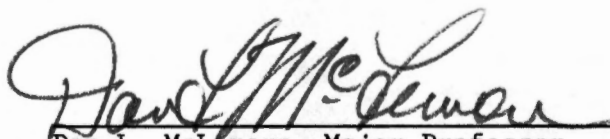
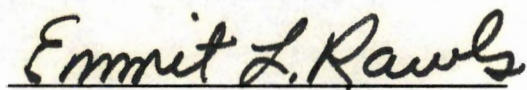


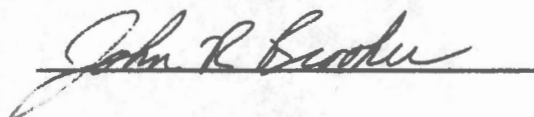
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AN ECONOMIC ANALYSIS OF THE EFFECTS OF FEEDER
CALF CHARACTERISTICS ON IMPORTANT FEEDLOT
AND CARCASS CHARACTERISTICS

A Thesis
Presented for the
Master of Science
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ABSTRACT

The identification of relationships between feeder calf characteristics and important feedlot and carcass characteristics would improve the efficiency of the marketing link between commercial cow-calf producers and stocker and feedlot operators. The feeder calf characteristics examined in this study were initial weight and fat thickness, breed, and subjective frame size and muscle thickness. A bioeconomic simulation model was utilized to examine the individual effects of those observable feeder calf characteristics on the length of the feeding process, final live weight and fat thickness, carcass yield grade and marbling score, feed cost, profitability of the feeding process, and derived value of the feeder animal.

The bioeconomic simulation model was used to represent 784 animals individually during the feedlot finishing process. The set of mathematical equations included in the model described the individual purchase, feeding, growth and selling process for the Angus, Hereford, Charolais-cross, and Angus-Hereford-cross animals in the study. Regression analysis was utilized to generate coefficients for growth and development of the animal in terms of weight, fat thickness, feed consumption, yield and quality grades, and salable carcass weight.

The analysis included separate results for maximizing net revenue to the animal and to the feedlot facility for differing cost-price scenarios. Net returns to the animal and to the feedlot facility were calculated every five days (from 100 to 340) on feed and the optimum selling point was determined. An individual animal's important feedlot

and carcass characteristics utilized in this study correspond to the animal's optimum selling point.

In order to examine the relationships between individual feeder calf and important feedlot and carcass characteristics, each feedlot and carcass characteristic was regressed on the set of feeder calf characteristics while accounting for the animal's diet. Separate regressions were analyzed when maximizing net returns to the animal and to the feedlot facility for each cost-price condition.

The general findings of this study indicated that initial weight was negatively related to days on feed, marbling score, and feed cost and positively related to final live weight. Initial fat thickness was negatively related to days on feed, final live weight, net returns from feeding, feed cost, and derived feeder animal value while initial fat thickness was positively related to final fat thickness and yield grade.

As for breed effects, the general findings indicated that Angus was negatively related to final live weight, net returns from feeding, and derived feeder value. Charolais-cross was negatively related to final fat thickness and yield grade and positively related to days on feed. The results indicated that Angus-Hereford-cross was positively related to net returns from feeding and derived feeder value.

Subjective frame size was negatively related to net returns from feeding and positively related to days on feed, final live weight, feed cost, and derived feeder value. Also, the results indicated that subjective muscle thickness was negatively related to net returns from the feeding process.

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CHAPTER 1

PROBLEM AND OBJECTIVES OF THE STUDY

Introduction

Beef is the most important meat item in the United States in terms of production, as well as consumption. Aggregate red meat and poultry production for the nation totaled 56,032 million pounds in 1985. Beef accounted for 42.03 percent of total production, while pork and poultry represented 26.27 percent and 30.18 percent, respectively [U.S.D.A. Livestock and Poultry, March, 1986]. Cash receipts for all the nation's livestock products were forecast to total 69-71 billion dollars in 1985 [U.S.D.A. Agricultural Outlook, March, 1986]. The marketing of cattle and calves provided 28.74 billion dollars, while pork sales accounted for 9.01 billion dollars [U.S.D.A. Meat Animals, April, 1986]. Poultry and egg receipts were forecast to total 10-12 billion dollars during the same period [U.S.D.A. Agricultural Outlook, January-February, 1986]. Despite recent downward trends in the production and associated cash receipts from cattle and calves, it is evident that beef's importance in American agriculture will continue.

Most American consumers continue to show a preference for beef over all other meat products in terms of per capita consumption. In 1985 the average diet consisted of 79.1 pounds of beef, 62.0 pounds of pork and 58.0 pounds of broiler meat on a retail weight basis [U.S.D.A. Livestock and Poultry, May, 1986]. In recent years, beef consumption has declined relative to broiler consumption. The primary

causes of this decline have been the focus of several analyses. Some researchers maintain that consumer preference for beef is declining, while other analysts argue that economic reasons such as relatively higher beef prices and reduced consumer purchasing power have led to the decline in beef consumption [Taylor, p. 25]. Although the downward trend in recent years has caused much concern in the beef industry, it is apparent that the flavor and eating satisfaction of beef remain important criteria in the selection of the American diet.

In terms of monetary value, cattle and calves are the most important agricultural product in Tennessee. Cash receipts for all of the state's farm products totaled 1,985 million dollars in 1984. Cattle and calves accounted for 24.0 percent of total receipts, the largest segment for a single commodity. Dairy products, tobacco, and soybeans accounted for 13.6 percent, 12.7 percent and 12.2 percent of the aggregate, respectively [Tennessee Agricultural Statistics, p. 82].

The majority of Tennessee's beef operations are engaged in the commercial cow-calf segment of the beef industry. Tennessee ranks 10th among the states in the number of beef cows on farms with 1,050 thousand head in 1984 [Tennessee Agricultural Statistics, p. 55] and 1,040 thousand head in 1986 [Beefweek, 14 March, 1986, p. 44]. The inventory of cattle and calves in Tennessee has trended upward since the 1920's at an average of 19 percent each decade [McManus and Cunningham, p. 39].

The primary product of the commercial cow-calf operator is a six to ten month old calf which weighs 450 to 600 pounds. An important

marketing segment of the beef industry is the link between the cow-calf producer and the stocker or feedlot operator. Stocker operations involve growing light calves to the desired weight (usually 600 to 900 pounds) for the feedlot or finishing segment of the industry. The feedlot operation consists of intensive feeding of concentrates (grains) to produce slaughter animals weighing 900 to 1,200 pounds. Thus, an efficient industry would be one in which cow-calf operators produce the type of feeder calf that will perform efficiently and profitably in the stocker and feedlot operations. This type of feeder animal would be an efficient converter of feed to lean meat and would possess the desirable carcass characteristics demanded by consumers.

Today's beef industry faces a challenging future as a result of economic pressures encountered by producers as well as consumers. The January 1, 1986, inventory of cattle and calves on farms in the United States was 105.5 million head. This inventory had declined 4 percent during the previous year and represented the smallest national herd since 1963. Beef cattle producers have been liquidating their herds due to low net returns, as well as falling land values, in order to lessen cash flow and debt problems [U.S.D.A. Livestock and Poultry, March, 1986].

The higher relative prices of beef compared with its primary substitutes, pork and poultry, impacts strongly on consumer demand. Many beef products, such as steaks and roasts, are less competitive on a price basis with substitutes because of their higher cost per serving. Some analysts suggest that declines in the percentage of

consumers' disposable income spent for beef, from 2.6 percent in 1965 to 1.6 percent in 1985, is an indication of reduced demand for beef [BEEF, February, 1986, p. 76]. However, if real incomes of consumers increase, the percent of disposable income spent for beef could decline without reducing consumer demand for beef.

The beef industry faces the challenge of addressing those consumer interests which have an impact on the demand for beef. These interests include the price and quality of the retail product as well as diet and health concerns. In order for beef to maintain its importance among the nation's agricultural products, the industry must recognize and adapt to changes in consumer demand.

Statement of the Problem

The modern beef industry can be divided into five interlocking segments: commercial cow-calf producers, stocker operators, feedlot operators, packers, and retailers. The demands and expectations for beef are established by consumers in the retail sector of the industry. Those consumer demands are transmitted through the industry beginning with the retailer and concluding with the commercial cow-calf producer. According to economic theory, the animal or product flow through the industry is determined in response to initial consumer demand and associated derived demands for the product. The product flow which is initiated by the feeder calf producer, culminates with the purchase of retail cuts by the consumer.

One primary question that concerns each segment of the beef industry is, "What type of animal is most profitable?" Economic

theory suggests that there should be some optimal point in the feeding process of beef cattle at which net returns are maximized. The net returns may be maximized either to an individual animal or to the feedlot space which the animal occupies [McLemore and Butts, 1982]. In order to maximize net returns to the animal or to the feedlot space, it is necessary for the feedlot manager to identify the optimal feeding point of the animal and to attempt to sell the animal at that optimum [Harrison; McLemore and Butts, 1979].

McLemore and Butts [1982, p. 1] state that the optimal feeding point of a given animal is . . . "dependent upon the characteristics and physiological development of the animal, as well as costs of inputs and price structure for the product." The feeder animal characteristics which may be important in identifying that optimal point include sex, breed, relative frame size and muscle thickness as well as measures of weight, height, and external fat when the animal enters the feedlot.

The physiological development of the feeder calf is primarily dependent upon the animal's genetics and diet. The animal's relative average daily gain, efficiency of feed conversion, and accumulation of internal and subcutaneous fat are major determinants in the optimal length of the feeding process.

The purchase cost of the feeder animal and feed cost account for approximately 57 percent and 28 percent, respectively, of total cost of the feeding process [U.S.D.A. Livestock and Poultry, October, 1985]. Once the feeder animal is purchased, feed cost comprises the largest single percentage of variable costs associated with the

feedlot operation, and thus it is expected to have the greatest impact on the optimal length of feeding.

The primary product of the feedlot operation is a 500 to 900 pound beef carcass. In order to maximize net returns from the feeding operation, the feedlot manager will find it desirable to feed the type of beef animal that will gain weight efficiently and that will produce the most valuable carcass characteristics which are demanded by packers and by consumers at the retail level. Those carcasses which provide the retail cuts demanded by consumers will sell at a premium over less desirable carcasses. Thus, either increases or decreases in consumer demand, as well as changes in consumer preference for beef, will affect the price structure of the product. These changes in price structure in turn affect the optimal length of the feeding process.

The individual feeding and management of feeder cattle to optimal points is probably impractical. In fact, the convention of feedlot managers is to manage, feed, and market animals by pen. In order to maximize net returns, animals should be penned in fairly uniform groups which reach their optimal points simultaneously. The set of standards used by feedlot managers for purchasing and penning feeder cattle may substantially influence the net returns of the feedlot operation [McLemore and Butts, 1982].

Anderson found that the most important feeder cattle characteristics which influenced feedlot managers' purchasing decisions were sex, weight, frame size, and degree of finish or subcutaneous fat. This study hypothesizes that these characteristics can be used as

purchasing guidelines and to predict the optimal length and profitability of the feeding process, the derived value¹ of the feeder animal, and the development of carcass traits demanded by consumers. If feeder cattle characteristics can successfully predict these significant economic factors, the efficiency of the marketing link between the commercial cow-calf producer and the stocker or feedlot operator will be increased. The feedlot manager will desire to feed those animals possessing the characteristics which will yield profitability which, in turn, will be affected by costs of gain and consumer demand for carcass traits. The commercial cow-calf producers can then adjust their operations to produce feeder calves with those characteristics desired by the stocker and feedlot operations. The result of such an improvement in this marketing link within the beef industry should be increased net returns which are shared within the industry.

Review of Literature

Since the advent of computer technology, the analytic technique of simulation has become increasingly important to researchers.

Shannon [p. 2] defines simulation as:

. . . the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system.

¹Derived value of the feeder animal is equal to the carcass value minus the cost of gain during the feeding process.

Simulation provides the opportunity to examine the behavior of complicated interactive systems in an experimental environment. A realistic simulation model is useful . . . "for testing hypotheses, decision rules, and alternate systems of operation under a variety of assumed conditions" [Meir et al., p. 21]. Since their inception, simulation models have been used extensively in the fields of business, economics, and the social sciences [Meir et al.; Norlen].

Different segments of the beef industry have been analyzed with the aid of simulation models. The Texas A and M University Beef Cattle Simulation (TAMU) Model has been widely used to study variations in production of beef cow herds. The biological description of the model was detailed by Sanders and Cartwright as well as Cartwright and Doren. Stokes et al. used the TAMU model to examine the impact of varying beef cattle genotype and management systems on economic returns to the cow-calf producer. Applications of the model have included incorporating risk analysis in forage-beef production systems, examining alternative management and production systems in foreign countries, and studying the economic significance of different stocker cattle production alternatives [Sullivan and Capella].

Maximizing net revenue of the feeding process of beef cattle has been the focus of two similar studies which used simulation techniques. Harrison developed a model which represented the purchase, growth, feeding, and marketing of 150 crossbred steers. His model was designed to select the optimal selling point of individual animals by calculating average net returns per day and choosing the maximum as the optimal point. Harrison reported that the most important factors

in maximizing net revenue (excluding costs and prices) were the steer's efficiency of feed conversion and ability to produce the desired quality and yield grades.

McLemore and Butts [1979] developed a simulation model to examine the impact of price changes on optimal feeding periods of feeder steers. Their findings suggest that optimal lengths of the feeding process vary greatly under differing price alternatives. A similar model was also used to investigate the effect of alternative feeder cattle penning or allotment systems on net revenue from feeding [McLemore and Butts, 1982]. In this latter study, the allotment systems examined provided no substantial gains in net revenue compared with slaughtering the animals by pen at the mean subcutaneous fat thickness of 12 millimeters (mm). The range of the data restricted this study due to the fact that the 350 animals simulated had been slaughtered on an individual basis at approximately 12mm backfat thickness.

The logistic or growth curve has been an important tool in simulating the growth of an individual beef animal. The logistic curve represents a time sequence of measures of body size, usually body weight, across the lifetime of the individual animal [Fitzhugh]. This nonlinear curve is generally sigmoid in shape and contains a point of inflection. This inflection point represents where the estimated growth rate changes from increasing at an increasing rate in the early portion of life to increasing at a decreasing rate as the animal nears maturity [Brown et al.].

