classes being valued at the same price. A spreadsheet program created by the author allows producers to evaluate the value of gain in 50 pound increments. Required inputs are the prices for 12 weight classes of both steers and heifers. This spreadsheet is a valuable tool that allows producers to make more informed production decisions regarding purchase weight, duration of the grazing season, and sex of the stocker animal. The differences in cost of gain are not taken into account.

Lambert used a discrete stochastic programming model to approximate the decisions that cow/calf producers face when determining how to market their calves and the length of time that calves should be backgrounded. Backgrounding involves retaining calves and adding gain in order to market them or to maintain the calves until a forage grazing season begins.

These decisions were:

1) Should calves be retained in the fall given current production costs and expected output prices?

2) What level of nutrition should calves be fed if retained?

3) Should the calves be sold or placed on grass the following summer?

Gain was the highest when a spring selling date was expected, and a positive relationship was found to exist between gain and the rancher's expected prices. Likewise, lower rates of gain were found to exist for stocker animals when placement on grass the following summer was expected. The lower cost of gain from summer forage allowed producers to take advantage of compensatory gain that resulted from the lower plane of nutrition stockers received throughout the winter when a marketing date of late summer or fall was expected. Even though the model indicates higher returns when calves are retained, the majority of calves are sold in the fall. Four reasons were given for the decision to market calves early:

1) Producers are more risk averse than surveys predict.
2) Many ranchers may be forced to sell in the fall due to cash flow problems.
3) Traditional fall markets may result in acceptable profits for ranchers.
4) Constraints on labor and facilities may reduce the ability of ranchers to background calves.

This study considers the factors that account for profitability. The wheat pasture grazing modeled in this research takes advantage of the profit potential that is available for producers that retain calves as indicated by Lambert's study. Also, a lower rate of gain prior to turnout on forage during the preconditioning period is expected based upon this study.

Popp and others constructed a discrete choice logit model that predicted the likelihood of a producer's decision to retain calves. Popp noted that studies conducted by economists (Lambert; Feuz and Wagner; Johnson, Ferguson, and Rawls; Pardue, Popp, and Garner; Watt, Little and Petry) indicate that retaining ownership could increase profitability for producers although most of the calves produced in the United States are sold at weaning. Several explanations were given for the difference between the results of previous research and the practices of ranchers. First, ranchers may be very risk averse, and more risk averse producers are less likely to retain calves. Restrictions on cash flow and labor can also reduce a producer's ability to retain calves past weaning.

Additionally, not all managers possess the skills required to develop a marketing plan that would allow them to benefit from price cycles and seasonal variation.

The objective of Popp's study was to determine and rank the factors that influence the decision to feed calves to heavier weights after weaning. The survey used in the study was mailed to Arkansas cow-calf producers in 1996 to determine their production and marketing practices. Many factors were taken into account that influenced the decisions of producers, and the model was able to predict producers' decisions accurately 85% of the time.

The variable that measured producer's perceptions about the benefits and costs of backgrounding was determined to be the most significant in the decision making process. The producer's opinion of the price risk associated with backgrounding calves was the second most important variable influencing the decision. Next, the amount of time producers invested in forecasting prices was found to have a positive correlation to the retention of calves after weaning. Finally, the farm size variable was found to have a positive relationship with the likelihood of producers retaining calves after weaning. Every 100 acre increase in farm size led to a 1% increase in the probability that producers would background calves. The age, education, and location of the producer within the state were found not to be significant in the model. The authors believed that more research was necessary to include producer experience and labor utilization in the decision making process. Popp's research indicate that perceptions strongly influence producer's decisions which will help to explain the results of the thesis research.

Ethridge and others (1990) used linear programming and Bayesian analysis to model the risks associated with cattle prices and forage yields in maximizing income on

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the Southern Plains of Texas. Only one of the enterprises modeled consisted of the traditional approach of spring buying and fall selling. The study concluded that moving away from conventional methods could increase ranch incomes. However, if a significant number of producers were to change the time in which they marketed their animals, price patterns that make nontraditional methods advantageous could change.

Retained ownership was examined as an option for ranchers in a study by Schroeder and Featherstone using a discrete stochastic programming model. Steer, heifer, and corn prices were used as the stochastic variables. Producers have historically marketed the majority of their calf crop at weaning. In 1980, 64% were sold at weaning and 36% were sold as yearlings with almost no cattle placed in the feedlot by producers. The decision whether to sell calves at weaning is based upon current profitability, expected future profit, and risk aversion. The study found that hedges and options were used by risk-neutral producers on at least a portion of their cattle. Producers that were risk-averse forward priced most of the cattle they retained. Hedging was found to be the preference of risk-averse porducers regardless of volitility levels of the futures market. However, low to moderate risk producers chose options in periods of low futures volatility while hedging was the preference during periods of high futures volatility. Schroeder and Featherstone adequately described how producers handle risk based upon their preferences and illustrated how calf retention can increase profitability.

Johnson and others determined the most profitable backgrounding programs and best purchase and selling dates within each program. Four backgrounding programs were considered: Fescue, Fescue with supplemental feeding, small grain, and corn silage.

This was a useful guide for producers making backgrouding decisions showing clearly how different backgrounding programs and marketing dates affect profitability.

Watt, Little, and Petry provided estimates of profitability for retaining ownership of calf crops from 1958 to 1983, and marketing them either as yearlings or slaughter cattle. The costs and profits for nine different production options were given. The budgets were made based upon opportunity cost by assigning inputs a value based upon market worth. This paper provided an evaluation of the profit potential from retained ownership.

A survey was taken of Texas cow-calf producers by Young and Shumway to determine the factors that would influence whether producers would consider themselves to be profit maximizers. The variables that increased this probability were acreage, percent income earned from the cow/calf operation, desire to increase net worth, perception of cattle production as a business venture, and off farm income. The authors decided that more research was needed to determine how so many cow-calf producers can claim to be profit maximizers when the levels of return for the industry are so low. This article effectively brought out the point that a great deal of emphasis is placed upon the cow-calf industry as a way of life, but did not address how to deal with this issue.

Research by Biswas and others tested producer rationality based upon the rules of profit maximization. These tests have been common in under-developed countries but rare in high-income countries. The study's main objective was to determine whether profit maximization was the predominate explanation for producer's decisions. Additionally, regression estimates were calculated for the elasticities of supply of capital and labor. Data were collected from 69 ranchers in Southeastern Montana with personal interviews. The study determined that reasonable conformity to the laws of profit maximization existed, and confirmed the current assumptions that are made by economists.

Ethridge and others (1998) studied marketing strategies for stocker producers. The normal strategy for ranchers is to purchase stocker cattle in the spring and sell them in the fall. This strategy produces the highest rate of gain and matches the period of time in which forage production is available in the greatest quantity and is the most nutritious. However, this strategy creates a seasonal pattern of prices where ranchers buy when prices are high and sell at seasonal lows in the annual price cycle. Wheat pasture grazing takes advantage of these seasonal tendencies.

A previous study by Ethridge, Nance and Dahl had examined whether weight gain efficiency could be exchanged for more favorable pricing conditions by using nontraditional purchase and selling dates. However, these studies did not consider cow-calf production as an alternative or examine the risks that were involved. Risk exists in the form of price risk from varying cattle prices and as production risk resulting from uncertain rainfall. The purpose of the research by Ethridge was to develop production and marketing systems which maximize income under different price levels and rainfall amounts. A Linear Programming model was used to develop a procedure that maximized profit given both price and weather risk. Stocking rate was found to be affected more by forage production than changes in price levels. Also, diversification of production between the cow-calf and stocker operations was found to be the most profitable under all the different combinations of price levels and forage conditions.

Epplin researched the historical returns from wheat for grain only compared to wheat used for both harvest and pasture (dual-purpose) from 1980 to 1999. This study provides guidelines to estimate costs for wheat pasture stocker cattle across time. On the Southern Plains, an estimated 30 to 80% of wheat is grazed every year. Returns were calculated for grain-only wheat, dual-purpose wheat planted in early September, and dual-purpose wheat planted late September. Dual-purpose wheat generated the greatest returns 16 out of 20 seasons. Grain-only wheat generated the highest returns for 4 of 20 seasons while dual-purpose wheat planted in early September had the highest returns for seven seasons and late planted September wheat had the highest returns for 9 seasons.

Anderson and Trapp (1997) studied the effect of corn prices upon feeder cattle prices. This study found that for every $1 increase in the price per bushel of corn, feeder cattle prices were reduced by $7.50. Also, changes in price per bushel of corn have had a decreased effect on feeder cattle prices as feed efficiency has increased. Increased feed efficiency has resulted in corn prices having a smaller effect upon feeder cattle breakeven prices. Corn prices were also found to impact both the placement and shipping weights of cattle in the feedlot. High corn prices would encourage cattle feeders to put more weight on with grass and decrease the weight at which fed cattle are marketed which would reduce the amount of corn used in beef production. Low corn prices would result in the lighter placement weights and heavier marketing weights with more corn used in the production of beef. Cattle feeders have a strong economic incentive to alter production practices in response to changes in corn prices.

Cattle Cycles

The final segment of the literature review examines the effect that cattle cycles have upon the decisions that stocker producers make. The cyclical aspect of cattle production results in shifts in profitability between the cow-calf and stocker sectors of the industry. The cyclical price patterns that exist in the cattle market are highly correlated to the peaks and troughs of cattle production and have a large impact upon profitability within the stocker sector. The cattle cycle has a normal duration of approximately 10 to 12 years, but has ranged from 9 to 16 years in the past. Cyclical patterns in cattle numbers have been observed since 1867. Producers have a tendency to overreact to price changes which results in the normal peaks and valleys observed in the cattle market. Producers expand production in periods of rising prices. However, increases in the supply of slaughter cattle are delayed as a result of the biological lags in production. As a result, prices can remain high even though breeding herds have reached adequate sizes allowing producers to over expand before prices are affected. As more heifers are removed from the pool of feeder cattle and retained for breeding, prices become higher until their progeny reach slaughter. The over-expansion will result in falling prices as beef supply exceeds demand. The herd reduction that results from falling prices creates shortages which once again lead to higher prices. In this manner, the cattle cycle is repetitive.

Several different factors exist that can cause variations in the regularity in which cattle cycles occur and cause the cycles to become less predictable. Generally, a cycle consists of 6 to 7 years of expansion, 1 or 2 years of consolidation, and 3 to 4 years of declining cattle numbers (Matthews). First, weather affects forage and crop production.

Drought will reduce available forage and force producers to either sell cattle to reduce stocking density or to supplement cattle with hay or feed. When cows are sold or stockers are removed early from pasture, downward pressure is placed upon cattle prices, and the reduction of cow herd inventories is accelerated or the expansion of cattle numbers is slowed. Grain and livestock trade also create variations in cattle cycles. Corn exports have been observed to have significant and lasting effects upon beef prices. Additionally, the U. S. commodity program policies create variations in the cattle cycle by influencing whether land is used as cropland or pasture. An inverse relationship exists between the number of acres harvested for crops and cowherd inventories. New technology in slaughter plants has also had an effect by allowing the packers to slaughter beef cattle at heavier weights leading to a large increase in cattle weights. Finally, beef's market share has been declining for the last 25 to 30 years. All these factors combine to make cattle cycles less predictable (Matthews, 1999).