Nair states that the logistic curve is probably the most used mathematical curve in examinations of individual animal and plant growth. A variation of the logistic curve, the Gompertz curve, was used to represent the growth process of feeder animals in a simulation model analyzing the maximization of returns to the feedlot space an animal occupies [Nelson and Purcell, 1973]. The importance of the logistic and similar curves in describing size-age relationships has led to a considerable amount of research concerning the estimation and techniques for altering the shape of growth curves [Fitzhugh; Oliver; Brown et al.].

The economic theory which applies to maximizing net returns to the feeding process is well developed for cases in which net returns are maximized to an individual animal or to the feedlot space which the animal occupies. The operator who maximizes returns to individual animals feeds one group of cattle and plans not to replace the finished animals with another group. According to theory, the feedlot manager who desires to maximize net revenue to an individual animal should continue feeding until the marginal net revenue of the feeding process is zero [McLemore and Butts, 1979]. General economic theory explains that when the marginal net revenue of a production process equals zero, the corresponding total net revenue of the process is maximum [Hirshleifer, p. 47].

The maximization of returns to the feedlot space which an animal occupies is also referred to as maximizing returns to time or as the feedlot replacement decision. The pioneering work in replacement decision-making was done by Faris in 1960. He noted that the

replacement problem was characterized by a relatively short production period in which the revenue from the enterprise is generated solely from the sale of the asset. Faris concluded that feedlot operators who plan to promptly replace each lot of cattle finished with a new lot, should attempt to maximize their average net returns over time. Thus to maximize returns to time, the feedlot operator should feed the current group of cattle to the point where marginal net revenue per unit of time for the current group is equal to the maximum average net revenue anticipated from the replacement group [Faris; Dillon, pp. 71-76; Nelson and Purcell, 1973].

Nelson and Purcell [1972] developed a simulation model based on the Gompertz curve along with cost and revenue data to examine the feedlot replacement decision. This model was later used to compare live weight, carcass weight, and yield of lean meat as criteria for replacement decision-making [Nelson and Purcell, 1973]. McLemore and Butts [1979; 1982] examined the replacement decision by means of two similar simulation models. Their studies focused on the impact of price changes on optimal feeding lengths and the effect of alternative penning systems on net returns from feeding.

The feeder cattle grading system has been an important tool for assessing the expected performance of feedlot cattle. In 1979, the U.S.D.A. implemented a new feeder cattle grading system based upon the criteria of frame size and muscling. To reflect differences in frame size, cattle are graded as either Large Frame, Medium Frame, or Small Frame. The variation in degree of muscling (thickness) is described in terms of No. 1, No. 2, or No. 3 muscle scores [U.S.D.A. Federal

Register]. This new system replaced a system which was based on carcass quality terms such as Prime, Choice, and Good. The change was judged desirable in order to improve the relationship between feeder grades and desirable carcass characteristics.

Although the change in grading standards was deemed appropriate by U.S.D.A., the efficiency of the new system has been questioned. The thickness of a feeder animal was identified by the U.S.D.A. as muscle thickness, and this muscle score was proposed to be an indicator of the animal's potential carcass yield grade [U.S.D.A. Federal Register]. An alternative characteristic proposed for inclusion in the grade system was the animal's subcutaneous fat thickness or degree of finish [Anderson; U.S.D.A. Federal Register]. In a 1980 survey of feedlot managers, Anderson found that feeders placed more importance on degree of finish than on muscle thickness when making purchasing decisions. The lack of an indicator of the animal's feed conversion efficiency in the new grading standards has contributed to the questions concerning the effectiveness of the system [Anderson].

Under the old grading system, the Choice grade was established as the "base" grade since it was the grade with the largest volume of marketings and the most often reported price. For the same reasons, Medium Frame - No. 1 Muscle has evolved as the "base" grade for the new system [Trapp]. Trapp concluded that the new "base" group was less homogeneous in terms of equality of market price than the old "base" group, and the resulting prices under the new system would likely have less informational and functional value when compared to the old grading system. Despite the objections to the new feeder

grading system, it remains an important criterion in evaluating feeder cattle as to expected feedlot performance.

Feeder cattle characteristics include both subjective and objective measures. The primary subjective measures are frame size, muscle thickness and finish or subcutaneous fat thickness. Important objective characteristics are sex, breed, weight, height, and finish (by means of a subcutaneous fat probe or ultrasonic measurement). However, there is a dearth of information concerning the ability of subjective and objective measures to predict economically important feedlot and carcass characteristics, primarily subcutaneous fat thickness, yield grade and quality grade. Subjective and objective measures of live animal fat thickness have both been found to accurately reflect differences in actual carcass fat thickness. In general the accuracy of either measure decreases as fat thickness increases [Daley et al.]. Lee et al. found that Charolais steers produced a carcass with significantly less fat thickness and lower yield grades than Hereford steers slaughtered at similar endpoints. Breed effects have been found to significantly influence carcass quality grades, and muscle thickness was found to be unrelated to either quality or yield grades [Butts et al., I; II].

Taste appeal and tenderness of beef have been the primary evaluation criteria of consumers for many years, but today's health-conscious consumers demand leanness. Leanness, along with marbling, is an indication of quality in the minds of today's consumers. Thus, higher quality is denoted by low levels of trimmable fat

[Kester]. The increased consumer demand for lean beef has only recently received widespread attention, but in 1983, Daley et al. [p. 1] warned;

The urgency of improving overall efficiency of beef production, coupled with increased consumer demand for lean beef, necessitates selection and production of beef cattle with minimal levels of trimmable fat.

These new beef demand signals from consumers have brought adjustments in the packer and retailer segments of the beef industry. Safeway, the nation's largest food retailer, along with Excel, Monfort of Colorado, Inc., and Iowa Beef Packers, the country's leading beef packers, have led the campaign in marketing leaner, trimmed beef [Cornett; Fitzgerald, 24 April, 1986; Knop]. Some analysts predict that within a year the entire retail beef sector will be marketing either 1/2 or 1/4 inch trimmed beef [Cornett].

As packers adjust to the new consumer preference for lean beef, they will desire to buy cattle that emphasize cutability or low levels of fat. In response to the increased demand for lean beef, several packers have announced their intentions of paying a premium for cattle with less fat [Fitzgerald, 27 March, 1986; 17 April, 1986]. This new price structure should serve as an incentive for the commercial cow-calf operator to produce a leaner beef animal.

The beef industry in the United States has experienced many unstable and uncertain conditions. Beef producers of the 1970's and the 1980's have encountered volatile market prices, production cost-price squeezes, consumer diet-health issues, and increasing competition from other meat products. The industry has recognized that

today's consumers demand more than the eating satisfaction and flavor of beef. In order to maintain its importance in American agriculture, the beef industry must efficiently produce and feed those animals which yield carcass characteristics demanded by today's consumer.

Objectives of the Study

The general objective of this study was to analyze the effect of feeder calf characteristics on the optimal length of the feeding process, profitability of the feeding process, derived value of the feeder animal, and on economically important feedlot and carcass characteristics. The beef industry is a complex network of interlocking segments characterized by a series of marketing links which connect adjacent segments. The results of this analysis should provide a framework for identifying those animals which yield maximum net returns as well as carcass traits demanded by consumers. Such an identification should improve the marketing links between cow-calf producers, stockers, feeders, and packers resulting in increased net returns to the industry. Specific objectives were:

1. to develop a bioeconomic simulation model to identify points in the feeding process for beef cattle at which net returns are maximized.
2. to evaluate the ability of feeder calf characteristics to predict the optimal length and profitability of the feeding process, derived value of the feeder animal, and important feedlot and carcass traits at the optimal feeding points.

3. to evaluate the effects of changes in feed costs and carcass prices on optimal feeding points as well as the effect of the emerging preference for leaner beef on those optimal points.

The simulation model is developed and described in Chapter 2.

The third chapter describes and analyzes the results of the study; and the final chapter presents a summary of the results as well as the conclusions and implications drawn from them.

CHAPTER 2

METHODOLOGY

Concepts of the Simulation Model

The bioeconomic simulation model developed for this study consists of a sequence of mathematical equations which represent animals individually during the feedlot finishing process. The set of equations describes the purchase, feeding, growth, and selling process for individual animals in the analysis. Coefficients for growth, in terms of weight, fat thickness, feed consumption, yield grade, marbling score, and salable carcass weight were developed separately by regression analysis and used as input data for the simulation model.

The simulation model allows the optimization of selling dates for individual animals by calculating the maximum net returns to an individual animal or to the feedlot space which the animal occupies. Net returns to the animal or feedlot space are calculated every five days on feed, and the optimum selling point is selected by identifying the point of maximum net returns.² This optimum selling point is dependent upon physical and economic factors which include . . . "the characteristics and physiological development of the animal, as well as costs of inputs and price structure for the product." [McLemore and Butts, 1982, p. 1].

²The individual animals in the study were simulated at five-day increments from 100 to 340 days on feed. This range was chosen to limit the expense of computer analysis.

This study analyzed the maximization of net revenue to the individual animal as well as to the feedlot space which the animal occupies. The feedlot operator who intends to maximize net revenue to an individual animal should continue feeding until the marginal net revenue of an additional day of feeding is zero [McLemore and Butts, 1979]. Figure 1 illustrates the optimum number of days on feed at which net revenue is maximized to an individual animal. The optimum selling point (A) corresponds to the point in time where marginal net revenue (MNR) is zero and total net revenue (TNR) is maximum for the feeding process.

It is important to note that the smooth revenue curves presented in Figure 1 are not representative of individual animals' revenue curves. Purcell points out that the smooth revenue functions are characteristic of animals which will not be sold until they grade Choice. Thus, the Choice price is the only price used in calculating total revenue, resulting in the smooth curves. As a result of a discontinuous pricing structure for the product, individual animals are represented by broken, segmented revenue curves. However, the optimum selling point can still be identified as the point in time where marginal net revenue of an additional day's feeding for the individual animal is zero and total net revenue is maximized. When maximizing net revenue to an individual animal, the simulation model was designed to select the point of maximum total net revenue as the optimum slaughter point.

The feedlot operator who plans to promptly replace each lot of cattle finished with a new lot should attempt to maximize returns to

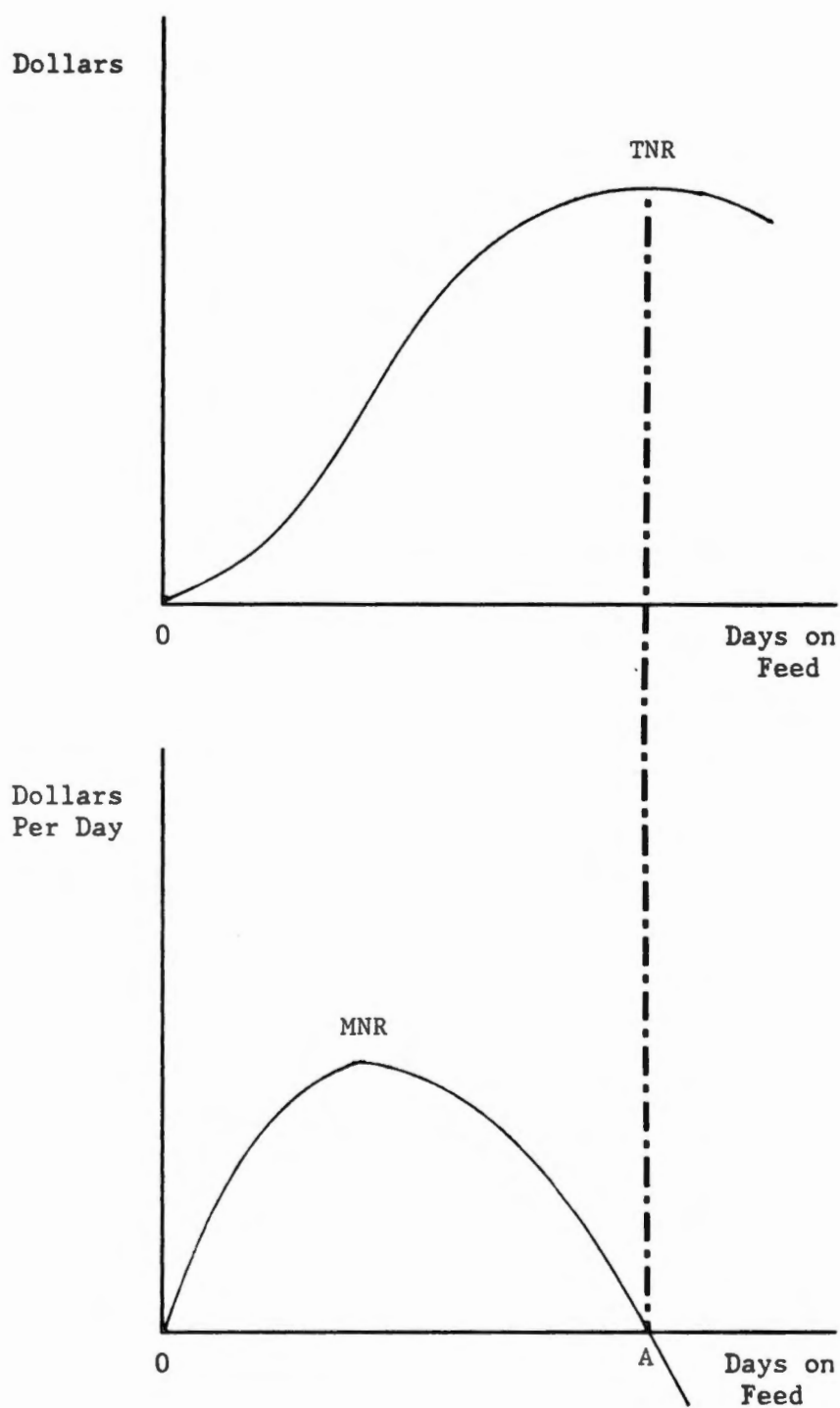


Figure 1. Net Revenue Functions for a Cattle Feeding Operation which Maximizes Net Revenue to the Animal.

the feedlot facility by maximizing the cattle's average net returns over time. Thus, to maximize returns to the feedlot, the feedlot operator should feed the current group of cattle to the point in time where marginal net revenue per unit of time for the current group is equal to the maximum average net revenue anticipated from the replacement group [Faris; Dillon, pp. 71-76; Nelson and Purcell, 1973].

Figure 2 illustrates the framework for determining the optimum replacement date where net revenue to the feedlot facility is maximized. The optimum replacement date or length of feeding (R) corresponds to the point where the marginal net revenue per day (MNR) of the current lot of cattle is equal to the maximum of the average net revenue per day (ANR) of the replacement lot. The logic of the replacement decision was summarized by Purcell [p. 322]:

For the continuous feeding operation, there is an opportunity cost of feeding the current set. That opportunity cost is the profits the replacement set of cattle would be making if those cattle were on feed. There is a point at which continued feeding of the current set, even though profits per head are still increasing, will contribute less to the total profit stream over time than will the replacement set of cattle.

When maximizing net returns to the feedlot space which an animal occupies, individual animals' returns to that space are represented by net revenue per day. Thus, an animal's returns to the feedlot space at the optimum length of feeding are represented by the individual's associated total net revenue at the optimum divided by the number of days on feed at that optimum.

The revenue curves depicted in Figure 2 are representative of groups of cattle. Since this study was designed to analyze individual

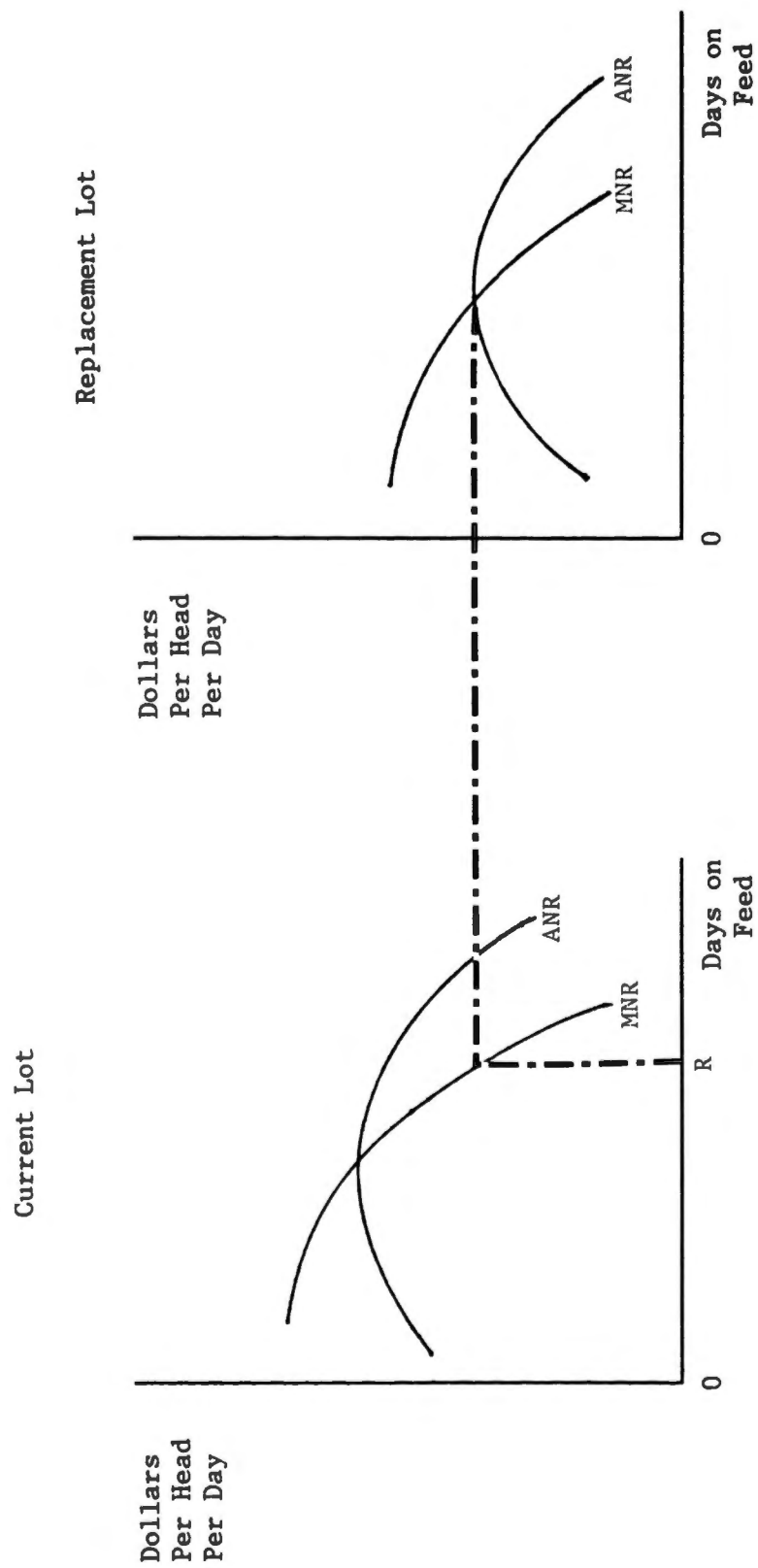


Figure 2. Net Revenue Functions for a Cattle Feeding Operation which Maximizes Net Revenue to the Feedlot Space.

animals, the optimum feeding length for an animal was represented by the point where MNR for the animal was equal to the maximum ANR for the average replacement animal. The discontinuous pricing structure for beef carcasses generates revenue curves for individual animals which are segmented instead of smooth. As a result of these segmented curves, it was found that some individual animal's MNR was equal to the maximum ANR for the average replacement animal at more than one point in the feeding process. This necessitated a means to determine which point represented the optimum net returns to the feedlot space which the animal occupies.

The optimum length of feeding was determined based on the concept of opportunity cost or total net revenue foregone. For example, the total net revenue foregone of an animal currently in the feedlot at t number of days on feed is represented by the maximum ANR for the average replacement animal multiplied by t . The total net revenue foregone or opportunity cost represents that total net revenue from feeding which would be realized if the average replacement animal was in the feedlot instead of the current animal. The optimum length of feeding where net returns to the feedlot facility are maximized is depicted as the point where the difference between total net revenue associated with the current animal and total net revenue foregone is maximum. In this study, the optimum length of feeding was represented by the maximum of the expression

$$TNR_c - (ANR_r)(DOF_c)$$

where

TNR_c = total net revenue of the current animal in
the feedlot

ANR_r = maximum expected average net revenue of the average
replacement animal

DOF_c = number of days on feed for the current animal.

The maximum of this expression depicts the point where the difference between the total net revenue from the current animal (TNR_c) and the anticipated total net revenue from the replacement animal, (ANR_r) (DOF_c), is greatest. This maximum is representative of the point in the feeding process where the difference between the total net revenue from the current animal and the total net revenue foregone is greatest.

The simulation model was designed to locate optimal points in the feeding process and predict economically important characteristics of an individual animal. These characteristics included the length and profitability of the feeding process, derived value of the feeder animal, and economically important feedlot and carcass characteristics. The general objective of this study was to analyze the effect of feeder calf characteristics on the economically important characteristics of individual animals at their optimum feeding points. The study was designed to analyze the effect of feeder calf characteristics on optimal days on feed, live weight, subcutaneous fat thickness, carcass yield grade and marbling score, feed cost, net returns to the animal or head space, and the derived value of the feeder animal. The effect of individual feeder calf characteristics on the economically important animal characteristics at optimum endpoints will be examined

by regressing each economically important characteristic on selected feeder calf characteristics. Throughout the remainder of this analysis, the economically important animal characteristics will be referred to as important feedlot and carcass characteristics. The feeder calf characteristics utilized in this study represent observable or measurable characteristics. However, it should be noted that due to cross-breeding the breed of an individual feeder animal is often difficult to determine by mere observation, but breed was included in this analysis since the breed of the animals in this study was easily distinguished.

Of particular interest is the analysis of effects of feeder calf characteristics on the derived value of the feeder animal. Derived value of the feeder animal is equal to the carcass value minus the cost of gain during the feeding process. This value can also be determined by adding the net revenue associated with an individual animal at any point during the feeding process to the purchase cost of the animal. In order to obtain a value per hundredweight (cwt.) of the feeder animals in the study, the derived value at optimum points was divided by the initial weight of the feeder animal. This initial weight represented the weight of the animal when it entered the feeding process. By regressing the derived value of the feeder animals on feeder calf characteristics, the relationship between value per hundredweight of initial weight and the feeder calf characteristics can be examined.

Sources of Biological Data³

Biological data for the development of the bioeconomic simulation model were gathered from three separate experiments. Two of the studies were similar in experimental procedure in terms of feeding and management of the feeder animals involved. The initial study of these two analogous studies was conducted from September, 1975 through August, 1977 and entailed the feeding and individual slaughter of 350 steers at an estimated constant subcutaneous fat thickness of 12mm. The second study involved the feeding of 630 steers from September, 1977 through August, 1980. The individual animals in this experiment were serially slaughtered at assigned dates ranging from 62 to 293 days on feed. This serial slaughter resulted in a wide range in maturity and carcass quality of the animals.

The experimental animals in the similar studies consisted of Angus, Hereford, Angus-Hereford-cross, and Charolais-cross calves. The majority of the Charolais-cross calves were sired by Charolais bulls and out of mostly Angus and Hereford dams, but a few higher percentage Charolais calves were represented in the study. Feeder steers were purchased annually in late September and early October from Tennessee Graded Feeder Calf sales and auction markets and represented early and late maturing types.

³Data for this study were collected from 1970 through 1980 from experiments conducted at the University of Tennessee Blount Farm, Knoxville, Tennessee.

After arrival at the University of Tennessee Blount Farm, objective measures of feeder calf characteristics were obtained. The objective measures included purchase weight, wither height, body length and depth, as well as an estimate of subcutaneous fat thickness. Ultrasonic fat estimates throughout each study were made over the twelfth rib of the animal by the same operator with a Branson Model 12 Sonoray.

After the subjective measures were obtained, the steers were wormed, treated for grubs, and penned in groups of six or seven for an approximately 30-day stabilization period. During this stabilization period, in which the calves recovered from shipping stress, the steers received a diet of corn silage fed ad libitum and limited grain.

Subjective measures of feeder calf characteristics were made at the end of the stabilization period by a live animal evaluator with approximately 30 year's experience. The subjective scores reflected individual animal differences in frame size, fat thickness, and muscle expression. Subcutaneous fat estimates were expressed as millimeters, with 1mm representing the minimum level. Frame and muscle measures were expressed on a scale of 1 to 15, with greater exhibition of a trait receiving a higher score.

Frame scores represented estimates of structural dimension associated with expected slaughter weights. A low (high) score indicated a relative structural dimension associated with an expected smaller (larger) slaughter weight. For example, frame scores of 4, 5, and 6 were representative of relative structural sizes associated with anticipated slaughter weights of 890 to 1,000 pounds. Scores of 7, 8,

and 9 denoted structural sizes representative of slaughter weights between 1,000 and 1,100 pounds [Butts et al., II].

Muscle scores reflected the individual animal's natural thickness and body shape. Butts et al. [II, p. 1307] note that the factors which influenced subjective muscle scores included . . . "thickness and shape of the quarter, 'expression' down the top, prominence of muscle in the stifle and forearm, and width of walk." Animals which were characterized as flat-quartered and narrow-fronted received low scores while thick-quartered, wide-fronted calves received high scores [Butts et al., II].

The feeder animals were assigned to diet treatments representing high and medium levels of energy, with approximately half of the animals finished on each diet. The high level or constant energy (concentrate) diet was fed ad libitum and was composed of: 59 percent shelled corn, 20 percent cottonseed hulls, 10 percent cottonseed meal, 5 percent molasses, 3 percent dehydrated alfalfa meal, 2 percent animal fat, 0.5 percent ground limestone, and 0.5 percent salt. The medium level or variable energy (silage-concentrate) diet consisted of corn silage, offered ad libitum, and a concentrate mixture composed of 86 percent corn and 14 percent cottonseed meal. The rate at which the concentrate mixture was fed varied during the feeding process. Initially the mixture was fed at a daily rate of 1.25 percent of body weight (pen mean) and increased to 1.40 and 1.55 percent when the animals reached a pen average of 8 and 10mm of subcutaneous fat, respectively. The concentrate and silage-concentrate diets were fed twice daily, and the concentrate was fed on top of the silage for the

medium energy diet. Animals receiving the silage-concentrate diet were also offered a free choice mixture of salt and dicalcium phosphate [Butts et al., 1].

Animals in both studies were weighed and subcutaneous fat thickness was estimated (ultrasonic measurement) at 28-day intervals for the initial two months of the experiments and at 14-day intervals thereafter. The animals in the initial study were randomly assigned to feeding groups of six steers each. Individual animals were slaughtered when their estimated subcutaneous fat thickness reached 12mm. Second-order polynomials were fitted to initial and biweekly fat thickness estimates of individual steers to predict the number of days on feed necessary to attain the 12mm slaughter point [Butts et al., 1].

Animals in the serial slaughter data set were assigned to feeding groups of 7 or 8 animals of similar maturity. Animals within breed were ranked from earliest to latest maturing by predicting the number of days needed to reach 12mm of fat, with animals needing fewer days to reach 12mm being earlier maturing [Young]. Once grouped by maturity, the steers were randomly assigned to serial slaughter groups with slaughter dates ranging from 62 to 293 days on feed. One animal from each maturity group was assigned to each slaughter group resulting in a range in carcass quality that coincided with the range in maturity [Young].

Hot carcass weights were taken immediately after slaughter for animals in both data sets. Additional carcass data were collected after a 48-hour chilling period. The chilled carcass data included

measures of external fat thickness, rib eye area, marbling, and kidney-pelvic-heart fat. In addition, carcass yield grades were estimated for animals in the serial slaughter data sets.

A third data set was utilized exclusively to estimate the consumption equation included in the simulation model. This experiment was conducted over a five-year period, from 1970 through 1974, and consisted of 113 Angus cow-calf pairs. Cows were selected from Tennessee Agricultural Experiment Station herds and exhibited variation in cow size as well as maternal ability [Bryson].

Cows were bred to calve in March, April, and May and the cow-calf pairs were fed in individual pens until weaning. After weaning, calves were individually fed a growing ration containing approximately 67 percent total digestible nutrients (TDN) ad libitum until slaughter. During the feeding process, biweekly measures of weight, subcutaneous fat, and feed consumption were obtained on the feeder animals. Biweekly feed consumption was converted to TDN (in kilograms) by nutrient composition values of feeds published by the National Research Council [Bryson]. This conversion resulted in individual calves' feed consumption being represented by biweekly as well as cumulative measures of TDN.

Development of the Bioeconomic Simulation Model

Individual Weight and Fat Equations

Equations depicting changes in weight and fat thickness of individual animals during the simulated feeding period were obtained from nonlinear regressions of biweekly weight observations or

ultrasonic estimates of subcutaneous fat on days on feed. Animals in the constant 12mm fat thickness and the serial slaughter data sets were utilized to develop the individual weight and fat equations. However, two criteria were established in order to determine the particular animals to be simulated. Individual animals were required to be fed a minimum of 100 days and to obtain a minimum subcutaneous fat thickness of 10 millimeters. These criteria were necessary to provide a sufficient number of biweekly weight and fat observations to estimate the nonlinear regressions. Each animal in the constant 12mm fat thickness data set met the established criteria, while 434 animals in the serial slaughter set satisfied the requirements resulting in a total of 784 animals to be simulated.