Bentley and Shumway believed that the low returns that cattle producers receive historically result from management strategies that do not take advantage of cattle cycles. Their research uses a model for decision making that allows for different assumptions about future beef prices. A variable cost function was used that allowed for a changing mix of inputs as the herd size changes. The most profitable replacement and culling decisions were made with the ability to make adjustments as needed. The basis for the model simulation was an East Texas cattle farm. A profit maximization model is used with a Lagrangean function as a constraint with an objective of maximizing the present value of profit over a ten year period. It was determined that culling and replacement strategies designed to take advantage of the cattle cycle may be inefficient. The unpredictable nature of cattle prices resulted in difficulty in determining when to retain replacement females. A policy of slow growth with cattle sales in times of declining prices was determined to be the best policy.

Rucker and others estimated regression equations for both breeding herds and total cattle inventories of Montana and the U. S. They believed past modeling had not adequately predicted or explained the reasons for inventory changes. The model developed predicted beef breeding herd inventories were similar for both the Montana and U. S. cattle industry. However, if the path of independent variables changed from the period of time that was studied, problems in the predictive ability of the equations could arise. The shift in cow numbers to the southeast and changes in the structure of the cattle industry could result in inaccuracies. The authors believed their study could be improved upon by developing regional equations for three or four areas of the U. S. instead of having only one national equation.

In an article by Rosen, Murphy, and Scheinkman, an econometric model was developed to explain the cyclical patterns of the cattle market. The decisions made by producers about breeding stock inventories were used as the basis for their theory explaining cattle cycles. Time series estimates for the period of 1875 through 1990 were used in the study. The authors determined that breeding herds accounted for 40% of the beef cattle population, and the time required for a beef animal to reach slaughter once breeding decisions were made resulted in the lengthy periods of time of inventory adjustment associated with the cattle industry. Shocks to demand and supply were determined to have significant long term impact on future inventories by changing the incentives that influence retention of breeding stock changing the makeup of beef cattle herds.

This literature review has focused upon the practices of stocker operators grazing wheat pasture and research that has analyzed the profitability of the stocker segment of the beef industry. Also, the impact of the cattle cycle on both production and marketing decisions have been reviewed. While flexibility exists in the purchase date of stocker cattle, the selling date is an exogenous variable that is imposed upon the model by the jointing stage of wheat in late February to mid March. It is likely that a stocker operator would fall out of favor with a farmer leasing winter wheat pasture by trying to shorten the grazing season. Generally, a strong demand exists to lease wheat pasture so the wheat producer is able to have the greatest influence in setting the stocking and removal dates of the grazing season. The producer has the incentive to maximize the length of grazing season while limiting factors that negatively impact grain yield. A set grazing period of approximately 110 days becomes the best representation of practices used in grazing winter wheat pasture. The typical purchase and selling dates of stockers grazed on wheat pasture take advantage of both the seasonality of prices and the forage production available from wheat pasture. This seasonal advantage allows the focus to shift to the analysis of price margins that indicate the most profitable purchase weights. Focusing on capturing these price signals should help to explain how the market allocates resources within the industry and how this allocation smoothes the volatility of beef supplies that results from the seasonal and cyclical nature of the beef industry.

CHAPTER III

MODEL

The linear programming model developed in this chapter selects the most profitable purchase weights of stocker steers grazing fall and winter wheat pasture between the years 1992 and 2000. Weights in twenty-five pound increments between 325 and 575 pounds are utilized in the model to represent different purchase weight options. The model consists of a linear programming tableau which draws upon input spreadsheets for both prices and input usage. Both prices paid and prices received change yearly but production estimates and input usage remain constant throughout the simulation.

The linear programming model is constructed in Microsoft Excel 2000 which contributes to the accessibility of the model. The model draws upon separate spreadsheets for stocker price data, prices paid for inputs, and production estimates. Prices are indexed by year for operating expenses including labor, feed, interest, marketing, hauling, medicine, and equipment expenses. Production estimates include forage production of wheat pasture, stocker intake, average daily gain, death loss, and the shrinkage resulting from hauling and marketing.

The model assumes 160 acres of cropland upon which wheat is produced for both pasture and grain. Any forage not consumed within a given month is carried over or stockpiled in the following month. Although the rate at which forage degrades is unknown, a default value of 90% of remaining forage is used to represent the unconsumed forage that was carried over every month (Smith, 1999). The carryover rate is the highest when forage is in a growing vegetative state such as wheat pasture during the fall and winter grazing season.

The costs and revenue from grain production are not included in the model as the intent is to maximize profit per acre based upon the available forage within a given growing season. Returns are maximized on a per acre basis instead of on per head basis in order to maximize the profit of a given area of land. Maximizing returns on a per head basis does not account for the decreasing number of head per acre as stocker weight increases. As a result, the greatest profit per head does not always result in the greatest profit per acre as stocking rate strongly impacts profitability. Returns per acre include returns to land and management.

Inputs for Livestock

Livestock inputs are estimated separately for each weight class in the model. Both the purchase and sale weight included in the tableau are drawn from the input spreadsheet. Forage dry matter and labor requirements along with other operating inputs and expenses such as capitol, feed, hay, salt and minerals, and equipment requirements are drawn from the input spreadsheet. The capitol requirements are based on the stocker purchase cost and operating input costs of 140 days of ownership. A grazing fee was not charged on a per head basis as profits were considered returns to land and management. Capital, labor, and other resources required in the grazing of stocker cattle are not constrained in the model although a land constraint of 160 acres was necessary to limit the number of stockers selected to maximize returns.

The linear programming model can be represented mathematically as:

(3) $$Max\,\Pi = \sum_{j}^{n} C_j X_j$$

where:

C_j = income or costs of activity j

X_j = level of activity j

j = activities of production

subject to the constraints:

$$\sum_j a_{ij} X_j \leq b_i$$

$$X_j \geq 0$$

where:

a_{ij} = quantity of resource i required per unit of activity j

X_j = level of activity j

b_i = total quantity of available land in acres

The X_j s consist of the following activities:

X_1 = acres of wheat pasture grazed
X_2 = number of head of stocker steers purchased at 325 pounds
X_3 = number of head of stocker steers purchased at 350 pounds
X_4 = number of head of stocker steers purchased at 375 pounds
X_5 = number of head of stocker steers purchased at 400 pounds
X_6 = number of head of stocker steers purchased at 425 pounds
X_7 = number of head of stocker steers purchased at 450 pounds
X_8 = number of head of stocker steers purchased at 475 pounds

X_9 = number of head of stocker steers purchased at 500 pounds
X_{10} = number of head of stocker steers purchased at 525 pounds
X_{11} = number of head of stocker steers purchased at 550 pounds
X_{12} = number of head of stocker steers purchased at 575 pounds
X_{13} = October labor hours
X_{14} = November labor hours
X_{15} = December labor hours
X_{16} = January labor hours
X_{17} = February labor hours
X_{18} = March labor hours
X_{19} = dollars of capitol borrowed
X_{20} = pounds of feed purchased
X_{21} = pounds of hay purchased
X_{22} = pounds of mineral purchased
X_{23} = total cwt. of liveweight upon which marketing fees were paid
X_{24} = total cwt. of liveweight upon which hauling fees were paid
X_{25} = number of head upon which equipment fees were paid
X_{26} = dollars of veterinary expense
X_{27} = pounds of dry matter transferred from November into December
X_{28} = pounds of dry matter transferred from December into January
X_{29} = pounds of dry matter transferred from January into February
X_{30} = pounds of dry matter transferred from February into March
X_{31} = total cwt. of 325 pound stocker steers purchased
X_{32} = total cwt. of 495 pound stocker steers sold
X_{33} = total cwt. of 350 pound stocker steers purchased
X_{34} = total cwt. of 526 pound stocker steers sold
X_{35} = total cwt. of 375 pound stocker steers purchased
X_{36} = total cwt. of 558 pound stocker steers sold
X_{37} = total cwt. of 400 pound stocker steers purchased
X_{38} = total cwt. of 590 pound stocker steers sold
X_{39} = total cwt. of 425 pound stocker steers purchased
X_{40} = total cwt. of 621 pound stocker steers sold
X_{41} = total cwt. of 450 pound stocker steers purchased
X_{42} = total cwt. of 653 pound stocker steers sold
X_{43} = total cwt. of 475 pound stocker steers purchased
X_{44} = total cwt. of 684 pound stocker steers sold

X_{45} = total cwt. of 500 pound stocker steers purchased
X_{46} = total cwt. of 714 pound stocker steers sold
X_{47} = total cwt. of 525 pound stocker steers purchased
X_{48} = total cwt. of 744 pound stocker steers sold
X_{49} = total cwt. of 550 pound stocker steers purchased
X_{50} = total cwt. of 772 pound stocker steers sold
X_{51} = total cwt. of 575 pound stocker steers purchased
X_{52} = total cwt. of 800 pound stocker steers sold

The standard Solver available in Microsoft Excel 2000 was utilized to maximize returns per acre by determining the most profitable purchase weight of stocker cattle. A table representing the linear programming tableau is referenced in Appendix 8. Land is constrained to 160 acres, but the other inputs of production are assumed to be non-limiting factors in the linear programming model. Adding a labor constraint would result in the selection of heavier purchase weights due to the higher labor requirements of light weight stockers cattle, but the assumption is made that adequate labor resources exist within the stocker enterprise or that hired labor was available. A separate linear programming tableau is constructed for each of the eight grazing seasons.

CHAPTER IV

DATA AND PROCEDURES

Forage Data

The forage production of wheat pasture is estimated in the model in pounds of dry matter produced per month per acre. Estimates of dry matter production per acre of winter wheat pasture are based upon data gathered by the Plant and Soil Sciences Department of Oklahoma State University in the Lahoma Planting Date Trials at the Lahoma Research Station (Krenzer, 1995). Planting date was determined to affect grain yield, forage yield, and the test weight of wheat based upon multiple planting date trials. Data were gathered on planting dates of August 30, September 13, September 27, and October 11 over a period of 4 years from 1991 to 1995 resulting in an average planting date of September 20. The wheat forage data were gathered by hand clipping near the soil surface in the fall, and the forage was cut with a mower in the spring three inches above the soil surface (Krenzer, 1995). Table 4.1 includes the forage production data gathered from the Lahoma Research Station upon which the a_{ij} values of dry matter forage produced per acre were based.

Table 4.1. Lahoma Planting Date Trials

Planting Date	Forage Yield (lb/a) 4-year average	Test Wt.(lb/bu) 4-year average	Grain (bu/a) 4-year average
Aug. 30	2079	53.9	20.8
Sept. 13	1213	54.2	28.3
Sept. 27	721	55.9	33.9
Oct. 11	22	56.4	40.4

Source: Krenzer.

Earlier planting dates had a positive effect upon forage yields while grain yield and test weights per bushel increased as result of planting later in the fall. Krenzer stated that the probability of increasing forage yield as a result of earlier planting dates decreased as production moved farther west in the state due to increased frequency of drought in the state's western regions.

Stocker Steer Price Data

The livestock price data used in this model for both prices paid and received were obtained from the "Oklahoma National Stockyards Weekly Weighted Average Feeder Cattle Report" published by the Agricultural Marketing Branch of the United States Department of Agriculture. The price data are recorded from Oklahoma National Stockyards at Oklahoma City, Oklahoma. Prices from the Oklahoma City Stockyards were chosen because the auction has the highest cattle sale numbers in the state, longevity, and a central location within the state. The price data were recorded in 50 pound increments for cattle weights on weekly basis between 300 and 1000 pounds for both steers and heifers from 1992 through the present (Appendix 1). The data were compiled by averaging both the weight and price of the livestock within each 50 pound increment for all quality grades. Prior to 1992, the price data were recorded in 100 pound increments. The average monthly prices from October and March were used to represent the stocker purchase and sell prices of every wheat pasture grazing season between 1992 and 2000.

Input Prices Paid by Stocker Operators

Prices paid by stocker operators were taken from several sources. The base budget used in the model was titled "Stocker Steers on Winter Wheat Pasture Grazing 135 Days" published by the Agricultural Economics Department at Oklahoma State University. This budget was used as a model for calculating the operating costs per head. The input weight of the steers in the budget was 436 pounds with a grazing period of 120 days and a backgrounding period of 15 days. Adjustments were made both for different purchase weights as well as a shorter grazing period of 110 days based upon a 1996 Oklahoma statewide survey of stocker operators (True et al) and a 1988 survey conducted in Oklahoma by Walker and others. Input prices were determined several ways. First, marketing, hauling, labor and equipment costs were based upon the 135 day stocker steer budget. All prices in which actual yearly data were not used were adjusted based upon indicies published in the 2000 summary of "Agricultural Prices" published by the National Agricultural Statistics Service (Appendix 4). Indicies were available for all input prices combined and also were calculated separately for production items, feed, interest, taxes, and wage rates. Both feed and mineral prices were based upon information provided by Stillwater Milling Company of Stillwater, Oklahoma for the base year of 2000 and then were converted to nominal values using the price indicies mentioned above. Average non-legume hay prices for each year in the state of Oklahoma were based on data compiled by the National Agricultural Statistics Service of the United States Department of Agriculture (Appendix 5).

Procedures

The second portion of this chapter will focus on the methods used in modeling the grazing of stockers on fall and winter wheat pasture. The production practices used in the management of both wheat pasture and grazing stockers are based upon surveys of stocker cattle producers, extension publications, and expert opinion.

The average forage yields between 1991 and 1995 (4 years) for the different planting dates at the Lahoma Research Station were averaged to provide an estimate of planting date and forage yield. The average forage yields for four planting dates were divided by 110 days based upon a typical winter wheat grazing season from November 15 to March 5 in order to determine daily forage production. This procedure allowed for the conversion of forage yield into pounds of dry matter produced per acre per month by multiplying the daily estimated dry matter forage production of wheat pasture by the number of days in each month. Table 4.2 includes the monthly forage production estimates used in the model.

Table 4.2. Fall and Winter Wheat Pasture Forage Production Estimates

Month	Pounds/Acre
November	137.557
December	275.114
January	275.114
February	275.114
March	45.852

Source: Krenzer

Pounds of dry matter produced per acre were used to model the forage production of fall and winter wheat pasture instead of the Animal Unit Months (AUM) commonly used in budgets produced in the Agricultural Economics department representing grazing livestock based upon several reasons. First, more data are available in pounds of dry matter forage produced per acre than of AUMs. (An AUM is the amount of Total Digestable Nutrients (TDN) required to maintain a 1,000 pound cow for 30 days or 300 pounds of TDN, (Tayler,1994)). Also, energy systems that are used in ration formulation and prediction of gain estimate forage intake in either kilograms or pounds of intake per day. As a result, the process of estimating the stocking density of wheat pasture is simplified by matching pounds of dry matter forage produced with pounds of dry matter intake required by stocker animals. Additionally, the relationship between pounds of body weight and forage consumption upon which AUMs are based is linear and does not accurately reflect nutrient requirements of grazing beef animals across different weights. Intake as a percentage of body weight decreases as live weight increases resulting in a less accurate measure of forage intake when AUMs are used to predict stocking rate. Due to these factors, forage production based upon pounds of dry matter produced per acre was used in the model. An equation with intake as a function of body weight and TDN was used to model the dry matter requirements of stocker animals and will be discussed later in the chapter.

Stocking Rate

The stocking rate of each weight class of stocker steers was first determined by estimating dry matter intake of wheat pasture forage. An intake function consisting of pounds of dry matter voluntarily consumed daily as a function of animal body weight and the energy available in the ration was utilized to calculate the consumption of stocker cattle on wheat pasture. This intake function was adapted from the *Nutrient*

Requirements of Beef Cattle developed by the National Research Council, Committee on Animal Nutrition (NRC 1984) and is represented by equation 4:

(4) $$I = W^{0.75}(.1493NE_M - 0.0460NE_M^2 - 0.0196)$$

where:

I = Daily voluntary intake of dry matter (kg/day)

W = Animal body weight (kg)

NE_M = Net Energy Maintenance (Mcal/kg).

Equation 4 estimates intake in kilograms per day. As discussed previously in the chapter, wheat pasture forage production was estimated on a monthly basis. In order to calculate monthly intake, animal body weight was determined by averaging the estimated beginning and ending weight of the different classes of stocker steers each month throughout the grazing season from November 15 to March 5. The daily consumption estimate calculated was then multiplied by the number of days in each month to determine monthly consumption. Table 4.3 includes the estimated intake of stocker cattle over the grazing season that results from the intake function defined in Equation 4.

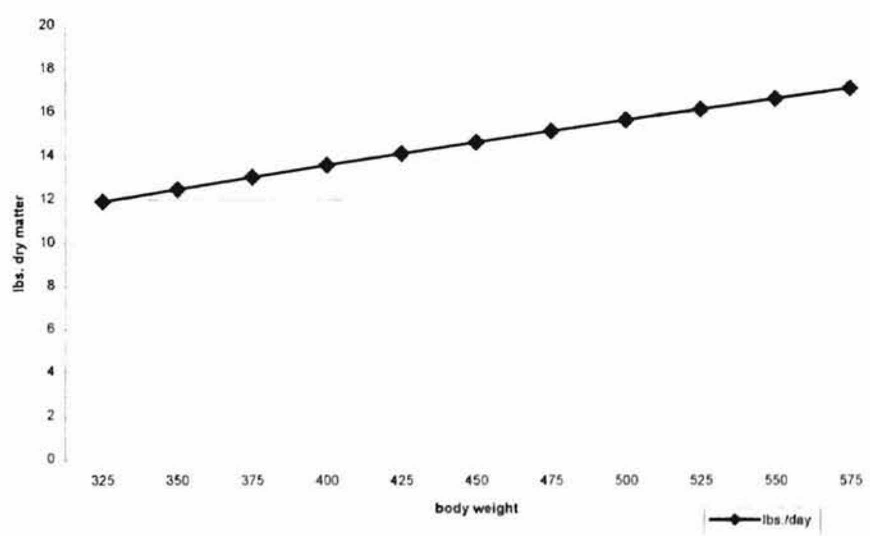
Table 4.3. Dry Matter Intake Estimates of Wheat Pasture Stocker Steers

Weight	Total Consumption (lbs/dry matter)	Daily Consumption (lbs/dry matter)
325	1308.724	11.8975
350	1371.355	12.4668
375	1432.613	13.0237
400	1492.625	13.5693
425	1551.514	14.1046
450	1609.372	14.6306
475	1666.283	15.1480
500	1722.319	15.6574
525	1777.542	16.1574
550	1832.006	16.5646
575	1885.762	17.1432

Source: Nutrient Requirements of Beef Cattle

Dry matter intake on a monthly basis is referenced in Appendix 5. Intake estimates were found to be similar to the projections made by Krenzer in "Wheat for Pasture" discussed in the literature review. Figure 4.1 represents the daily dry matter requirements of various weights of stocker steers grazing wheat pasture. Although the relationship between body weight and dry matter intake may appear to be linear, intake as a percentage of body weight decreases as body weight increases.

Figure 4.1. Average Daily Dry Matter Consumption of a Stocker Steer from November 15 to March 5



Average Daily Gain

Next, average daily gain was determined using a formula developed by Brorsen et al that was based upon the California Net Energy System (CNES) and is represented by equation 5, 6, and 7. The average daily gain function developed has separate equations to estimate the gain of stocker steers and heifers.

(5) $$ADG(lb/day) = \frac{\sqrt{.0001748 + (.003112)(NE_g^{\ a} / W^{.75})} - .01322}{.001556}$$

where:

$NE_g^{\ a}$ = net energy available for gain;

W = body weight of the animal (lb)

The calculation for $NE_g^{\ a}$ is represented in equation 6:

(6) $$NE_g^{\ a} = [Intake - (NE_M^R / NE_M)](NE_g)$$

where:

$NE_g^{\ a}$ = net energy available for gain(Mcal/day);

$Intake$ = daily dry matter intake (lb/day);

NE_M^R = net energy required for energy balance (Mcal/day);

NE_M = net energy for maintenance value of the feedstuff (Mcal/lb);

NE_g = net energy for gain value of the feedstuff (Mcal/lb).