The logistic equation. The logistic curve was chosen to represent the changes in weight and fat thickness of the simulated animals. Stoodley et al. described the behavior of the curve in relation to growth. Initially, weight gain is slow. Then weight increases at an increasing rate until it reaches a point of nearly linear growth. The near linear growth is followed by a "slackening off" (weight increases at a decreasing rate), after which weight reaches a maximum.

The logistic equation may be written

$$(1) \quad Y_t = \frac{k}{1 + be^{-at}}$$

where a, b, and k are constants or parameters to be estimated from the observed data (Y_t , t) for $t = 1, 2, \dots, T$ and t is a time scale beginning at zero. This equation contains upper and lower asymptotes,

is sigmoid in shape, and has a point of inflection located midway between the two asymptotes [Nair].

There are many variations of the basic logistic model described by Nair and these were discussed and compared by Brown et al. and by Fitzhugh. Some of the more commonly utilized variations include the Brody, Gompertz and Richards curves, and the Von Bertalanffy equation.

The version of the logistic equation utilized in this study was described by Kmenta and is of the form

$$(2) \quad Y_t = \frac{\beta_1}{1 + e^{\frac{\beta_2 + \beta_3 t}{\beta_1}}}$$

where β_1 , β_2 , and β_3 are parameters to be estimated from the observed data (Y_t , t) for $t = 1, 2, \dots, T$ and $e = 2.71828$. The population regression line from this version of the logistic equation is represented by the logistic "growth" curve as shown in Figure 3. The estimated values of Y_t are confined to the values between 0 and β_1 (the lower and upper asymptotes) of equation 2. The regression line in Figure 3 represents an individual animal's weight gain and subcutaneous fat deposition from birth. Therefore, at birth (0 days on feed) the lower asymptote for weight and fat thickness has a positive value. In Figure 3, the lower asymptote, inflection point, and upper asymptote of the logistic curve are represented by A, B, and C, respectively.

Jeske examined the influence of the values of β_2 and β_3 on the shape of the logistic curve. By manipulating the values for β_2 and β_3 for selected logistic equations, he found that β_2 primarily influenced

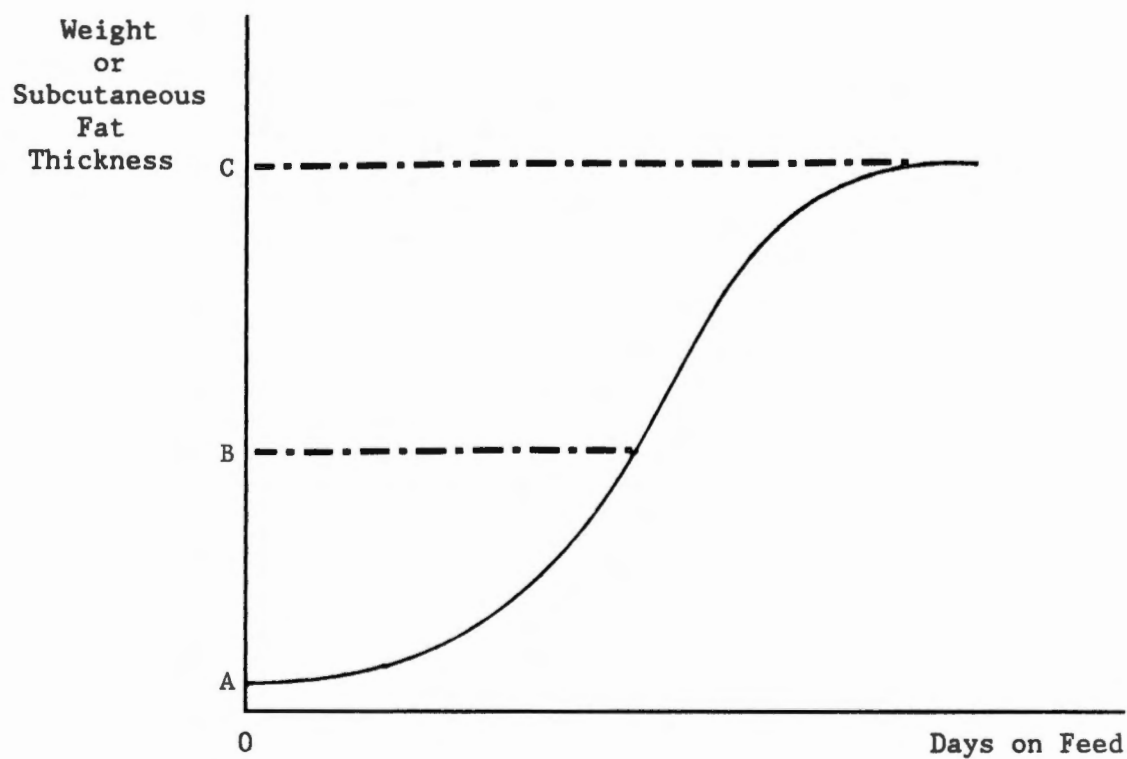


Figure 3. Representative Shape of the Logistic Curve (where A, B, and C Represent the Lower Asymptote, Inflection Point, and Upper Asymptote, Respectively).

the lateral displacement of the curve with respect to observed data points, while β_3 primarily influenced the slope of the curve. Larger values of β_2 shifted the curve to the right without affecting the slope, while larger values of β_3 resulted in greater slope.

The 784 individual animal weight and fat equations were estimated by utilizing the nonlinear least squares iterative procedure available in the Stastical Analysis System [SAS Institute Inc., pp. 576-606]. The nonlinear procedure generates the least squares estimates for the parameters by examining the residual or error sum of squares (ESS) at successive iterations (i). The procedure is considered to have converged and the best estimates of the parameters are given if:

$$(ESS_i - ESS_{i-1}) (ESS_i + 10^{-6}) < 10^{-8}.$$

Individual weight equations. The logistic equation was utilized to estimate individual weight equations for the 784 animals in the study. The individual nonlinear regressions of biweekly weight observations on days on feed were of the form

$$WT_t = \frac{\beta_1}{1 + e^{\beta_2 + \beta_3 DOF_t}}$$

where

WT_t = biweekly weight (lbs.) at t

DOF_t = number of days on feed at t

t = 1, 14, 28, . . . T

β_1 , β_2 , and β_3 = parameters to be estimated (β_1 represents the upper asymptote)

e = 2.71828

The estimates of the parameters from the logistic equations enabled the prediction of individual animal's live weight at any number of days on feed. The prediction of the animal's live weight was the initial equation in the simulation model and was of the form

$$(4) \quad \hat{WT} = \frac{\hat{\beta}_1}{1 + e^{\hat{\beta}_2 + \hat{\beta}_3 \text{DOF}}}$$

where

$\hat{WT}$ = predicted live weight (lbs.)

DOF = days on feed

$\hat{\beta}_1$, $\hat{\beta}_2$ and $\hat{\beta}_3$ = estimated coefficients from individual nonlinear regressions (equation 3)

$e = 2.71828 \dots$

Examination of plots of predicted live weight against days on feed, between 0 and 400 days, for individual animals revealed that the estimated regression line was primarily representative of the portion of the logistics curve between the inflection point and the upper asymptote. This portion of the curve is characteristic of animals in feedlot situations where weight is increasing at a decreasing rate as the animal matures.

Plots of actual and predicted live weights against days on feed for the individual animals revealed that the nonlinear equations were accurate representations of the animals' actual weight change during the feeding process. Pindyck and Rubinfeld [p. 265] note, "The statistical tests used to evaluate the fit of a linear regression equation are not directly applicable to a nonlinear regression."

However, they also report that the conventional sense of an R^2 value can be utilized to examine the proportion of the variation in the dependent variable explained by the nonlinear regression. Thus as a measure of degree of fit for the individual nonlinear regressions, the proportion of the variation in live weight explained by the regressions was represented by

$$1 - \frac{\sum (WT - \hat{WT})^2}{\sum (WT - \overline{WT})^2}.$$

The proportion of explained variation of the individual regressions was calculated for a random sample of 50 animals in the study and was equal to 0.999 or more in each case.

Individual fat equations. The logistic equation was also used to estimate individual subcutaneous fat thickness levels for the simulated animals. Jeske estimated fat thickness for 66 steers by means of the logistic equation. His findings suggested that it was desirable to fix β_1 at a constant value of 50 which forced all the curves to become asymptotic at 50mm of fat. Thus, the rate and number of days on feed at which the maximum of 50mm occurred was determined by the estimates obtained for β_2 and β_3 .

Following Jeske, the individual nonlinear regressions of biweekly ultrasonic fat thickness estimates on days on feed were of the form

$$(5) \quad FT_t = \frac{50}{1 + e^{\beta_2 + \beta_3 DOF_t}}$$

where

FT_t = biweekly ultrasonic estimate of subcutaneous fat thickness (mm) at t

DOF_t = number of days on feed at t

$t = 1, 14, 28, \dots T$

50 = upper asymptote in mm (β_1 of the logistic equation)

β_2 and β_3 = parameters to be estimated

$e = 2.71828 \dots$

As with the weight equations, the estimates of the parameters from the nonlinear fat equations enabled the prediction of an animal's subcutaneous fat thickness at any number of days on feed. The equation predicting individual fat thickness levels was of the form

$$(6) \quad \hat{FT} = \frac{50}{1 + e^{\hat{\beta}_2 + \hat{\beta}_3 DOF}}$$

where

$\hat{FT}$ = predicted subcutaneous fat thickness (mm)

DOF = days on feed

50 = upper asymptote in mm

$\hat{\beta}_2$ and $\hat{\beta}_3$ = estimated coefficients from individual nonlinear fat regressions (equation 5)

$e = 2.71828 \dots$

Plots of predicted fat thickness against days on feed for individual animals showed that the estimated regression line was characteristic of the portion of the growth curve between the lower

asymptote and the inflection point. This is representative of the deposition of subcutaneous fat since most animals deposit fat at an increasing rate throughout the feeding process.

Examination of plots of actual and predicted fat thickness against days on feed revealed that the nonlinear fat equations were accurate representations of the actual changes in individual animal's subcutaneous fat thickness levels. As a measure of goodness of fit, the proportion of the variation in fat thickness explained by the individual regressions was represented by

$$1 - \frac{\sum (FT - \hat{FT})^2}{\sum (FT - \overline{FT})^2}.$$

The proportion of explained variation of the individual fat thickness regressions was calculated for a random sample of 50 animals and ranged in value from 0.914 to 0.997.

Carcass Grade Equations

Beef carcass value per pound is highly dependent upon marbling score and yield grade [Butts et al., I; McLemore and Butts, 1982]. The current U.S.D.A. beef carcass grading system requires that all carcasses be graded on both a quality and yield basis [U.S.D.A., 1975]. U.S.D.A. yield grades of 1, 2, 3, 4, or 5 represent the yield of boneless, closely trimmed, retail cuts from the round, loin, rib, and chuck of the carcass, with the grade of 1 depicting the highest yield. Carcass quality grades are Prime, Choice, Good, Standard, Commercial, Utility, Cutter, and Canner. These quality grades are expected to represent consumer palatability characteristics of

tenderness, juiciness, and flavor, with Prime relating to the highest degree of palatability [Taylor, pp. 340-341; U.S.D.A., 1975].

The two most important factors used to determine quality grades are bone maturity and marbling. Maturity classifications are principally determined by bone ossification and are based on the concept that tenderness of the meat decreases as an animal's age increases. Maturity groups and their corresponding approximate ages in months (mo.) are represented by A (9 - 30 mo.), B (30 - 48 mo.), C (48 - 72 mo.), D (72 - 96 mo.), and E (over 96 mo.). Carcasses having A maturity are graded as either Prime, Choice, Good, or Standard. Finished feeder steer and heifer carcasses almost exclusively receive one of these four quality grades since they are generally slaughtered at less than 30 months of age. Within maturity classifications, marbling receives primary consideration when determining quality grades [Tatum et al.; Taylor, p. 340; U.S.D.A., 1975]. Marbling or intramuscular fat refers to the small flecks of fat located within muscle groups.

Equations to estimate marbling score and yield grade were developed from the serial slaughter data set. These 630 animals were serially slaughtered at intervals from Standard to Prime quality grade resulting in a wide variation in carcass characteristics. The animals in the constant 12mm fat thickness data set were not utilized to develop the carcass grade equations because of the narrow range of carcass characteristics resulting from slaughter at a constant fatness endpoint.

Marbling Score Equations. Marbling scores are generally reported to the nearest tenth and are determined by the degree of intramuscular fat found within muscle groups. The nine degrees of marbling used to quality grade beef carcasses are abundant, moderately abundant, slightly abundant, moderate, modest, small, slight, traces, and practically devoid. Abundant refers to the highest degree of fat flecks located within the muscle while practically devoid refers to the lowest degree [Taylor, pp. 341-342; U.S.D.A., 1975]. The conversion of marbling scores to quality grades for A maturity carcasses is summarized in Table 1.

Bidner et al. found that grain-fed steers had significantly higher marbling scores than forage-fed steers when slaughtered at a similar weight. Following McLemore and Butts [1982], carcass data were used to fit equations to estimate marbling score separately for the concentrate and the silage-concentrate diets.

Subcutaneous fat thickness and time on feed have been identified as important factors in determining marbling scores [Jeremiah et al.; Kaufman et al.; Zinn et al.]. Thus, subcutaneous fat thickness and days on feed were chosen as appropriate variables for predicting marbling scores of the simulated animals. The functional form utilized to estimate the marbling score equations was a nonlinear regression of marbling score on fat thickness and days on feed in a natural exponential form. McLemore and Butts [1982, p. 5] validated the applicability of this functional form and reported that use of this form resulted in . . . "marbling score asymptotically approaching a limit, determined by fat thickness, as days on feed increased."

Table 1. Conversion of Marbling Score to Quality Grade for A Maturity Carcasses.

Marbling Score	Degree of Marbling	Quality Grade
2.0 - 3.9	Practically Devoid Traces	Standard
4.0 - 4.9	Slight	Good
5.0 - 7.9	Small Modest Moderate	Choice
8.0 and above	Slightly Abundant Moderately Abundant Abundant	Prime

The nonlinear regression of marbling score on subcutaneous fat and days on feed gave the following relationships:

(7) Concentrate Diet:

$$MS = 6.45639 + 0.03047FT - 4.56038e^{-0.00714DOF}$$

$$(0.90348) \quad (0.01478) \quad (0.74424) \quad (0.00419)$$

$$N = 289$$

(8) Silage-Concentrate Diet:

$$MS = 13.43711 + 0.11007FT - 11.11982e^{-0.00081DOF}$$

$$(53.54451) \quad (0.01620) \quad (52.98941) \quad (0.00494)$$

$$N = 284$$

where

MS = marbling score

FT = subcutaneous fat thickness (mm) at slaughter

DOF = days on feed.

The difference in the number of animals in the serial slaughter data set (630) and the number of animal observations used in estimating the marbling score equations (573) was due to the fact that several animals were withdrawn from the experiment because of sickness or injury.

McLemore and Butts [1982, p. 18] note that since the regressions to estimate marbling score were intrinsically nonlinear in form ... "the standard errors listed are asymptotic standard errors and are not strictly interpretable as in a linear model." Thus, as an indication of degree of fit, the variation in marbling score explained by the nonlinear regressions was determined by

$$1 - \frac{\sum (MS - \hat{MS})^2}{\sum (MS - \overline{MS})^2}$$

and was equal to 0.958 for the concentrate equation and 0.963 for the silage-concentrate equation. Examination of actual versus predicted marbling scores indicated that the marbling score equations provided accurate estimates of actual scores. During the simulation process, an individual animal's marbling score for a given diet was expressed by the relationships shown in equation 7 or 8 where the animal's subcutaneous fat thickness at slaughter was estimated by equation 6.

Yield grade equation. Yield grades (also called cutability) are determined by the following four carcass characteristics:

1. subcutaneous fat thickness measured over the ribeye muscle.
2. amount of kidney, pelvic, and heart fat (KHP fat--usually expressed as a percentage of carcass weight).
3. area of ribeye muscle, measured in square inches.
4. hot carcass weight, which is expected to reflect the amount of intermuscular fat. In general, the amount of intermuscular fat increases as carcass weight increases [Taylor, p. 342; U.S.D.A., 1975].

However, previous research has shown subcutaneous fat thickness to be the primary factor in determining yield grades [Abraham et al.; Crouse and Dikeman; Taylor, p. 342].

The equation to predict U.S.D.A. yield grade was developed from the serial slaughter data set. The simple linear form was used to regress yield grade on subcutaneous backfat thickness. This

relationship was chosen since fat thickness is the principal determinant of yield grade. Also, the other carcass characteristics which determine yield grade were not available from the individual animal data used to represent the 784 animals simulated.

The simple linear regression of yield grade on subcutaneous fat thickness resulted in the following relationship:

$$(9) \quad YG = 1.20875 + 0.13735FT$$

$$(0.03205) \quad (0.00262)$$

$$N = 559 \quad R^2 = 0.831$$

where

YG = carcass yield grade

FT = subcutaneous fat thickness (mm) at slaughter.

Actual carcass yield grades were only available for 559 of the 630 animals in the serial slaughter data set.

The estimated yield grade equation indicates that carcass yield grade increases as subcutaneous fat thickness increases. Thus, as an animal's subcutaneous fat thickness increases the yield of boneless, closely trimmed, retail cuts from the round, loin, rib, and chuck of the carcass decreases. Examination of actual versus predicted yield grades indicated that the yield grade equation provided accurate estimates of actual carcass yield. Yield grades for individual animals in the simulation were represented by the relationship shown in equation 9 where the animal's subcutaneous fat thickness at slaughter was estimated by equation 6.

Hot Carcass Weight Equation

Nour et al. noted that hot carcass weight or dressing percentage at a given live weight was a primary factor determining live cattle price. However, in this simulation process the price received for the fed animal was expressed in terms of price per hundredweight of the finished carcass. Thus, the value of the finished animal was determined on a carcass weight basis. This necessitated use of a method for determining carcass weight for slaughter animals over a wide range of degrees of finish.

Hot-carcass weights were estimated by Harrison for small- and large-type steers with 75 animals in each group. He estimated a continuous linear carcass weight function by regressing hot carcass weights on final live weights. Raikes et al. found that hot carcass weight was significantly affected by housing treatment, marketing arrangement treatment, rate of gain, quality grade, yield grade, and final feedlot weight. Their study was conducted over a three-year period on 1,282 steers with final feedlot weights ranging from 770 to 1,445 pounds.

The equation to predict hot carcass weight was also developed from the serial slaughter data set. The multiple linear functional form was used to regress hot carcass weight on subcutaneous fat thickness and slaughter weight. Animals in the serial slaughter set were housed in the same manner and alternative marketing arrangements were not considered. The findings by Raikes et al. indicate that carcass yield and quality grades significantly affect hot carcass weight. Thus in addition to slaughter weight, fat thickness was

chosen as an explanatory variable in this study since it is a primary factor in determining carcass yield and quality grades. Slaughter weights were available only for those animals in the serial slaughter data which were purchased in the fall of 1977. These 196 animals were slaughtered at dates varying from 77 to 257 days on feed.

The multiple linear regression of hot carcass weight on subcutaneous fat thickness and slaughter weight gave the following relationship:

$$(10) \quad HCWT = -59.65809 + 1.69284SFT + 0.64115SWT$$

$$(10.22825) \quad (0.40256) \quad (0.01155)$$

$$N = 196 \quad R^2 = 0.945$$

where

HCWT = hot carcass weight (lbs.)

SFT = subcutaneous fat thickness (mm) at slaughter

SWT = live weight (lbs.) at slaughter.

This relationship indicates that individual animal's hot carcass weight increases as subcutaneous fat thickness and live weight at slaughter increase.

The hot carcass weight equation was estimated based on actual slaughter weights. However during the simulation process, individual animals were represented by live weight (WT) from equation 4. This necessitated the adjusting of predicted hot carcass weight to account for shrinkage between final live weight and slaughter weight, as well as shrinkage associated with chilling the carcass. To obtain salable carcass weight, a 4 percent shrink was deducted from predicted hot

carcass weight. Thus for the animals in the simulation, salable carcass weight was determined by the following relationship:

$$(11) \quad \hat{SCWT} = 0.96(-59.65809 + 1.69284\hat{FT} + 0.64115\hat{WT})$$

where

$\hat{SCWT}$ = predicted salable carcass weight (lbs.)

$\hat{FT}$ = predicted subcutaneous fat thickness (mm) at
slaughter (from equation 6)

$\hat{WT}$ = predicted live weight (lbs.) at slaughter (from
equation 4).

Consumption Equation

Estimation of animal consumption or feed requirements was necessary in order to estimate daily feed costs for the simulated animals. The third data set, consisting of 113 individually fed Angus steers and heifers, was utilized to develop the consumption equation. In a study of individually fed Angus, Charolais, and reciprocal cross cows, Anderson et al. reported that Angus cows had lower TDN requirements than the other breeds. However, they also note that the greatest difference in TDN requirements was between Angus and Charolais cows, but this difference was only 23.7 kilograms for a 90 day feeding period. Relevant data to develop the consumption equation for this study were only available from Angus steers and heifers. The results were applied to animals in the study of differing breeds and cross-breds. Based on the findings of Anderson et al., it was assumed there were no significant differences in intake between breeds.

Biweekly measures of weight, fat, and individual feed consumption were obtained from each of the 113 feeder animals. Biweekly feed consumption was converted to a TDN basis from nutrient composition values of the feed components in the animals' diet. Successive biweekly measures of TDN were summed to provide a cumulative measure of TDN (in kilograms) throughout the feeding process. For the analysis of this study, the cumulative measures of TDN representing consumption were converted to pounds.

Daily estimates of TDN consumption were obtained for the 113 animals by regressing cumulative TDN on days on feed in simple linear form. The individual linear regressions of cumulative TDN on days on feed were of the form

$$(12) \quad \text{CTDN}_t = \alpha + \beta_1 \text{DOF}_t$$

where

CTDN_t = cumulative TDN (lbs.) at time t

DOF_t = days on feed at t

$t = 1, 14, 28, \dots T.$

The R^2 's for the 113 equations ranged from 0.981 to 0.999 which indicates that cumulative TDN is a continuous linear function of days on feed. The goodness of fit of the linear functions implies that individual daily TDN (lbs.) is represented by the slope of the function or the estimated value of β_1 for each individual animal. Stated differently, daily TDN is represented by the derivative of predicted cumulative TDN with respect to days on feed and is of the form

$$(13) \quad \hat{CTDN}_t = \alpha + \hat{\beta}_1 DOF_t, \text{ and}$$

$$\frac{\partial \hat{CTDN}_t}{\partial DOF_t} = \hat{\beta}_1$$

where

$\hat{CTDN}_t$ = predicted cumulative TDN (lbs.) from equation 12

DOF_t = days on feed at t

$\hat{\beta}_1$ = predicted daily TDN (lbs.) from equation 12.

$t = 1, 14, 28, \dots T.$

These findings suggest that consumption, in terms of daily TDN, is constant for individual animals throughout the feeding process. These estimates of daily TDN were utilized to develop a consumption equation which could be applied to the 784 simulated animals individually.

Lofgreen and Garrett found that net energy requirements for maintenance and for production of weight gain increased with individual animal weight for steers and heifers. Their findings support the general assumption that maintenance requirements are dependent on the weight of the animal, and thus, consumption is related to weight.

The proportion of fat in the beef carcass varies indirectly with muscle, and the energy level of an animal's diet affects the relative amount of fat deposition. Thus, animals fed high-energy diets will deposit fat faster than animals on lower energy diets [Taylor, pp. 362-363]. Berg and Butterfield [p. 42] note, "A high plane of nutrition, such as ad libitum feeding of a high quality ration, would result in surplus energy going to fat deposition" Young noted that fat thickness or condition is an indicator of maturity. In

Young's study, animals were ranked from earliest to latest maturing by predicting the number of days needed to reach 12mm of fat with animals requiring fewer days to reach 12mm being earlier maturing. These findings support the general assumption that earlier maturing animals (those which deposit fat faster) require more energy in terms of TDN per day than do later maturing animals.

Based on the findings that energy or intake is related to level of maturity and weight, the equation to predict consumption in terms of daily TDN was developed by regressing daily TDN on the number of days required to reach 12mm of fat and the animal's live weight at 12mm. The choice of explanatory variables necessitated the estimation of individual weight and fat equations by means of the logistic curve for the 113 animals in the third data set. The number of days to 12mm was estimated by converting the individual fat equations (equation 6) to the form which expressed days on feed as a function of fat thickness. The converted equation was of the form

$$(14) \quad \hat{DOF} = \frac{\text{LN}(50(\hat{FT})^{-1}) - 1 - \hat{\beta}_2}{\hat{\beta}_3}$$

where

$\hat{DOF}$ = predicted days on feed

$\hat{FT}$ = predicted subcutaneous fat thickness (mm, from equation 6)

$\hat{\beta}_2$ and $\hat{\beta}_3$ = estimated coefficients from individual nonlinear fat regressions (equation 6)

50 = upper asymptote in mm.

The equation to estimate days on feed to 12mm fat is obtained by inserting the value of 12 for the predicted fat thickness (FT) in equation 14. This equation in reduced form is expressed by

$$(15) \quad \hat{DOF}_{12} = \frac{1.15268 - \hat{\beta}_2}{\hat{\beta}_3}$$

where

$\hat{DOF}_{12}$ = predicted days on feed to 12mm fat
 $\hat{\beta}_2$ and $\hat{\beta}_3$ = estimated coefficients from individual animal
 nonlinear fat regressions (equation 6).

Individual animal's weight at 12mm of fat was estimated by inserting the predicted number of days to 12mm fat for a given animal for the variable days on feed (DOF) in the individual weight equations (equation 4). This equation is of the form

$$(16) \quad \hat{WT}_{12} = \frac{\hat{\beta}_1}{1 + e^{\hat{\beta}_2 + \hat{\beta}_3 \hat{DOF}_{12}}}$$

where

$\hat{WT}_{12}$ = predicted live weight (lbs.) at 12mm fat
 thickness

$\hat{DOF}_{12}$ = predicted days on feed to 12mm fat (from
 equation 15)

$\hat{\beta}_1$, $\hat{\beta}_2$ and $\hat{\beta}_3$ = estimated coefficients from individual
 animal nonlinear weight regressions
 (equation 4)

$e = 2.71828 \dots$

The multiple linear regression of daily TDN on days to 12mm fat thickness and weight at 12mm gave the following relationship:

$$\begin{aligned}
 (17) \quad DTDN = & 9.65204 - 0.02367\hat{DOF}12 + 0.01100\hat{WT}12 - 0.40982Y_0 + \\
 & (1.04913) (0.00443) \quad (0.00086) \quad (0.24163) \\
 & 0.19689Y_1 + 0.73077Y_2 + 0.20897Y_3 - 0.72680Y_4 \\
 & (0.190390) (0.21090) \quad (0.19429) \quad (0.28604) \\
 & N = 113 \quad R^2 = 0.661
 \end{aligned}$$

where

$DTDN$ = daily TDN consumption (lbs.)

$\hat{DOF}12$ = predicted days on feed to 12mm fat (from equation 15)

$\hat{WT}12$ = predicted weight (lbs.) at 12mm fat (from equation 16)

$Y_0 - Y_4$ = a set of zero-one-minus-one dummy variables representing the years the experiment was conducted, from 1970 to 1974.

The set of dummy variables was included to account for seasonal variations in climate which may have affected animal consumption. A binary variable differentiating sex of the feeder animal (1 = steer and 0 = heifer) was included and the consumption equation was reestimated. The null hypothesis of no relationship between sex and daily TDN consumption could not be rejected ($P > 0.10$) for the above relationship. Thus, the estimated consumption equation could be utilized to estimate daily TDN consumption for the individual steers in the simulation.

In order to apply the estimated consumption equation to the 784 animals in the simulation, the number of days to 12mm fat and weight at 12mm was estimated for each of those animals. The consumption equation was then expressed in the following form:

$$(18) \quad \hat{DTDN} = 9.65204 - 0.02367\hat{DOF12} + 0.01100\hat{WT12}$$

where

$\hat{DTDN}$ = predicted daily TDN consumption (lbs.)

$\hat{DOF12}$ = predicted days on feed to 12mm fat (from
equation 15)

$\hat{WT12}$ = predicted weight (lbs.) at 12mm fat (from
equation 16).