The calculation for NE_M^R is represented by equation 7:

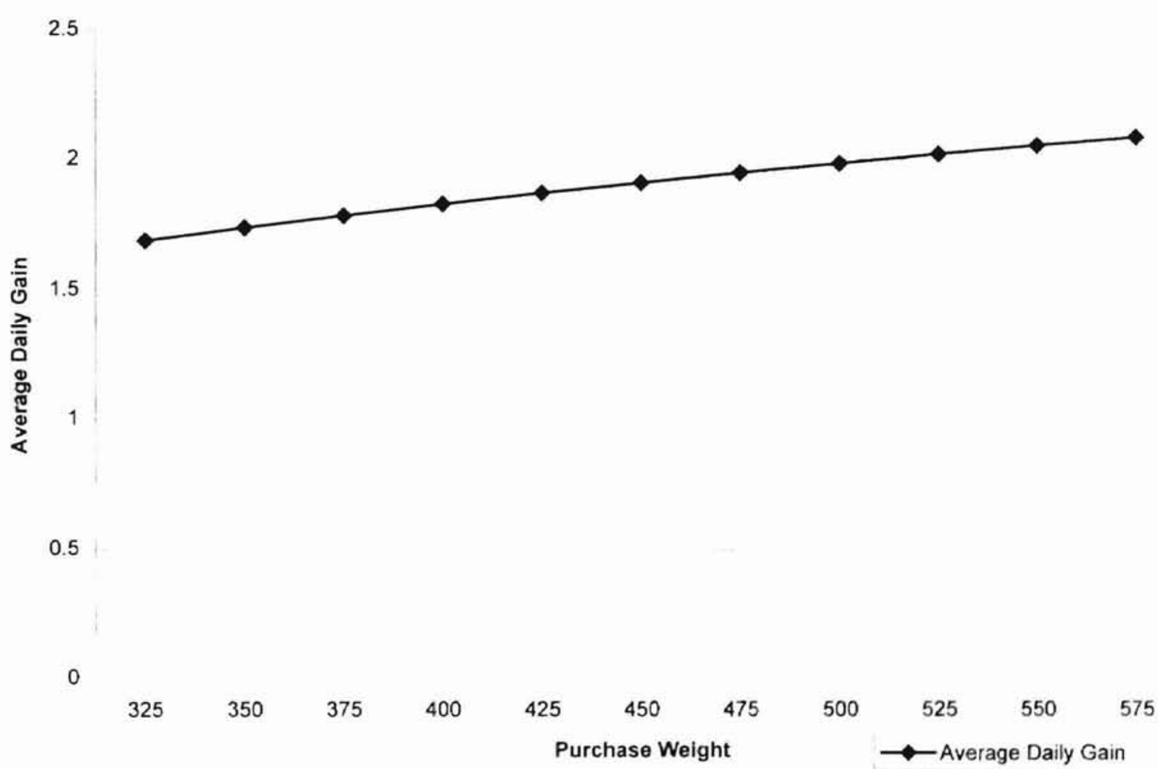
(7) $$NE_M^R = 0.043W^{0.75}$$

where:

W = empty body weight of the animal (lb).

The average daily gain function provides a basis for the methodology of this research by providing the framework to calculate average daily gain as a function of purchase weight. Although certain production factors and expenses are fixed on a per head basis, the majority are a function of purchase weight. Purchase weight and nutrient value of wheat pasture forage are the independent variables while the average daily gain of stocker steers is the dependent variable. The relationship between average daily gain and body weight was determined to be positive based upon the gain prediction function and is represented by Figure 4.2. The varying rates of gain resulting from different purchase weights were scaled to 1.9 pounds per day based upon surveys of wheat pasture grazing operators (True et al. and Walker et al.)

Figure 4.2. Average Daily Gain of Stocker Steers Grazing Wheat Pasture



Next, a preconditioning period of 30 days was selected to represent the length of time steer calves were preconditioned between purchase and turn-out on wheat pasture based upon an October purchase date and a November 15 turn-out date. The ration used in the model consisted of a 20% protein supplement and non-legume hay. This preconditioning program results in an average daily gain of 1 pound per day with stocker steers not excessively fleshy prior to turn-out where forage-based gain will be less expensive than higher rate of gain resulting from the preconditioning ration.

Labor requirements were determined to be a function of purchase, and were based upon the 1997 budget of stocker steers on wheat pasture produced by the Agricultural Economics Department at Oklahoma State University. As no data were discovered that provided a relationship between labor requirements and different purchase weights, estimates were based upon expert opinion . Morbidity is consistently higher in light weight calves indicating higher labor requirements during the first several months of ownership until cattle are healthy and gaining at a high level (Lalman, 2001). After approximately 2 months, labor requirements would be expected to be similar across purchase weights with a possible advantage for lighter weight calves in the later half of the grazing season due to increased stocking density. The labor requirements of different weight classes utilized in the model are represented in Appendix 7.

Death loss estimates were based upon stocker cattle surveys and Animal Science Research Reports conducted at Oklahoma State University. A negative correlation exists between purchase weight and death loss resulting in the highest death loss percentage for the lightest purchase weights. Appendix 6 represents the death loss percentages used in the research.

Sale weight was calculated with a 3% shrink (loss in body weight resulting from stress in transport) and death loss subtracted from the predicted ending weight. Equation 8 represents the method in which sale weight was calculated.

(8) $X_t = \text{EW}[1-(\text{S}/100)][1-(\text{D}/100)]$

where:

X_t = sale weight in pounds at the end of the grazing season;

EW = predicted ending weight in pounds;

S = shrinkage percent;

D = death loss percent as a function of purchase weight.

Marketing and hauling charges were calculated based upon purchase weight and predicted ending weight using budget numbers and adjusted per year with price indices obtained from the National Agricultural Statistics Service. Interest costs were calculated by adding two percent to the prime rate and adjusted for the 140 days of ownership of the stocker cattle. In addition, the interest costs were calculated for 140 days on the other operating expenses involved in the management of the wheat pasture stockers.

Stocker prices were regressed using price as a function of purchase weight for both the purchase and sale dates. Total gain estimates for each stocker weight class resulted in predicted sale weights that did not evenly match reported sale weights resulting in the need for price functions that interpolated between prices. Also, price regressions allowed the creation of a purchase weight class for every 25 pound increment between 325 and 575 pounds. Price data for sale weights between 300 and 900 pounds in 50 pound increments from 1992 to 2000 (Appendix 1) were used to create a price to weight relationship for the purchase month of October and selling month of March in the following year for each growing season. Prices representing all quality types were averaged within each 50 pound increment in creation of the data. A separate function for both October and March of each grazing season was regressed resulting in 16 different regressions. The regression function determined for the purpose of interpolation between the different values per pound of weight classes for the purchase price in October of 1992 is represented by Equation 9.

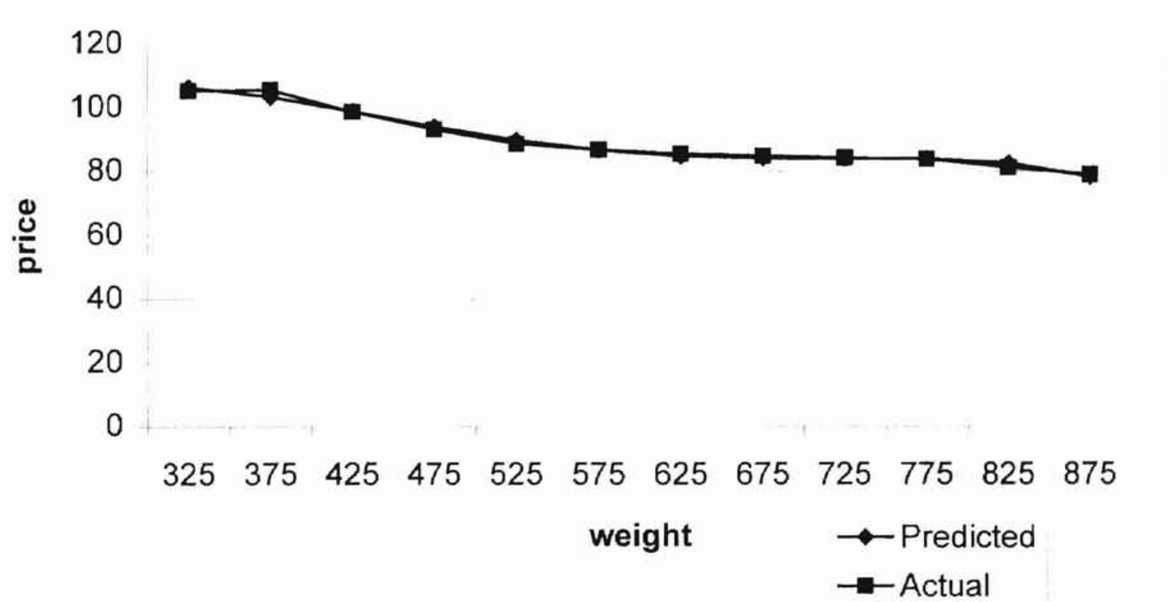
$$(9) \qquad P = -50.5279 + 1.39802X_1 - .00428X_1^2 + .00528X_1^3 - .00023X_1^4$$

where: P = price as a function of weight

X = body weight in pounds

The variables X_1^3 and X_1^4 were scaled by dividing by one thousand and one million in order to limit the decimal places of the corresponding coefficients. Figure 4.3 illustrates both actual prices and predicted prices for October of 1992. The described method results in the most accurate methods of determining historical returns.

Figure 4.3. Comparison of Actual and Predicted Prices for October 1992



A second price regression was estimated in order to determine the impact of factors other than weight upon the price of stocker steers. This regression accounts for bias that may exist in the price to weight relationship parameters when price is solely a function of weight as in Equation 9. The creation of a second price function will result in two different estimates of returns per acre of stocker steers grazing wheat pasture and will help to explain the variability of returns. Although estimates of historical returns resulting from a price function representing market determinants are less accurate than those from price as function of weight alone, more useful inferences can be drawn from the second function. Stocker cattle prices are a function primarily of five factors: 1) body weight 2) position in the cattle cycle 3) seasonal tendencies 4) feed prices, and 5) the price of heavier weight cattle. The relationships between these five factors and stocker prices are considered in order to explain the price structure within the cattle industry.

The price function was estimated based upon the independent variables discussed previously. The model contains sixteen variables and an intercept term. The log-linear function used to estimate the stocker steer price function is represented by Equation 10.

$$
\begin{aligned}
(10)\quad LogP = {} & \beta_0 + \beta_1 \, March + \beta_2 March * Weight + \beta_3 Weight + \beta_4 Weight^2 + \beta_5 Dummy93 \\
& + \beta_6 Dummy94 + \beta_7 Dummy95 + \beta_8 Dummy96 + \beta_9 Dummy96b + \beta_{10} Dummy97 \\
& + \beta_{11} Dummy98 + \beta_{12} Dummy99 + \beta_{13} Inventory + \beta_{14} RationCost + \beta_{15} Live\,\mathrm{Pr}\,ice
\end{aligned}
$$

Table 4.4 references the parameter estimates of the price equation developed to explain stocker price variation.