This equation yielded estimates of daily feed intake for each animal in the simulation.⁴

Carcass Grade and Weight Price Differentials

Carcasses were valued based upon weekly average price data for Central U.S. (Omaha) and Los Angeles markets for 1983 and 1984 taken from U.S.D.A.'s Livestock Meat Wool Market News weekly booklets. Price differentials for carcass quality and yield grades and weight were developed based upon these data. The price data represented U.S.D.A. yield grades of 2, 3, and 4 as well as Good and Choice

⁴The set of zero-one-minus-one dummy variables representing yearly variation in climate was omitted from the consumption equation because the animals in the study were simulated for the same time period.

quality grades. Weights were represented in one-hundred pound increments and ranged from 500-599 pound to 800-899 pound carcasses.

Following McLemore and Butts [1982] a multiple regression was estimated to provide an index of carcass values based upon the price of Choice, Yield Grade 3, 600-699 pound (P_{c36}) carcasses. The multiple regression gave the following results:

$$\begin{aligned}
 (19) \quad I_{ijk} = \frac{P_{ijk}}{P_{c36}} = & 97.1058 - 3.2924Q + 3.7421Y_2 + 3.1218Y_3 - \\
 & (0.0615) \quad (0.0992) \quad (0.0636) \quad (0.0526) \\
 & 6.8639Y_4 + 0.0444W_5 + 0.0647W_6 - 0.0605W_7 - \\
 & (0.0730) \quad (0.1011) \quad (0.0602) \quad (0.0713) \\
 & 0.0486W_8 \\
 & (0.0935) \\
 & N = 1691 \quad R^2 = 0.866
 \end{aligned}$$

where

I_{ijk} = index of price for carcasses of i th quality grade, j th yield grade, and k th weight class based upon the price of Choice, Yield Grade 3, 600-699 lb. steer carcasses

P_{ijk} = weekly average price per cwt. for steer carcasses of i th quality grade, j th yield grade, and k th weight class

P_{c36} = weekly average price for Choice, Yield Grade 3, 600-699 lb. steer carcasses

Q = a zero-one dummy variable differentiating Good (1) and Choice (0) quality grades

Y_j = a set of zero-one-minus-one dummy variables

differentiating Yield Grades 2, 3 and 4

W_k = a set of zero-one-minus-one dummy variables

differentiating carcass weight classes from 500-599
to 800-899 lbs.

One variable from each set of zero-one-minus-one dummy variables (Y_j and W_k) was omitted from the price index regression. These omissions were necessary to avoid a singular $X'X$ matrix in which the least squares normal equations are dependent [Kmenta, p. 413]. The coefficient value for the omitted variables was determined by the negative sum of the remaining coefficients of each set of zero-one-minus-one dummy variables.

The coefficients in equation 19 indicate that Good carcasses were discounted 3.29 percent under Choice. Yield Grade 3 carcasses were discounted 0.62 percent below Yield Grade 2 while Yield Grade 4 carcasses were discounted 10.61 percent and 9.98 percent under Yield Grade 2 and Yield Grade 3, respectively. Neither of the carcass weight classifications was significant in explaining differentials in price which indicates that yield and quality grades are the primary factors determining carcass price differences. However, the coefficients for carcass weight classes indicate, for example, that 500-599 pound carcasses are discounted 0.02 percent under 600-699 pound carcasses, and 800-899 pound carcasses are discounted 0.11 percent below 600-699 pound carcasses.

Prices were not available from the U.S.D.A. weekly reports for carcasses with a quality grade of Standard or for carcasses weighing

less than 500 pounds. A telephone survey of three packers provided the necessary information to establish price differentials for Standard and less than 500 pound carcasses. The packers indicated that Standard carcasses were discounted 15.38 percent below Choice. By adjusting for the regression estimate of 3.29 percent discount of Good carcasses below Choice, Standard carcasses were discounted 12.09 percent (15.28 percent minus 3.29 percent) below Good. Also, packers indicated that carcasses weighing 400-499 pounds were discounted 4.5 percent below 600-699 pound carcasses.

In order to value the carcasses during the simulation, a base price for Choice, Yield Grade 3, 600-699 pound carcasses was necessary. The selected base price was the average of Choice, Yield Grade 3, 600-699 pound carcasses during 1983 and 1984 from both the Omaha and Los Angeles markets. This average, base price was found to be \$100.42 per hundredweight of chilled carcass. Prices for 1985 were not utilized to establish the base price since they were deemed unrepresentative of typical market prices. During 1985, prices for Choice, Yield Grade 3, 600-699 pound carcasses reached a minimum weekly average of \$77.12 and \$81.00 per hundredweight for Omaha and Los Angeles markets, respectively [U.S.D.A. Livestock Meat Wool Market News, 1985].

Using the system described above, the average price per hundredweight of a Good, Yield Grade 2, 700-799 pound (G27) carcass is determined in the following manner. The coefficients from the price index regression yield the following results:

$$I_{G27} = 97.1058 - 3.2924 + 3.7421 - 0.0605 = 97.50.$$

Carcass value is equal to the base price for Choice, Yield Grade 3, 600-699 pound carcasses (\$100.42) multiplied by the given price index on a percentage basis. This results in a carcass value per hundred-weight of \$97.91 (\$100.42 x 0.975) for G27 carcasses. The price index is based on a 100 point system, and thus if the number of carcass prices in each yield and quality grade and weight class were equal, the index for Choice, Yield Grade 3, 600-699 pound carcasses would equal 100. However, the number of prices in each grade and class were not equal resulting in an index value of 100.29 for the base carcass. A summary of the price indexes for carcasses representing combinations of quality and yield grades and weight are presented in Table 2.

Feeder Animal and Other Costs

Feeder animal costs. Purchase prices per hundredweight for the 784 animals in the simulation were determined by weight class and by feeder grade (frame size and muscle score). The animals were priced according to classifications by the feeder calf characteristics of initial weight and subjective frame and muscle scores. Purchase weights were represented by the initial biweekly weight measurements obtained at the end of the stabilization period. The weight classes of 400-499 pound, 500-599 pound, and 600-699 pound were represented.⁵

⁵Two steers in the study had initial weights exceeding 699 pound, but they were priced, according to given feeder grades, in the 600-699 lb. weight category.

Table 2. Index of Steer Carcass Prices by Weight, Yield, and Quality Grade, Based on Choice, Yield Grade 3, 600-699 Pound Prices.

Carcass Weight (lbs.)	Standard		Good		Choice	
	YG2	YG3	YG2	YG3	YG2	YG3
400-499	81.03	80.41	93.12	92.50	96.41	95.79
500-599	85.51	84.89	97.60	96.98	100.89	100.27
600-699	85.53	84.91	97.62	97.00	100.91	100.29
700-799	85.41	84.79	97.50	96.88	100.79	100.29
800-899	85.42	84.80	97.51	96.89	100.80	100.18

Feeder grade classifications were based on the subjective scores ranging from 1 to 15 for frame and muscle. Small Frame steers were depicted by subjective scores of 1-6, while Medium and Large Frames were represented by scores of 7-12 and 13-15, respectively. No. 1 Muscle steers were represented by scores of 6-15, while No. 2 and No. 3 muscling related to subjective scores of 3-5 and 1-2, respectively.

The prices for given grade-weight categories were obtained for 1985 from Tennessee Agricultural Statistics. Prices for animals represented by Medium Frame, No. 1 and No. 2 muscling were annual averages from 14 reported auctions within the state. State averages were not reported for Small Frame - No. 1 and - No. 2 Muscle steers. Annual prices from the Memphis auction market were utilized to represent Small Frame animals but, the Memphis prices were adjusted since they were found to be less than the 14-auction average for Medium Frame animals. Small Frame - No. 1 and - No. 2 Memphis prices were adjusted by the amount which 14-auction average prices exceeded Memphis prices for Medium Frame - No. 1 and - No. 2 Muscle steers of given weight classes. Annual state averages were also not available for Large Frame steers and, only a limited number of price observations were available from the Memphis market. Large Frame steers were discounted \$3.24 per hundredweight below Medium Frame steers. This discount was based on the difference between 1984 average prices for Medium Frame - No. 1 and Large Frame - No. 1 steers from nineteen market locations within Virginia [1984 Virginia Feeder Calf Sales Results]. Table 3 contains a summary of purchase prices used in the simulation for given grade-weight categories.

Table 3. Feeder Steer Purchase Prices (\$/cwt.) by Frame Size, Muscle Thickness, and Weight Class.

Weight Class (lbs.)	Small Frame		Medium Frame		Large Frame	
	No. 1 Muscle	No. 2 Muscle	No. 1 Muscle	No. 2 Muscle	No. 1 Muscle	No. 2 Muscle
	(\$/cwt.) - - - - -					
400-499	58.30	49.62	67.14	59.86	63.90	56.62
500-599	52.55	46.48	63.18	56.72	59.94	55.48
600-699	48.70	44.04	59.33	54.28	56.09	51.04

^aPurchase prices for No. 3 muscled steers were not included since none of the 784 animals in the simulation were classified in that grade.

A death loss allowance of 1 percent was added to the individual animal's purchase cost. In addition, a procurement charge of \$5.28 per head was added to represent the expense of transportation (400 miles) to the feedlot [Ray and Walch; U.S.D.A. Livestock and Poultry, October, 1985].

Feed costs. Individual animal feed costs were developed from representative 1985 U.S.D.A. prices for corn-belt cattle feeders. These representative prices included corn at \$2.63 per bushel, silage at \$22.74 per ton, and protein supplement at \$10.81 per 100 pounds [U.S.D.A. Livestock and Poultry, October, 1985]. The feed component costs were converted to a per pound basis resulting in prices of \$0.04696, \$0.01137, and \$0.1081 per pound for corn, silage, and protein supplement, respectively.

Following McLemore and Butts [1982], the cost for the concentrate (high energy) diet was developed on a component basis of 6 parts corn to 1 part cottonseed meal (protein supplement). This was necessary due to the lack of representative prices for the other ingredients in the concentrate diet. The component pricing scheme resulted in a cost of \$0.05570 per pound or \$122.54 per metric ton for the concentrate diet.

The price of the silage-concentrate (medium energy) diet was based on a concentrate mixture of 86 percent corn and 14 percent cottonseed meal (protein supplement). This resulted in a price of \$0.05552 per pound for the concentrate while silage costs were represented by a price of \$0.01137 per pound. The amount of the concentrate mixture fed was varied during the simulation of individual

animals. Initially the mixture was assigned at a daily rate of 1.25 percent of body weight and increased to 1.40 and 1.55 percent when the animal reached 8 and 10mm of subcutaneous fat, respectively.

Miscellaneous costs. Miscellaneous costs were based on 1985 estimates by Ray and Walch for Tennessee and by the U.S.D.A. [U.S.D.A. Livestock and Poultry, October, 1985] for corn-belt cattle feeders. Machinery, mineral, labor, and management costs were expressed on a per head per day basis. The per head per day costs were \$0.0289 for machinery, \$0.00455 for minerals, and \$0.131 for labor and management. A per head charge of \$5.32 was included for veterinary costs.

Interest costs were computed on animal, feed, and other costs at an annual rate of 13.55 percent [U.S.D.A. Livestock and Poultry, October, 1985]. Interest on the purchase cost of the feeder animal was calculated for the total number of days the simulated animal was fed. The interest charge for feed was applied to total feed cost for 1/2 of the total days on feed. One-half of the total cost for machinery, minerals, veterinary services, labor, and management was assessed an interest charge for the total days on feed.

A per head charge was also included for transportation of the finished animal to slaughter (100 miles) and for marketing commission fees. Transportation and marketing expense was represented by a cost of \$5.66 per animal [U.S.D.A. Livestock and Poultry, October, 1985].

Total Revenue, Total Cost, and Net Revenue

Total revenue. The total revenue obtained from an individual animal was determined on a carcass weight basis. The final carcass value or total revenue was represented by the following relationship:

$$(20) \quad TR = (P_{c36}) (I_{ijk}) (\hat{SCWT}) - 5.66$$

where

TR = total revenue (\$)

P_{c36} = predetermined price (per cwt.) for Choice, Yield Grade 3, 600-699 lb. carcasses (\$)

I_{ijk} = index of price for carcasses of ith quality grade, jth yield grade, and kth weight class based upon the price of P_{c36} carcasses (from equation 19)

$\hat{SCWT}$ = predicted salable carcass weight converted to hundredweight (from equation 11)

5.66 = transportation and marketing expense (\$).

Total cost. The total cost of the carcass for individual animals was represented by the sum of costs for feeder animal purchase, feed, machinery, labor, management, veterinary charges, and interest. Feed price, feeder animal cost and other costs per head or per day were determined as described in the previous section.

The estimates of consumption in terms of daily TDN (equation 18) were utilized to predict daily feed cost for the individual animals. For animals on the concentrate diet, daily TDN intake (lbs.) was converted to pounds of actual feed based on nutrient composition of

the feed components in the concentrate diet. Daily feed cost is then represented by pounds of actual feed consumed multiplied by the price per pound of the concentrate diet. Since daily TDN consumption was constant for individual animals, daily feed costs were constant throughout the feeding process for animals receiving the concentrate diet.

For animals on the silage-concentrate diet, the amount of concentrate received was dependent on the subcutaneous fat thickness of the animal. Initially the concentrate was fed at a daily rate of 1.25 percent of body weight and increased to 1.40 and 1.55 percent when the animal reached 8 and 10mm of backfat, respectively. The amount of concentrate fed was calculated depending on the fat thickness and weight of the animal. The pounds of concentrate fed daily were converted to pounds of TDN and subtracted from the daily TDN consumption (lbs.). The remainder of daily TDN was converted to actual pounds of silage consumed, and daily feed cost was represented by the pounds of concentrate fed multiplied by the price per pound for concentrate plus the pounds of silage fed multiplied by the price per pound for silage. Since the amount of concentrate fed varied according to weight and fat thickness, daily feed costs were not constant for animals fed the silage-concentrate diet.

The total cost of feeding is represented by the following relationship:

$$(21) \quad TC = (LBF) (FP) + PC + MC + LMC + VC + IC$$

where

TC = total cost

LBF = pounds of feed converted from predicted daily TDN
consumption (equation 18)

FP = feed price per lb.

PC = purchase cost of the feeder animal

MC = machinery cost

LMC = labor and management cost

VC = veterinary charge

IC = interest charge.

Net revenue. An individual animal's net revenue was represented by the difference between total revenue and total cost. Thus, net returns to an individual animal were given by the following relationship:

$$(22) \quad NR = TR - TC$$

where

NR = net revenue

TR = total revenue

TC = total cost.

For the feedlot replacement decision, individual animal's net returns to the feedlot or space which the animal occupies were represented by:

$$(23) \quad \text{NRPD} = \frac{TR - TC}{\text{DOF}}$$

where

NRPD = net revenue per day

TR = total revenue

TC = total cost

DOF = number of days on feed.

A summary of the bioeconomic simulation model developed for this study is illustrated in Table 4.

Average Net Revenue

Feedlot operators who desire to maximize net revenue to the feedlot space should feed the current group of cattle to the point where marginal net revenue (MNR) for the current group is equal to the maximum average net revenue (ANR) anticipated from the replacement group [Faris; Dillon, pp. 71-76; Nelson and Purcell, 1973]. This study analyzed individual animals, and thus, the optimum length of feeding period for individual animals was represented by the point where the animal's MNR was equal to the maximum ANR anticipated from the average replacement animal. The individual animal analysis necessitated the calculation of ANR for the average replacement animal. The average replacement animal was represented by the average of the 784 animals in the base replacement decision simulation. Average net revenue for the animals in the base simulation was calculated at five-day intervals during the simulation process. The maximum ANR for the average replacement animal was found to be \$-0.32597 at 200 days on feed. The maximum ANR was negative since losses were incurred at all levels of days on feed for the average animal in the base simulation.

Thus, the optimum replacement date for individual animals was determined by the maximum of the expression

Table 4. Summary of the Bioeconomic Simulation Model.

	Relationship	From Equation Number
Liveweight	$WT = f(DOF)$	4
Subcutaneous Fat Thickness	$FT = f(DOF)$	6
Marbling Score ^a	$MS = f(FT, DOF)$	7 or 8
Yield Grade	$YG = f(FT)$	9
Salable Carcass Weight	$SCWT = f(FT, WT) (.96)$	11
Carcas Price, Index	$I = f(Q, YG, SCWT)$	19
Total Revenue	$TR = (P_{c36}) (I) (SCWT) - \5.66	20
Feed Consumption ^b	$DTDN = f(DOF12, WT12)$	18
Total Cost	$TC = (DTDN) (\text{feed price}) +$ feeder animal and other costs ^c	21
Net Revenue	$NR = TR - TC$	22
Net Revenue Per Day	$NRPD = \frac{TR - TC}{DOF}$	23

^aMarbling scores (MS) are converted to quality grades (Q) according to Table 1.

^bFeed consumption is predicted in terms of daily TDN (DTDN).

^cTo determine feed cost, daily TDN is converted to pounds of actual feed according to nutrient composition values of feeds published by the National Research Council [1982].

$$(24) \text{ TNR}_t - (-0.32597) (\text{DOF}_t)$$

where

TNR_t = total net revenue associated with an individual
animal at t days on feed

DOF_t = number of days on feed

$t = 100, 105 \dots 340.$

The total net revenue foregone or opportunity cost is represented by $(-0.32597) (\text{DOF}_t)$, and this portion of the expression provides an estimate of the total net revenue from feeding which would be generated if the average replacement animal was in the feedlot instead of the current animal. The maximum of the above expression depicts the optimum length of feeding period where the difference between total net revenue associated with the current animal (TNR_t) and total net revenue foregone is maximum.

Derived Value of the Feeder Animal

The derived value of the individual feeder animals in the simulation was determined by the following relationship:

$$(25) \text{ DV} = \text{NR} + \text{PC}$$

where

DV = derived value of the feeder animal

NR = net revenue

PC = purchase cost of the feeder animal.

This derived value represents the animal's carcass value minus the cost of gain during the feeding process. In order to value each

animal in relative terms, the animal's derived value was expressed in terms of value per hundredweight of initial weight:

$$(26) \quad \text{DVIWT} = \frac{\text{DV}}{\text{IWT}} \times 100$$

where

DVIWT = derived value per cwt. of initial weight

DV = derived value of feeder animal (from equation 25)

IWT = initial feeder weight (lbs.).

These relative, derived values were utilized to value selected feeder calf characteristics which will be discussed in Chapter 3.

Adjustments to the Model

One of the specific objectives of this study was to evaluate the effects of changes in feed costs and carcass prices on optimal feeding points as well as the impact of the emerging preference for leaner beef on those optimal points. Also, these adjustments provided a means to examine the validity of the model under differing cost-price scenarios.

Feed cost. Since feed cost comprises the largest single percentage of variable costs associated with the feedlot operation, it was expected to strongly influence optimal feeding points. To assess the impact of feed costs on optimal points, additional simulations were conducted with an increase in feed costs of 20 percent as well as a decrease of 20 percent while other costs and prices remained the same. The increase of 20 percent resulted in a price of \$0.06684 per pound

for the concentrate diet while the silage-concentrate diet was priced at \$0.01364 per pound for silage and \$0.06663 per pound for the concentrate mixture. Prices for the 20 percent decrease in feed cost were \$0.04456 per pound for the concentrate diet and \$0.00910 and \$0.04442 per pound for silage and concentrate, respectively for the medium energy diet.

It was expected that results from the increased feed cost simulation would include lower net revenue per head as well as fewer days on feed at optimal points when compared to the initial simulation. Likewise, a decrease in feed costs was expected to be associated with increased net revenue per head and additional days on feed at the optimum.

Carcass price. Since the individual animals in the simulation were valued on a carcass weight basis, optimal feeding points are dependent on carcass price per hundredweight. Separate simulations were conducted to examine the effect on optimal points of a 20 percent increase and a 20 percent decrease in carcass prices (feed and other costs were held at their initial values).

During the simulation, individual carcass value, for given weight yield and quality grades, was based on the price of Choice, Yield Grade 3, 600-699 pound carcasses by means of the price index. Thus, the adjustment of carcass prices necessitated adjusting only the value of the base carcass to account for increases and decreases in all carcass prices. The increase of 20 percent resulted in a price of \$120.51 per hundredweight for Choice, Yield Grade 3, 600-699 pound

carcasses while the 20 percent decrease was represented by a price of \$80.34 per hundredweight for base carcasses.

It was anticipated that increased carcass prices would be associated with increased net revenue per head and an increased number of days on feed at optimal points when compared to initial simulation results. Similarly, a decrease in carcass prices was expected to be related to decreased net revenue per head and a decrease in number of days on feed at the optimum.

Consumer preference for lean beef. Today's health-conscious consumers are demanding retail cuts of beef with low levels of trimmable fat. In response to the increased demand for leaner, trimmed beef, several packers, including Monfort of Colorado, Inc., have announced their intentions of paying a premium for cattle with less fat [Fitzgerald, 27 March, 1986; 17 April, 1986]. Fitzgerald [24 April, 1986] states that the key to producing cattle with less fat is genetics, but it will take time for cow-calf producers to adjust their breeding programs to produce a leaner beef animal. However, if the majority of packers adopt the practice of paying a premium for cattle with less fat, the price structure for beef carcasses will be adjusted.

To examine the impact of emerging consumer preference for less fat an additional simulation was conducted on an adjusted price index for carcasses of given weight, yield and quality grades. This new carcass price structure was based on the concept of selling beef cuts with 1/4 inch of cover fat. If animals can be produced which yield carcasses with a subcutaneous fat thickness of 1/4 inch or less, those

carcasses should be priced at a premium over carcasses of similar weight and quality which have greater levels of subcutaneous fat.

Since carcass fat thickness levels are indicated by yield grades, the yield grade associated with a 1/4 inch fat thickness was calculated. From equation 9, the Yield Grade of 2.08 was calculated for carcasses with 1/4 inch (6.35mm) of subcutaneous fat. The price index system was adjusted so that the highest prices would be received for carcasses with yield grades of 2.1 or less while carcasses with higher yield grades would be discounted. The highest price index values in the original price index system was for Choice, Yield Grade 2 carcasses. These original highest values were used to represent Choice carcasses of Yield Grade 2.1 or less in the new carcass pricing system.

The discounts and premiums for carcass weight and quality grades were maintained from the original price index. However, Yield Grade 2.11-2.99 carcasses were discounted 3 percent below Yield Grade 2.1 carcasses and Yield Grade 3 and 4 carcasses were discounted 6 and 15.98 percent, respectively, below Yield Grade 2.1. These discounts were based on informed assumptions which were drawn from personal contact with University of Tennessee Food Technologists. Table 5 provides a summary of price indexes for carcasses representing the combinations of quality and yield grade and weight for the 1/4 inch fat cover pricing system.

Table 5. Index of Steer Carcass Prices by Weight, Yield, and Quality Grade, Based on Choice, Yield Grade 3, 600-699 Pound Prices for 1/4" Trim Beef Price Structure.

Carcass Weight (lbs.)	Standard			Good			Choice			
	YG0-2.1	YG2.11-2.99	YG3	YG0-2.1	YG2.11-2.99	YG3	YG0-2.1	YG2.11-2.99	YG3	YG4
400-499	81.03	78.03	75.03	93.12	90.12	87.12	96.41	93.41	90.41	80.43
500-599	85.51	82.51	79.51	97.60	94.60	91.60	100.89	97.89	94.89	84.91
600-699	85.53	82.53	79.53	97.62	94.62	91.62	100.91	97.91	94.91	84.93
700-799	85.41	82.41	79.41	97.50	94.50	91.50	100.79	97.79	94.79	84.81
800-899	85.42	82.42	79.42	97.51	94.51	91.51	100.80	97.80	94.80	84.82

CHAPTER 3

RESULTS AND ANALYSIS

Important Feedlot and Carcass Characteristics

The primary objective of this study was to analyze the effect of feeder calf characteristics on important feedlot and carcass characteristics which included the optimal length and profitability of the feeding process and the derived value of the feeder animal. These important characteristics were represented by an individual animal's number of days on feed, final live weight, final subcutaneous fat thickness, carcass yield grade and marbling score, net revenue or net revenue per day of the feeding process, feed cost and derived feeder animal value per hundredweight of initial weight. An individual animal's important feedlot and carcass characteristics were determined by the simulation model and correspond to the optimal point at which net revenue to the animal or to the feedlot space is maximized.

Maximizing Net Revenue to the Animal

The means, standard deviations, minimum and maximum values of the important feedlot and carcass characteristics when maximizing net revenue to the individual animal are summarized in Table 6. Values are included for each cost-price condition examined in the simulation procedures described earlier.

Base prices and costs. The base simulation routine (Base Prices and Costs) indicated that the 784 animals reached their optimal point at an average of 175.63 days on feed with an average final live weight

Table 6. Means, Standard Deviations, Minimum and Maximum Values of Important Feedlot and Carcass Characteristics When Maximizing Net Revenue to the Animal.

Characteristic	Mean	Standard Deviation	Minimum Value	Maximum Value
<u>Base Prices and Costs</u>				
Days on Feed	175.63	51.33	100.00	340.00
Final Live Weight (lbs.)	929.15	128.60	684.57	1775.46
Final Fat Thickness (mm)	10.27	3.92	3.07	25.59
Yield Grade	2.62	0.54	1.63	4.72
Marbling Score	5.11	0.61	4.00	7.11
Net Revenue (\$)	-41.98	44.68	-181.36	112.26
Feed Cost (\$)	183.20	56.74	75.51	488.75
Derived Feeder Value (\$/cwt.)	50.12	6.62	20.04	72.44
<u>High Carcass Price</u>				
Days on Feed	202.91	57.58	100.00	340.00
Final Live Weight (lbs.)	978.16	142.22	684.57	1800.03
Final Fat Thickness (mm)	11.99	4.24	3.37	27.16
Yield Grade	2.86	0.58	1.67	4.94
Marbling Score	5.45	0.63	4.01	7.18
Net Revenue (\$)	68.21	52.32	-111.44	237.88
Feed Cost (\$)	212.72	63.63	75.51	496.04
Derived Feeder Value (\$/cwt.)	69.97	8.98	31.61	104.41
<u>Low Carcass Price</u>				
Days on Feed	135.85	32.81	100.00	340.00
Final Live Weight	850.91	101.37	684.57	1775.46
Final Fat Thickness (mm)	8.03	3.08	2.29	25.59
Yield Grade	2.31	0.42	1.52	4.72
Marbling Score	4.60	0.53	4.00	7.04
Net Revenue (\$)	-142.06	39.85	-257.01	-21.57
Feed Cost	140.52	38.64	75.51	488.75
Derived Feeder Value (\$/cwt.)	32.09	4.92	8.46	49.97
<u>High Feed Cost</u>				
Days on Feed	147.76	39.66	100.00	340.00
Final Live Weight (lbs.)	875.13	108.97	684.57	1775.46
Final Fat Thickness (mm)	8.69	3.38	2.50	25.59
Yield Grade	2.40	0.46	1.55	4.72
Marbling Score	4.76	0.58	4.00	7.04
Net Revenue (\$)	-76.64	43.97	-215.26	68.45
Feed Cost (\$)	183.94	54.06	90.62	586.50
Derived Feeder Value (\$/cwt.)	43.83	6.16	14.42	64.75

Table 6 (Continued)

Characteristic	Mean	Standard Deviation	Minimum Value	Maximum Value
<u>Low Feed Cost</u>				
Days on Feed	201.04	57.09	100.00	340.00
Final Live Weight	974.90	141.50	684.57	1803.00
Final Fat Thickness	11.88	4.20	3.37	25.59
Yield Grade	2.84	0.58	1.67	4.72
Marbling Score	5.42	0.63	4.01	7.18
Net Revenue (\$)	-1.06	46.63	-147.46	156.06
Feed Cost (\$)	168.59	50.70	60.41	396.83
Derived Feeder Value (\$/cwt.)	57.53	7.52	25.65	86.14
<u>1/4" Trim Pricing</u>				
Days on Feed	158.10	42.30	100.00	340.00
Final Live Weight (lbs.)	894.67	111.57	684.57	1775.46
Final Fat Thickness (mm)	9.20	3.40	3.07	25.59
Yield Grade	2.47	0.47	1.63	4.72
Marbling Score	4.89	0.58	4.00	7.04
Net Revenue (\$)	-56.14	42.11	-203.28	76.36
Feed Cost (\$)	164.40	47.49	75.51	488.75
Derived Feeder Value (\$/cwt.)	47.56	6.24	16.41	71.27

and fat thickness of 929.15 lbs. and 10.27mm, respectively. Mean values for carcass characteristics were 2.62 for yield grade and 5.11 for marbling score. These results indicate that the premium prices associated with Yield Grade 2 and Choice (marbling score of 5.0 and above) carcasses were primary influences on the point at which individual animals reached their optimum. Additional mean values for the base prices and costs condition were negative \$41.98 for net revenue, \$183.20 for feed cost, and \$50.12 per hundredweight for feeder animal value. These findings indicate that the average feeder animal generated a negative return to the feeding process when maximizing net revenue to the animal under the base prices and costs condition developed for this study.