Table 4.4. Parameter Estimates of the Stocker Steer Price Equation

F Value = 446.92 Dependent Variable: Log of Steer Price
Length = 8 years
R squared = .9747 N = 190

Variable	Parameter	t-Value	Pr > |t|
(1) Intercept	8.9467	21.31	<.0001
(2) March	4.5489	2.11	<.0001
(3) March*weight	-.34302	-12.47	<.0001
(4) Weight	-0.00152	-14.81	<.0001
(5) Weight2	0.08153	9.82	<.0001
(6) Dummy 1993	0.11466	13.75	<.0001
(7) Dummy 1994	0.18001	6.63	<.0001
(8) Dummy 1995	0.04364	1.82	0.0698
(9) Dummy 1996	-0.05353	-2.44	0.0157
(10) Dummy 1996b	0.11237	11.99	<.0001
(11) Dummy 1997	0.21388	14.55	<.0001
(12) Dummy 1998	0.14088	4.86	<.0001
(13) Dummy 1999	0.14042	6.20	<.0001
(14) Cattle Inventory	-0.00005484	-10.05	<.0001
(15) Ration Cost	.00208	3.00	0.0031
(16) Live Cattle Price	0.01734	11.74	<.0001

The regression model explained 97.47% of the variation in stocker steer prices based upon 190 observations. The first variables created represent the seasonality of cattle prices from fall to spring. Variables 2 and 3 are dummy variables that act as intercept and slope shifters and account for the seasonal price variation between October and March. As expected, the seasonal impact from October to March is positive with a high significance level shown by Variable 2, the seasonal intercept shifter. Variable 3, the interaction variable between seasonality and weight, indicates that a steeper negative slope exists in the price to weight relationship in the spring. The steer weight variables, represented by Variables 4 and 5, create a quadratic relationship between price per hundredweight and body weight that results in declining prices per hundredweight as body weight increases. A light weight stocker animal has a high value per pound due to the fact that total initial investment in the animal is lower and lighter stockers gain more efficiently. As stockers reach heavier weights, price per pound will decrease as feed efficiency decreases. The slope of the relationship between price and weight is also determined by the changing relative prices of production inputs.

Variables 6 through 14 are dummy variables that adjust the intercept for each grazing season and help to account for the cyclical aspect of the cattle cycle represented by USDA cattle inventories. Each dummy variable represents one grazing season with an October purchase date and a March selling date. The year included in the title of each dummy variable represents the purchase date in the fall of each grazing season. The 1996 grazing season was represented by two separate dummy variables due the strong shift in both price level and structure from fall to spring. Due to the combined impact of high grain prices, large cattle inventories, and limited forage as a result of widespread drought in the Southern Plains in 1996, the slope of the price to weight relationship leveled in 1996 before resuming a more typical relationship in the following spring. Spring prices of the 1995-1996 grazing season were also represented by the intercept due to the extremes in the market previously discussed. Variable 15 estimates the relationship between stocker prices and feedlot ration costs. Feedlot ration costs were estimated using the combined value of 4.5 bushels of soybeans and 45 bushels of corn. These two commodities comprise the majority of feedlot ration costs in the proportion estimated above. However, an unexpected positive relationship exists which does not verify the economic theory that high ration costs would place downward pressure upon stocker prices as feedlot profit margins decrease. Variable 16 indicates a positive relationship exists between slaughter cattle prices and stocker prices. This relationship is very intuitive as greater profits within the feedlot industry translate into higher stocker prices through derived demand.

A test of first and second moment specification produces a Chi-Square value of 61.30 and a p-value of .2306. Heteroskedasticity was corrected with Harvey's Procedure. First, the log of the residuals squared from the original regression was calculated. These values were then regressed as a function of the independent variables. The inverse of these predicted values set as the exponent of the natural log rhythm *e* created the weight used for correcting the heteroskedasticity of the parameters.

CHAPTER V

RESULTS

The purchase weights of stocker steers that maximized returns per acre grazing winter wheat pasture were determined for stocker steers purchased in the years of 1992 through 1999. The linear programming model calculated returns per acre of purchase weights between 325 and 575 pounds in 25 pound increments. Price was regressed as a function of weight separately for both the purchase and selling month of each grazing season in order to match the production environment by interpolating between the reported data. Production estimates and input usage remain the same for each grazing season while the corresponding costs are indexed based on data available from the National Agricultural Statistics Service of the USDA (Appendix 2). Table 5.1 illustrates the estimates of prices paid by stocker operators during each grazing season that were used in the model.

Table 5.1. Prices Paid by Stocker Operators

Year	Labor $/hour	Interest % rate	Feed $/lb.	Hay $/lb	Mineral $/lb	Market $/cwt.	Hauling $/cwt.	Equipment $/head
1992	5.55	0.083	0.087	0.030	0.068	1.50	0.30	9.83
1993	5.71	0.080	0.088	0.037	0.071	1.54	0.31	10.12
1994	5.87	0.091	0.093	0.040	0.072	1.57	0.31	10.31
1995	6.02	0.108	0.090	0.037	0.074	1.62	0.32	10.60
1996	6.18	0.103	0.113	0.047	0.078	1.71	0.34	11.19
1997	6.50	0.104	0.109	0.039	0.080	1.75	0.35	11.48
1998	6.82	0.104	0.096	0.041	0.078	1.71	0.34	11.19
1999	7.13	0.100	0.088	0.036	0.078	1.71	0.34	11.19

Source: National Agricultural Statistics Service

A linear programming tableau was constructed to represent each of the eight grazing seasons modeled. Returns per acre to land and management were positive for all years and weight classes except the 1995-1996 grazing season. Tables 5.2 and 5.3 represent estimated returns per acre of stocker steers purchased in October, grazed on wheat pasture, and sold in early March of the years of 1992 through 2000. The estimated returns provided in Table 5.2 are based on price as a function of weight (Equation 9), while Table 5.3 provides returns based upon price as a function of weight and other market determinants (Equation 10).

Table 5.2 Returns per Acre by Year and Weight (Equation 9)

Year	1992	1993	1994	1995	1996	1997	1998	1999
325	70.16	44.34	27.09	-6.13	104.7	54.55	65.15	104.48
350	64.6	39.27	23.27	-9.24	97.37	44.26	59.46	98.02
375	60.08	34.94	19.87	-11.44	89.85	36.12	54.96	92.35
400	56.3	30.91	16.62	-13.30	82.09	29.38	50.98	86.9
425	53.45	27.32	13.83	-14.81	74.61	24.02	47.59	81.86
450	51.33	23.94	11.33	-16.37	67.45	19.6	44.39	76.91
475	50.37	21.29	9.64	-17.57	61.21	16.38	41.84	72.4
500	49.41	18.48	7.82	-19.58	55.39	13.56	38.9	67.55
525	49.26	16.38	6.58	-21.60	50.67	11.77	36.94	62.93
550	49.07	14.57	5.36	-24.27	46.65	10.6	33.71	58.11
575	49.18	13.42	4.32	-27.25	43.62	10.36	31.23	53.27

Source: Linear Programming Model

Table 5.3 Returns per Acre by Year and Weight (Equation 10)

Year	1992	1993	1994	1995	1996	1997	1998	1999
325	81.37	44.05	21.93	-9.49	69.86	46.01	52.87	88.72
350	77.95	40.90	20.10	-9.80	67.09	42.55	51.38	84.64
375	74.68	37.87	18.24	-10.28	64.48	39.49	49.85	80.99
400	71.23	34.65	16.05	-11.28	61.76	36.34	47.84	77.28
425	67.84	31.45	13.77	-12.48	59.15	33.37	45.68	73.77
450	64.34	28.13	11.25	-14.06	56.46	30.37	43.17	70.25
475	61.28	25.22	9.05	-15.41	54.11	27.74	41.00	67.16
500	57.68	21.76	6.27	-17.37	51.33	24.68	38.15	63.60
525	54.48	18.69	3.81	-19.11	48.87	21.98	35.64	60.44
550	51.18	15.50	1.24	-20.94	46.30	19.16	33.02	57.19
575	48.21	12.63	-1.06	-22.59	43.48	16.62	30.66	54.25

Source: Linear Programming Model

The model selected 325 pounds as the most profitable purchase weight for all eight years included in the research. A pattern of decreasing returns was found to exist as purchase weight increased in both models. The greatest disparity between the two models exists in the profitability of lighter weight calves during the 1996 and 1999 grazing seasons. The disparity can be explained by the failure of the exogenous price function to completely account for rapid price increases and a strong shift in the slope of the price to weight relationship within a grazing season. During the 1995-1996 grazing season every weight class of stocker steers grazing wheat pasture resulted in a negative return. However, the 325 pound weight class minimized the negative returns per acre indicating a similar pattern exists in comparison to the other grazing seasons simulated. Table 5.4 illustrates the average value of gain for each weight class of stocker steers purchased in October and sold in March for the years 1992-1999.

Table 5.4 Value of Gain

Purchase Weight Lbs./head	Purchase Price $/cwt.	Sale Weight Lbs./head	Sale Price $/cwt.	Value of Gain $/cwt
325	95.07	482.65	94.21	92.45
350	94.06	513.79	91.27	85.31
375	92.58	544.91	88.38	79.13
400	90.77	576.04	85.60	73.85
425	88.77	607.22	82.95	69.39
450	86.70	638.47	80.49	65.69
475	84.65	669.80	78.25	62.65
500	82.72	699.46	76.37	60.45
525	80.96	729.08	74.73	58.71
550	79.43	756.77	73.44	57.50
575	78.16	784.32	72.39	56.53

Source: USDA/AMS (U. S. Department of Agriculture, Agricultural Marketing Service, Livestock and Seed Division). 2000. "Oklahoma National Stockyards Weekly Weighted Average Feeder Cattle Report." Oklahoma City, OK.

Value of gain is calculated by subtracting the purchase price times the purchase weight from the selling price times the selling weight and dividing by the weight gain added by the stockers. The advantage that stocker steers purchased at lighter weights possess in value of gain is illustrated in Table 5.4. When cost of gain, which includes all the costs of production, is subtracted from value of gain, profit per pound of gain is determined. The linear programming model determines the optimal combination of pounds produced per acre and the profit per pound of gain which will result in the greatest return per acre. An additional advantage in pounds of gain per acre that exists for lighter weight steers is illustrated by Table 5.5 which further explains the advantage in profitability that exists for lighter weight steers. Although lighter weight stockers gained less on a per head basis, their advantage in stocking rate per acre allowed for a greater total weight gain per acre. Total gain per acre was calculated by multiplying stocking rate (head/acre) times pounds gained per head.

Table 5.5 Pounds Gained per Acre by Purchase Weight

Purchase weight	Head/acre	Gain/head	Gain/acre
325	.7631	169.91	129.67
350	.7281	176.48	128.50
375	.6975	183.01	127.65
400	.6694	189.54	126.88
425	.6444	196.12	126.36
450	.6212	202.73	125.94
475	.6000	209.42	125.65
500	.5806	214.38	124.47
525	.5631	219.31	123.50
550	.5463	222.26	121.41
575	.5306	225.06	119.42

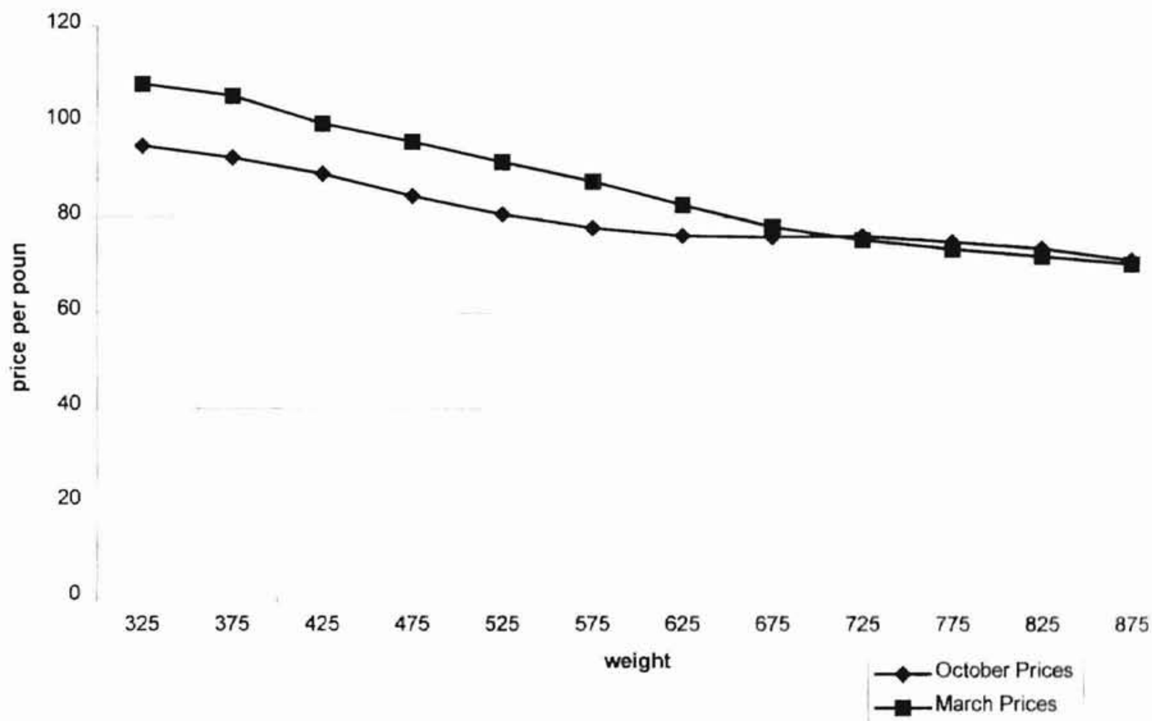
Source: Linear Programming Model

Although lighter weight stockers have a greater cost of gain due to increased labor requirements, veterinary costs and death loss, the advantage possessed in value of gain and pounds of liveweight produced per acre allows them to consistently be the most profitable option indicating the market is sending several signals. First, the market is rewarding those producers with the management skills to precondition and graze lighter weight calves. Higher labor requirements exist in the management of lighter weight calves, and greater diagnostic and veterinary skills are required. Producers may avoid the purchase of calves below a certain weight because they do not have the skills or facilities necessary for their management. The market may be providing a reward to risk-seeking individuals as the variability in veterinary costs, labor requirements and death loss is much greater for lighter weight calves. Depending upon previous vaccination programs, health of stockers upon arrival, and the severity of the weather, the production costs associated with lighter weight stockers can be volatile deterring both risk neutral and risk averse producers. An additional risk that faces potential purchasers of lighter weight calves is possibility of a strong winter snow storm which generally has a much greater impact upon death loss as body weight decreases. The bias that may exist for lighter calves was accounted for through greater labor requirements, higher veterinary costs, a slower rate of gain, and a higher death loss.

Several factors exist that create an advantage for calves purchased at lighter weights. Stockers placed upon wheat at light weights have the flexibility to either return to grass in the spring or be placed in the feedlot where they will have an advantage in cost of gain due to more efficient feed conversion over heavier weight placements. Due to the fact that demand exists from both the stocker and feedlot sectors of the industry, the price to weight relationship of stockers shifts in the spring resulting in an advantage in the price margin for stockers purchased at lighter weights when marketed in the spring.

Figure 5.2 includes the average price for the eight grazing seasons studied and illustrates how the slope of the price to weight relationship shifts from fall to the following spring creating an advantage in value of gain for light weight stockers.

Figure 5.2. Average Steer Prices of 1992-2000 Wheat Pasture Grazing Seasons



The results favoring lighter purchase weights are representative of operations within the state of Oklahoma that purchase light weight calves to add gain through both grazing and backgrounding and consistently record high returns (Lalman, 2001). No special time of purchase was noted but the intent of the stocker operations described was to add cheap forage based gain to calves purchased at light weights. The sale of a three hundred pound calf is generally considered unprofitable for cow-calf producers and thus returns beyond normal economic profits may exist for stocker operators purchasing light weight calves. As the percentage of expense resulting from the purchase cost of stocker cattle decreases, the price risk for stocker producers also decreases. Adding large amounts of gain to individual stockers protects producers against falling prices. As gain is added to the stocker animal, the percent of total costs represented by the purchase price decreases and the risk created by a market downturn is reduced.

Although bias favoring lighter purchase weights may exist in the model that is unaccounted for by increased labor costs, death loss, veterinary costs, and a slower rate of gain, lighter purchase weights were constantly the most profitable on a per acre basis. During periods of inventory reduction, the variation between returns per acre of light and heavy weight stockers was the greatest.

Sensitivity Analysis

Sensitivity analysis was conducted to determine the effect of different factors of production upon returns per acre. Realizing the impact that factors of production have separately upon returns allows for priorities to be determined in the process of allocating resources. This aspect was especially important to determine the effect of individual factors of production when production estimates were based upon expert opinion. Prices paid and prices received by producers were averaged from the years 1992 through 1999 to analyze the production factors considered to have a significant impact on returns. Sensitivity analysis was conducted to determine the impact of average daily gain, stocking rate, death loss percentage, seasonality, and labor requirements per weight class. Table 5.6 illustrates the returns resulting from averaged prices.

Table 5.6 Returns based on Averaged Prices Received and Prices Paid

Purchase weight	Returns per head	Returns per acre
325	$66.53	$50.77
350	$62.81	$45.73
375	$59.40	$41.43
400	$55.96	$37.46
425	$52.82	$34.04
450	$49.69	$30.87
475	$47.51	$28.51
500	$44.65	$25.92
525	$42.49	$23.93
550	$40.24	$21.97
575	$38.33	$20.34

Source: Linear Programming Model

Gain

The impact of changing average daily gain resulted in the greatest effect on returns per acre. Every 1% increase in average daily gain was determined to result in a 3.15% increase in profit. Factors that impact gain are: health, quality, and type of stockers; quality of forage; and number of days forage is covered by snow. Table 5.7 illustrates the effects upon returns per acre of changing average daily gain. The high impact of average daily gain upon returns indicates the importance of optimizing the tradeoff between stocking rate and average daily gain.

Table 5.7 Impact of Changing Average Daily Gain upon Returns per Acre

Weight Pounds	Average returns returns/acre	25% decrease returns/acre	25% increase returns/acre
325	$50.77	$20.76	$80.79
350	$45.73	$17.02	$74.44
375	$41.43	$13.96	$68.89
400	$37.47	$11.18	$63.76
425	$34.04	$8.84	$59.24
450	$30.87	$6.68	$55.06
475	$28.51	$5.22	$51.79
500	$25.92	$3.47	$48.37
525	$23.93	$2.22	$45.63
550	$21.98	$ .94	$43.01
575	$20.33	$-.10	$40.80

Source: Linear Programming Model

Stocking Rate

The impact of stocking rate upon returns is not well determined by this analysis as the relationship between average daily gain and stocking rate was not estimated. Average daily gain begins to decrease when stocking rates surpass a certain level, and the stocking capacity of wheat pasture varies from year to year depending upon precipitation, temperature, and planting date. Every 1% increase in stocking rate resulted in a 1% increase in returns per acre as a result of the constant returns to scale that apply to linear programming models. Changing the stocking rate per acre without affecting other input usage or production estimates results in a proportional change in returns per acre. Table 5.8 illustrates the impact of changing stocking rate upon profit.

Table 5.8. Impact of Changing Stocking Rate upon Returns per Acre

Weight Pounds	Average returns returns/acre	25% decrease returns/acre	25% increase returns/acre
325	$50.77	$38.08	$63.47
350	$45.73	$34.30	$57.16
375	$41.43	$31.07	$51.79
400	$37.47	$28.10	$46.84
425	$34.04	$25.53	$42.55
450	$30.87	$23.15	$38.59
475	$28.51	$21.38	$35.63
500	$25.92	$19.44	$32.40
525	$23.93	$17.94	$29.91
550	$21.98	$16.48	$27.47
575	$20.33	$15.25	$25.43

Source: Linear Programming Model

Labor

In order to determine the effect of labor costs upon returns per acre, labor requirements were increased by 50% and 100%. Table 5.9 illustrates the impact of increasing labor requirements upon returns per acre. On average, a 1% increase in labor requirements resulted in a .25% decrease in returns per acre.

Table 5.9 Impact of Changing Labor Requirements upon Returns per Acre

Weight Pounds	Average returns returns/acre	50% decrease returns/acre	50% increase returns/acre	100% increase returns/acre
325	$50.77	$59.74	$37.16	$32.84
350	$45.73	$52.87	$35.97	$31.44
375	$41.43	$47.05	$34.82	$30.19
400	$37.47	$42.01	$33.03	$28.38
425	$34.04	$37.79	$31.09	$26.52
450	$30.87	$34.20	$28.61	$24.22
475	$28.51	$31.43	$26.77	$22.65
500	$25.92	$28.76	$24.02	$20.26
525	$23.93	$26.67	$21.79	$18.43
550	$21.98	$24.64	$19.55	$16.65
575	$20.33	$22.93	$17.56	$15.16

Source: Linear Programming Model

Increasing labor requirements narrowed the gap that exists between light and heavy purchase weights and decreased profitability at a greater rate for lighter purchase weights. The results indicate a possibility that labor requirements were underestimated for lighter purchase weights and could have a greater impact in decreasing the profitability of lighter weight stocker cattle.

The fact that increasing labor requirements has the greatest negative impact upon lighter weight stockers could indicate that light weight stockers offer opportunity for grazers with less leverage and credit history. Operations with limited capital resources and available family labor could take advantage of the opportunities available grazing light weight stockers by substituting labor for capital to increase returns to limited equity.

Death Loss

Every 1% increase in death loss results in a .279% decrease in returns per acre. Proportional changes in death loss have a greater impact as purchase weight decreases. This fact indicates that greater risk exists at lighter purchase weights as death loss increases as illustrated by Table 5.10. The actual variability in death loss is much higher for lighter weight calves consistent with the finding of the analysis.

Table 5.10. Impact of Changing Death Loss Percentage upon Returns per Acre

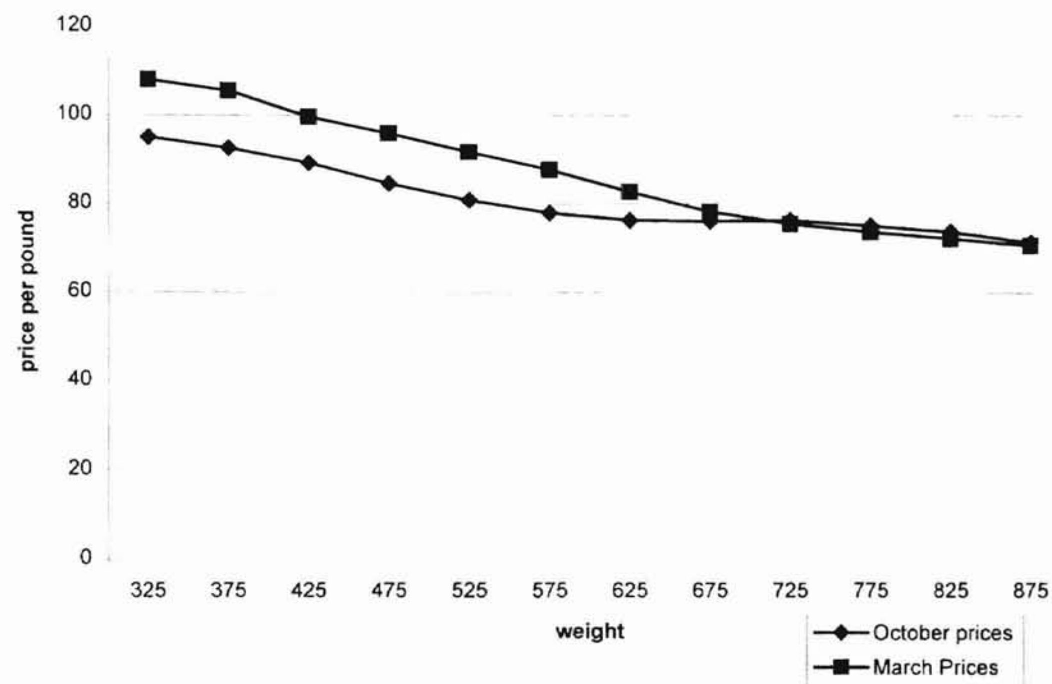
Weight Pounds	Average returns returns/acre	50% increase returns/acre	50% decrease returns/acre
325	$50.77	$41.41	$60.14
350	$45.73	$37.48	$53.98
375	$41.43	$34.26	$48.60
400	$37.47	$31.34	$43.60
425	$34.04	$28.90	$39.17
450	$30.87	$26.69	$35.06
475	$28.51	$25.22	$31.79
500	$25.92	$23.10	$28.75
525	$23.93	$21.54	$26.31
550	$21.98	$19.62	$24.34
575	$20.33	$18.00	$22.68

Source: Linear Programming Model

Seasonality

The existence of seasonality gave light weight stockers a strong advantage as shown by figure 5.2. The relative prices of stocker cattle shift upward from fall to spring creating a positive seasonal advantage. As body weight increases, the seasonal advantage that exists for stocker steers purchased in October and sold in March decreases. Seasonal price variations result from the environmental conditions in which cattle are produced and the seasonality of beef demand (Simon, 1981). Forage availability and weather patterns result in the majority of calves being born in the spring calving season resulting in the greatest number of stocker animals entering the market in the fall. Also, beef demand generally peaks during the late spring and summer contributing to the seasonality of cattle prices.

Figure 5.2. Average Steer Prices of 1992-2000 Wheat Pasture Grazing Seasons



In order to determine the impact that seasonality has upon returns per acre, price as a function of weight was regressed combining both October and March average stocker prices and substituted into the linear programming model. Removing seasonality had the greatest impact upon the profitability of stockers purchased at lighter weights indicating that a great deal of the advantage in estimated returns per acre results from a positive trend in seasonality from fall to spring. The negative impact in profitability resulting from removing seasonality decreased substantially for purchase weights greater than 500 pounds. Table 5.11 illustrates the impact resulting from removing seasonality by combining October and March prices.

Table 5.11. Impact of Removing Seasonality upon Returns per Acre

Weight Pounds	Average returns returns/acre	Seasonality removed returns/acre	% change returns/acre
325	$50.77	$23.37	-53.97%
350	$45.73	$19.60	-57.14%
375	$41.43	$16.98	-59.02%
400	$37.47	$15.21	-59.41%
425	$34.04	$14.56	-57.22%
450	$30.87	$14.76	-52.19%
475	$28.51	$16.23	-43.06%
500	$25.92	$17.54	-32.34%
525	$23.93	$19.39	-18.96%
550	$21.98	$20.74	-5.63%
575	$20.33	$21.71	6.74%

Source: Linear Programming Model

Limitations of the Model

The first limitation is that the variability in weather resulting from different grazing seasons is not accounted for in the model. Forage production is assumed to be constant for every year in the model. A precipitation index could be used to adjust forage production based upon rainfall within a specific year. Also, heavy winter snow accumulation and/or extreme temperatures could result in a greater increase in death loss of lighter weight cattle.

The model assumes average values for the state in regard to stocking rate, forage production, rate of gain, and the number of days in a grazing season. Regional or county analysis could be conducted that would increase the accuracy of the study. Also, the assumption is made that grazing wheat has no impact upon grain yield. This implies that livestock were not placed upon wheat prior to sufficient root development or removed after development of the first hollow stem. Mismanagement in either of these situations will negatively impact grain yield.

Another factor that could be examined in greater detail is the rate of gain. The growth simulation model developed by Brorsen and others determined that average daily gain increases at a decreasing rate as weight of the stocker animal increases. The likelihood exists that average daily gain levels off at some point as purchase weight increases. However, this is a factor that would only increase the advantage that already exists for lighter purchase weights.

The calculation of forage estimates could be more precise. Based upon forage production over a growing season, a constant rate of growth is assumed throughout the grazing season. Although forage growth is the greatest at the beginning and end of the wheat pasture grazing season due to the fact that some degree of dormancy occurs during the coldest months, precise monthly data was not available for the research. Also, the model could be expanded to include a graze-out season of the wheat pasture although the heavier weight stockers could not efficiently be grazed for a longer period of time.

CHAPTER VI

CONCLUSIONS

The most important deductions to be drawn from this study are implications regarding the efficiency of the stocker market. Steer calves purchased at light weights were consistently the most profitable option based upon the estimated returns of the model. One might hypothesize that if the market is efficient, all purchase weight options would yield similar results. However, several conditions exist that may negate this hypothesis. First, the market may be in a constant state of moving toward efficiency. The availability of light weight calves is decreasing as weaning weights rise due to improved genetics in both growth and maternal traits. This fact is evidenced by performance data from the Angus breed (American Angus Association, 2001, Appendix 9). Also, improved production practices by cow-calf producers have contributed to increasing weaning weights further reducing the supply of light weight calves. Another explanatory condition may be the existence of bias in returns per acre favoring light weight calves that is unaccounted for by increased death loss, labor costs, veterinary costs, and slower rate of gain. If significant differences in returns between purchase weights exist and the market is not correcting this development, inefficiency in the stocker market is suggested.

However, the author concludes that this study confirms that additional value exists for stockers purchased at light weights. Thus, the market may be rewarding stocker graziers for the management skills necessary to diagnose and treat morbidity and successfully precondition light weight calves. Rewards may also exist for producers with the facilities to treat and care for light weight stockers and the willingness to accept the additional risks resulting from the volatility of production factors associated with lighter purchase weights. Although industry trends likely will decrease available supplies of light weight stockers and movements in market efficiency will narrow profit margin differences between stocker cattle weight classes, substantial profit potential still exists for stocker operators possessing the management skills and risk-seeking characteristics required to graze light weight stockers on winter wheat pasture.

Several different avenues exist that offer potential for further research. First, analysis could be conducted that would confirm that the market is rewarding producers with the characteristics necessary to graze light weight stockers. Also, the linear programming model could be expanded to examine the tradeoff between stocking rates and average daily gain and maximize returns per acre based upon the tradeoff between forage and grain yield of different planting dates.

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APPENDIX

Appendix 1. Oklahoma National Stockyards Monthly Weighted FeederCattleReport

	1992 October	1993 March	1993 October	1994 March	1994 October	1995 March	1995 October	1996 March
325	105.38	116.75	115.35	121	98.17		73.22	66
375	105.66	114.98	111.78	116	94.28		70.9	65.75
425	98.77	110.47	106.78	111.5	90.63	94.59	69	66
475	93.23	106.36	100.3	106.75	85.03	89.69	66.33	64.53
525	88.64	103.02	95.85	102.69	81.83	84.88	64.33	62.25
575	86.86	97.98	91.56	97.5	78.55	82.41	62.5	60.63
625	85.56	92.03	87.69	91.41	75.28	76.31	64.1	58.66
675	84.89	88.95	88.53	87.13	74.18	73.13	63.9	57.53
725	84.36	86.53	87.63	83.78	73.93	71.06	67.13	56.34
775	83.88	84.91	85.19	81.31	72.4	68.84	66.68	55.78
825	81.27	83.96	83.31	79.66	71.38	66.88	66.05	55.22
875	79.04	83	82.06	78.09	69.43	65.53	64.23	55.09

	1996 October	1997 March	1997 October	1998 March	1998 October	1999 March	1999 October	2000 March
325	69	98.37	102.83	115.88	88.96	107.28	107.06	130.5
375	68.25	99.32	101.5	109.6	86.5	105.23	101.3	127.73
425	67.41	94.63	98.18	103.54	85.15	97.13	97.57	119.38
475	65.88	91.61	94.01	99.18	79.5	93.35	92.3	115.75
525	64.69	87.29	89.81	93.7	75.14	90.11	86.01	109.3
575	63.34	85.3	84.85	89.93	72.63	85.95	82.84	101.41
625	63.63	77.64	79.55	85.65	71.67	81.14	82.03	98.68
675	63.13	72.61	79	78.39	71.63	75.35	82.59	92.44
725	64.47	69.88	78.93	76.16	71.97	73.54	81.22	86.17
775	64.19	69.14	76.84	73.95	70.26	70.98	80.53	83.84
825	64.22	68.26	75.53	73.07	68.68	68.98	78.53	80.53
875	62.75	66.47	72.77	70.87	64.45	67.22	74.69	77.58

Source: USDA/AMS (U. S. Department of Agriculture, Agricultural Marketing Service, Livestock and Seed Division). 2000. "Oklahoma National Stockyards Weekly weighted Average Feeder Cattle Report." Oklahoma City, OK.

Appendix 2. Indexes of Prices Paid by Farmers, United States, 1992-1999

Prices Paid by Farmers	Indexes of Prices Paid (1990-92=100)							
	1992	1993	1994	1995	1996	1997	1998	1999
Production Items	101	103	106	108	115	119	113	112
Feed	99	101	106	103	129	125	110	100
Livestock	96	104	94	82	75	94	88	95
Seed	99	101	108	110	115	119	122	121
Fertilizer	100	96	105	121	125	121	112	105
Chemicals	103	109	112	116	119	120	122	121
Fuels	96	93	91	89	102	106	84	93
Farm supplies	104	107	109	112	115	118	119	121
Autos & Trucks	102	105	111	115	118	119	119	119
Farm Machinery	104	107	113	120	125	128	132	136
Building Materials	101	106	109	114	115	118	118	120
Farm Services	103	109	110	115	116	116	115	115
Rent	104	100	108	117	128	136	120	117
Interest	93	87	94	102	106	105	104	106
Taxes	104	108	106	109	112	115	119	120
Wage Rates	105	108	111	114	117	123	129	135
Production Items, Interest, Taxes, and Wages	101	102	106	108	115	118	114	114

Source: United States Department of Agriculture, National Agricultural Statistic Service

Appendix 3. Bank Prime Loan Rate

Year	Loan Rate
1990	10.0091%
1991	8.4633%
1992	6.2517%
1993	6.0000%
1994	7.1383%
1995	8.8292%
1996	8.2708%
1997	8.4417%
1998	8.3542%
1999	7.9942%

Source: Federal Reserve Board, "Bank Prime Rate Loan"

Appendix 4. Average Non-legume Hay Prices for Oklahoma.

Year	Hay Prices ($ per ton)
1990	$72.5
1991	$61.5
1992	$60.5
1993	$74.5
1994	$79
1995	$73.5
1996	$93.5
1997	$78
1998	$81
1999	$71.5

Source: United State Department of Agriculture, National Agricultural Statistics Service

Appendix 5. Dry Matter Intake per Month of Stockers Steers Grazing Winter Wheat

Weight	Month				
	NOV	DEC	JAN	FEB	MARCH
325	153.94840	331.6445	362.4564	392.4177	68.2575
350	162.16790	348.3760	379.5978	409.9850	71.2277
375	170.23025	364.7650	396.3581	427.1322	74.1241
400	178.14943	380.8436	412.7750	443.9025	76.954
425	185.93731	396.6388	428.8801	460.3322	79.7250
450	193.60414	412.1741	444.7005	476.4518	82.4416
475	201.15878	427.4692	460.2592	492.2876	85.1086
500	208.60902	442.5417	475.5761	507.8619	87.7302
525	215.96171	457.4069	490.6686	523.1945	90.3097
550	223.22294	472.0783	505.5522	538.3025	92.8503
575	230.39814	486.5679	520.2404	553.2011	95.3545

Source: National Research Council. 1984. *Nutrient Requirements of Beef Cattle.* National Research Council, Board on Agriculture, Committee on Animal Nutrition, Subcommittee on Beef Cattle Nutrition

Appendix 6. Death Loss Percentage

Weight	% Death Loss
325	5.0%
350	4.5%
375	4.0%
400	3.5%
425	3.0%
450	2.5%
475	2.0%
500	1.75%
525	1.5%
550	1.5%
575	1.5%

Sources: Ackerman, C. J., S. I. Paisley, G. W. Horn, H. T. Purvis II, T. N. Bodine, and B. R. Karges. "Heavy vs. Light Weight Steers Grazing Old World bluestem at Three Stocking Rates: I. Steer Weight Gain and Economic Analysis." 1998 Animal Science Research Report. Oklahoma State University

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Appendix 7. Estimated Labor Hours per Month by Weight Class

Weight	325	350	375	400	425	450	475	500	525	550	575
LaborOctober	1.2	0.95	0.75	0.6	0.5	0.45	0.4	0.4	0.4	0.4	0.4
LaborNovember	0.8	0.65	0.5	0.4	0.35	0.3	0.25	0.25	0.25	0.25	0.25
LaborDecember	0.8	0.65	0.5	0.4	0.35	0.3	0.25	0.25	0.25	0.25	0.25
LaborJanuary	0.5	0.45	0.4	0.35	0.25	0.25	0.25	0.25	0.25	0.25	0.25
LaborFebruary	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
LaborMarch	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

Appendix 8. Linear Programming Tableau

Units> V		Equation Column V	Quantity of Res V	Acres Wheatpas	head 325str	head 350str	head 375str	head 400str	head 425str	head 450str	head 475str	head 500str	head 525str	head 550str	head 575str
		Level of Activites >		160.0	122.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
$	Gross Margin	6882.31		0	0	0	0	0	0	0	0	0	0	0	0
acres	Landpas	160.00	160	1											
aums	PastNov	0.00	0	-137.56	153.9	162	170.2	178.15	185.9	193.6	201.16	208.61	215.96	223.22	230.4
aums	PastDec	0.00	0	-275.11	331.6	348	364.8	380.84	396.6	412.17	427.47	442.54	457.41	472.08	486.57
aums	PastureJan	0.00	0	-275.11	362.5	380	396.4	412.77	428.9	444.7	460.26	475.58	490.67	505.55	520.24
aums	PastureFe	0.00	0	-275.11	392.4	410	427.1	443.9	460.3	476.45	492.29	507.86	523.19	538.3	553.2
aums	PastureMa	0.00	0	-45.852	68.26	71.2	74.12	76.954	79.73	82.442	85.109	87.73	90.31	92.85	95.355
aums	LaborOct	0.00	0		1.2	0.95	0.75	0.6	0.5	0.45	0.4	0.4	0.4	0.4	0.4
hours	LaborNov	0.00	0		0.8	0.65	0.5	0.4	0.35	0.3	0.25	0.25	0.25	0.25	0.25
hours	LaborDec	0.00	0		0.8	0.65	0.5	0.4	0.35	0.3	0.25	0.25	0.25	0.25	0.25
hours	LaborJan	0.00	0		0.5	0.45	0.4	0.35	0.25	0.25	0.25	0.25	0.25	0.25	0.25
hours	LaborFeb	0.00	0		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
hours	LaborMar	0.00	0		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
$	BorrowCap	-32.65	0		132.6	138	144.2	149.48	154.3	158.88	163.14	167.46	171.76	176.18	180.85
lbs	FeedBL	0.00	0		60	60	60	60	60	60	60	60	60	60	60
lbs	hayBL	0.00	0		255.5	275.1	294.79	314.44	334.10	353.75	373.4	393.06	412.71	432.36	452.01
lbs	Miin	0.00	0		9.11	9.11	9.11	9.11	9.11	9.11	9.11	9.11	9.11	9.11	9.11
cwt	MarketBL	-47.87	0		5.21	5.51	5.813	6.1093	6.403	6.6946	6.9839	7.2711	7.5565	7.8402	8.1224
cwt	HaulingBL	-47.87	0		8.46	9.01	9.563	10.109	10.65	11.195	11.734	12.271	12.806	13.34	13.872
head	VetBL	0.00	0		18	17.5	17	16.5	16	15.5	15	14.5	14	13.5	13
head	Equip	0.00	0		1	1	1	1	1	1	1	1	1	1	1
cwt	Strs325BL	0.00	0		3.25										
cwt	Strs495BL	0.00	0		-4.949										
cwt	Strs350BL	0.00	0			3.5									
cwt	Strs526BL	0.00	0			-5.26									
cwt	Strs375BL	0.00	0				3.75								
cwt	Strs558BL	0.00	0				-5.58								
cwt	Strs400BL	0.00	0					4							
cwt	Strs590BL	0.00	0					-5.895							
cwt	Strs425BL	0.00	0						4.25						
cwt	Strs621BL	0.00	0						-6.21						
cwt	Strs450BL	0.00	0							4.5					
cwt	Strs653BL	0.00	0							-6.527					
cwt	Strs475BL	0.00	0								4.75				
cwt	Strs684BL	0.00	0								-6.8442				
cwt	Strs500BL	0.00	0									5			
cwt	Strs714BL	0.00	0									-7.144			
cwt	Strs525BL	0.00	0										5.25		
cwt	Strs744BL	0.00	0										-7.4431		
cwt	Strs550BL	0.00	0											5.5	
cwt	Strs772BL	0.00	0											-7.723	
cwt	Strs575BL	0.00	0												5.75
cwt	Strs800BL	0.00	0												-8.0006

Appendix 8. Linear Programming Tableau

hours Octl	hours NovL	hours DecL	hours JanL	hours Febl	hours MarL	$ Borrow	lbs Buyfeed	lbs Buyhay	lbs Mineral	cwt MktExp	cwt HaulExp	head VetExp	head Equip	DMlbs tranNov	DMlbs tranDec	DMlbs tranJan	DMlbs tranFeb
35.0	21.9	21.9	21.9	21.9	11.4	15432.3	5244.4	37791.4	796.3	733.2	1213.9	1180.0	87.4	2497.9	5003.3	4332.4	866.0
-6.2	-6.22	-6.2	-6.2	-6.2	-6.2	-0.097	-0.095	-0.038	-0.075	-1.637	-0.327	-0.935	-10.738				
														1			
														-0.9	1		
															-0.9	1	
																-0.9	1
																	-0.9
-1																	
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Appendix 8. Linear Programming Tableau

cwt	Cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt
Buy325	Sell495	Buy350	Sell526	Buy375	Sell558	Buy400	Sell590	Buy425	Sell621	Buy450	Sell653
396.8	604.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-95 07	94.214	-94.06	91.27	-92.58	88.38	-90.77	85.596	-88.77	82.952	-86.7	80.494
-1											
	1										
		-1									
			1								
				-1							
					1						
						-1					
							1				
								1			
									1		
										-1	
											1

Appendix 8. Linear Programming Tableau

cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt	cwt
Buy475	Sell684	Buy500	Sell714	Buy525	Sell744	Buy550	Sell772	Buy575	Sell800
0.0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0
-84.65	78.25	-82.72	76.369	-80.96	74.73	-79.43	73.44	-78.16	72.386
-1									
	1								
		-1							
			1						
				-1					
					1				
						-1			
							1		
								-1	
									1

Appendix 9. Growth and Milk Data

Year	Weaning Weight Bulls	Weaning Weight Heifers	Yearling Weight Bulls	Yearling Weight Heifers	Milk EPD
1972	477	425	847	621	0
1973	476	425	857	638	0
1974	478	427	855	630	0
1975	475	427	866	642	0
1976	493	440	884	661	0
1977	500	446	881	657	0
1978	499	445	882	663	0
1979	508	453	901	674	0
1980	518	463	922	693	0
1981	530	474	926	692	0
1982	530	475	940	696	0
1983	534	480	938	703	1
1984	537	484	956	711	1
1985	554	498	978	730	2
1986	553	498	984	737	3
1987	572	516	1010	762	3
1988	589	531	1037	784	4
1989	599	542	1059	797	5
1990	601	542	1066	798	6
1991	599	539	1067	796	7
1992	614	553	1072	802	8
1993	611	551	1077	802	9
1994	613	553	1086	813	10
1995	610	551	1081	798	11
1996	602	544	1068	793	12
1997	612	554	1087	808	13
1998	612	553	1087	812	14
1999	623	564	1115	831	15
2000	634	571			

American Angus Association. 2001. "Average Adjusted Weights and Measurements by Year." www.angus.org.

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VITA

John Dayton Fast

Candidate for the Degree of

Master of Science

Thesis: UTILIZING PRICE MARGINS TO MAXIMIZE PROFITS FOR STOCKER OPERATORS

Major Field: Agricultural Economics

Biographical:

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