High carcass price. McLemore and Butts [1979] noted that an increase in carcass price increased the optimal slaughter age of animals when maximizing net revenue to the animal because of a positive shift in marginal net revenue. The theoretical effect of increasing carcass price is illustrated in Figure 4. An increase in carcass price results in a positive shift in the total net revenue and marginal net revenue curves from TNR to TNR' and MNR to MNR', respectively. Since the optimum feeding point when maximizing net revenue to the animal is determined where MNR equals zero, the increase in carcass price extends the optimum number of days on feed from A to B.

The simulation results for a 20 percent increase in carcass price (High Carcass Price) indicated that the mean optimum number of days on feed increased by approximately 27 days over the base prices and costs condition. The increase in optimum number of days on feed was

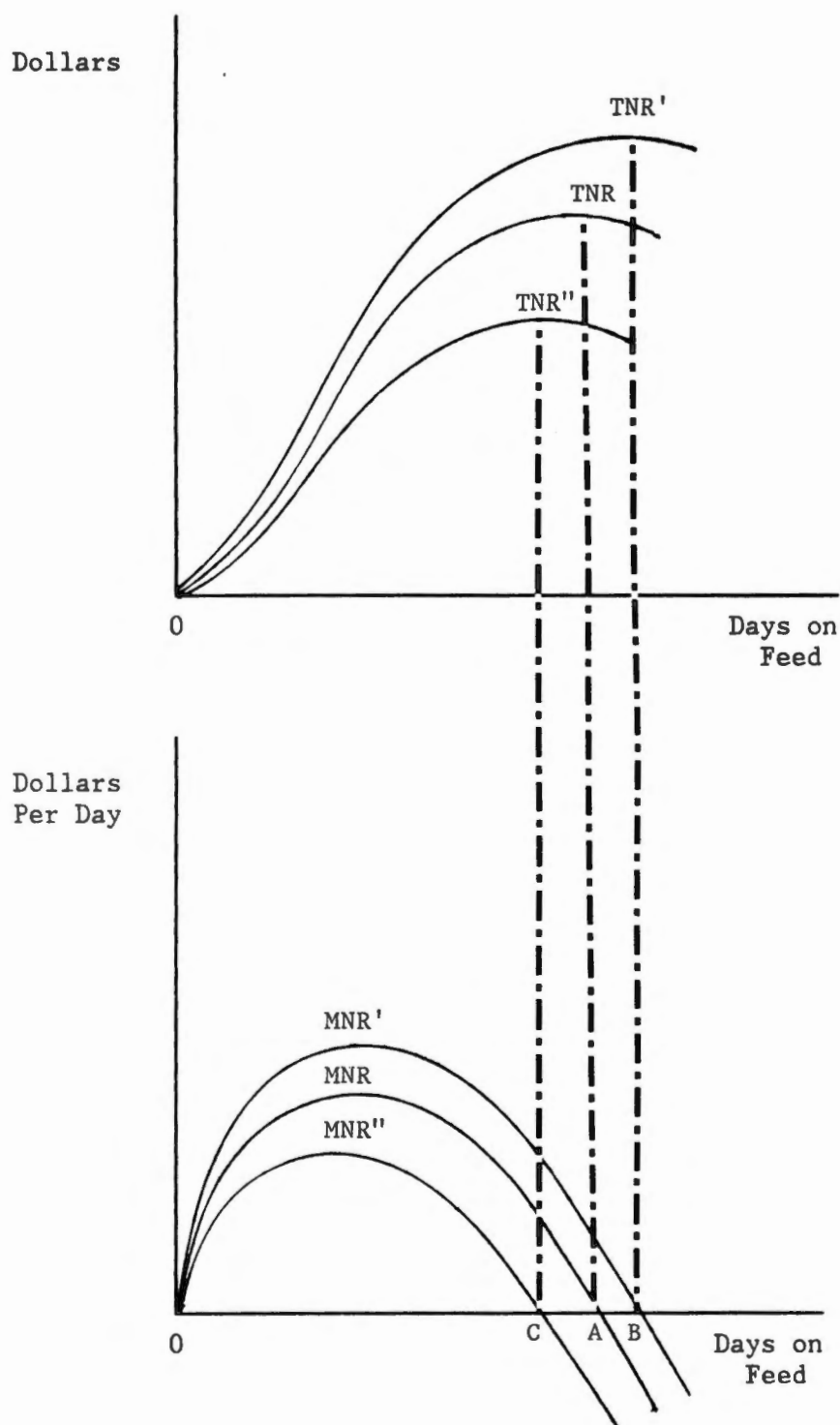


Figure 4. The Effects of Increases and Decreases in Carcass Price and Feed Cost on the Optimal Length of the Feeding Process When Maximizing Net Revenue to the Animal.

associated with greater mean values for final live weight and fat thickness as well as higher mean values for yield grade, marbling score and feed cost. Since subcutaneous fat thickness is a primary determinant of yield grade and marbling score in the simulation model, the increase in mean carcass yield grade and marbling score is associated with an increase in fat thickness. The mean net revenue from the feeding process was \$68.21 which represents a \$110.19 increase over the mean net revenue associated with base prices and costs. The average derived value of the feeder animal increased by \$19.85 per hundredweight as a result of the 20 percent increase in carcass price.

Low carcass price. A decrease in carcass price decreases the optimum number of days on feed due to a negative shift in marginal revenue. This theoretical effect is illustrated in Figure 4 by a negative shift in the total net revenue and marginal net revenue curves from TNR to TNR" and MNR to MNR", respectively and, the optimum number of days on feed is reduced from A to C.

Results from the 20 percent decrease in carcass price (Low Carcass Price) condition revealed a reduction in the mean optimal length of the feeding process of approximately 40 days from the base prices and costs condition. A similar reduction was evident in the mean values for final live weight and fat thickness, carcass yield grade and marbling score, net revenue, feed cost, and derived value of the feeder animal. It is important to note that the low carcass price condition resulted in a mean carcass quality grade of Good (mean marbling score of 4.60). Also, each animal in the study generated a

negative return to the feeding process in the low carcass pricing simulation.

High feed cost. Increasing feed cost ceteris paribus reduces the optimal number of days on feed when maximizing net revenue to the animal because marginal net revenue is reduced [McLemore and Butts, 1979]. An increase in feed cost has an effect on optimal feeding length which is similar to a decrease in carcass price. Thus, referring to Figure 4, higher feed costs are represented by a reduction in the optimum number of days on feed from A to C.

A 20 percent increase in feed cost (High Feed Cost) resulted in a reduction in mean values for each of the important feedlot and carcass characteristics, with the exception of feed cost, when compared to the base results. However, the magnitude of the reductions from the high feed cost simulation was less than the reductions associated with an increase in carcass price. While the optimum number of days on feed was reduced by approximately 28 days by increasing feed cost by 20 percent, feed cost remained approximately the same for high feed cost as for the base prices and costs condition.

Low feed cost. As with an increase in carcass price, a decrease in feed cost increases the optimal length of the feeding process due to a positive shift in marginal net revenue. Thus, a reduction in feed cost would extend the optimum number of days on feed in Figure 4 from A to B.

The 20 percent decrease in feed cost (Low Feed Cost) was represented by an increase in mean values for each of the feedlot and

carcass characteristics, again with the exception of feed cost, when compared to the results from the base prices and costs simulation. The magnitude of the increases was very similar to the increases associated with high carcass prices for the characteristics days on feed, final live weight and fat thickness, and carcass yield grade and marbling score. However, the increases in net revenue from the feeding process and derived value of the feeder animal were considerably less for the low feed cost simulation when compared to the increases associated with high carcass price. These findings would be expected since feed cost represents only a portion of the total cost of production while carcass price represents all the returns to the feeding process.

One-quarter inch trim pricing. The 1/4 inch trim pricing simulation (1/4" Trim Pricing) resulted in a reduction in the mean values for each feedlot and carcass characteristic when compared to the base results. The mean optimum number of days on feed for the 1/4" trim pricing was 158.10, and the animals were represented by mean values of 894.67 pounds for final live weight and 9.20mm (approximately 0.36 of an inch) for final fat thickness. The mean carcass characteristics were a yield grade of 2.47 and a marbling score of 4.89. This mean marbling score is associated with an average quality grade of Good for the 784 simulated animals. The mean derived value of the feeder animal was reduced by \$2.66 per hundredweight for the 1/4" trim pricing simulation under the base results. This reduction in mean derived feeder value is associated with the larger discounts applied to higher yield grades under the 1/4" trim pricing structure. These

discounts also led to a lower mean net revenue from the feeding process.⁵

Maximizing Net Revenue to the Feedlot Space

Table 7 contains a summary of the means, standard deviations, minimum and maximum values for the important feedlot and carcass characteristics when maximizing net revenue to the feedlot space. Values are included for each cost-price condition examined, with the exception of the 1/4" trim pricing. Maximizing net revenue to the feedlot space was examined for each cost-price condition based on the expectation that the replacement animal would be fed under the base price and cost condition. The 1/4" trim pricing condition is based on different yield grade discounts and premiums from those used for the base price and cost condition. Thus, if the 1/4" trim pricing structure was adopted by the beef industry, its adoption would probably be of a long term nature, and it would not be appropriate to examine the replacement decision based on the expectation that the replacement animal would be fed under base prices and costs. In order to accurately analyze the maximization of net revenue to the feedlot space for the 1/4" trim pricing condition, the expectations for the

⁵The implementation of the 1/4" trim system for retailing beef might result in higher prices for beef at retail. That is, leaner carcasses might rise in value rather than fatter carcasses declining in value as was simulated here under 1/4" trim pricing structure. If leaner carcasses received a premium rather than fatter carcasses incurring a discount, the result would be an increase in the average derived value of the feeder animal and an increase in the net revenue from the feeding process compared to base prices and costs.

Table 7. Means, Standard Deviations, Minimum and Maximum Values of Important Feedlot and Carcass Characteristics When Maximizing Net Revenue to the Feedlot Space.

Characteristic	Mean	Standard Deviation	Minimum Value	Maximum Value
<u>Base Prices and Costs</u>				
Days on Feed	212.35	58.72	100.00	340.00
Final Live Weight (lbs.)	993.09	142.01	699.80	1800.03
Final Fat Thickness (mm)	12.59	4.25	4.15	27.20
Yield Grade	2.94	0.58	1.78	4.94
Marbling Score	5.56	0.62	4.02	7.19
Net Revenue Per Day (\$)	-0.23	0.23	-1.29	0.62
Feed Cost (\$)	222.78	64.13	80.68	496.04
Derived Feeder Value (\$/cwt.)	49.03	6.99	19.56	72.44
<u>High Carcass Price</u>				
Days on Feed	237.26	63.23	100.00	340.00
Final Live Weight (lbs.)	1032.11	150.09	699.80	1800.03
Final Fat Thickness (mm)	14.32	4.45	4.15	27.29
Yield Grade	3.18	0.61	1.78	4.96
Marbling Score	5.87	0.64	4.02	7.19
Net Revenue Per Day (\$)	0.29	0.26	-0.62	1.22
Feed Cost (\$)	250.10	69.19	80.68	496.04
Derived Feeder Value (\$/cwt.)	68.95	9.23	31.48	104.41
<u>Low Carcass Price</u>				
Days on Feed	180.22	51.91	100.00	340.00
Final Live Weight	936.94	127.57	684.57	1775.46
Final Fat Thickness (mm)	10.55	3.97	3.18	25.59
Yield Grade	2.66	0.55	1.65	4.72
Marbling Score	5.16	0.61	4.00	7.11
Net Revenue Per Day (\$)	-0.87	0.29	-2.10	-0.12
Feed Cost (\$)	187.92	56.69	75.51	488.75
Derived Feeder Value (\$/cwt.)	30.72	5.59	8.00	49.97
<u>High Feed Cost</u>				
Days on Feed	186.82	53.57	100.00	340.00
Final Live Weight (lbs.)	948.92	130.62	684.57	1775.46
Final Fat Thickness (mm)	10.94	4.02	3.37	25.59
Yield Grade	2.71	0.55	1.67	4.72
Marbling Score	5.25	0.61	4.00	7.12
Net Revenue Per Day (\$)	-0.45	0.25	-1.50	0.45
Feed Cost (\$)	234.01	69.90	90.62	586.50
Derived Feeder Value (\$/cwt.)	42.68	6.73	14.42	64.75

Table 7 (Continued)

Characteristic	Mean	Standard Deviation	Minimum Value	Maximum Value
<u>Low Feed Cost</u>				
Days on Feed	243.18	62.76	100.00	340.00
Final Live Weight	1039.69	149.50	699.80	1800.03
Final Fat Thickness	14.71	4.37	4.15	27.29
Yield Grade	3.23	0.60	1.78	4.96
Marbling Score	5.94	0.62	4.04	7.19
Net Revenue Per Day (\$)	-0.03	0.21	-0.84	0.73
Feed Cost (\$)	205.20	54.85	64.54	396.83
Derived Feeder Value (\$/cwt.)	56.30	7.89	25.52	86.14

replacement animal should be based on prices associated with the 1/4" trim price structure. Thus, the 1/4" trim price structure was not considered for simulations that maximized net revenue to the feedlot space.

Base prices and costs. The base prices and costs simulation resulted in a mean optimum length of feeding period of 212.35 days on feed. The animals were represented by mean values of 995.09 lbs. for final live weight and 12.59mm for final fat thickness. Mean values for carcass characteristics were 2.94 and 5.56 for yield grade and marbling score, respectively. The animals generated a mean negative net return per day of \$0.23. Additional mean values included \$222.78 for feed cost and \$49.03 per hundredweight for the derived value of the feeder animals.

High carcass price. Purcell [p. 323] explains that if no changes occur in terms of expectations for the replacement cattle, the anticipation of higher selling prices for the current feedlot animals in the short run will extend the optimal number of days on feed. The effect of an increase in carcass price on the optimum length of feeding period is illustrated in Figure 5. The optimum length of feeding is determined by the point at which the marginal net revenue of the current animal is equal to the maximum expected average net revenue anticipated from the replacement animal. The maximum average net revenue for the 784 animals was found to be -\$0.3260 for the base prices and costs condition. This value was used as the maximum anticipated average net revenue from the replacement animal for each

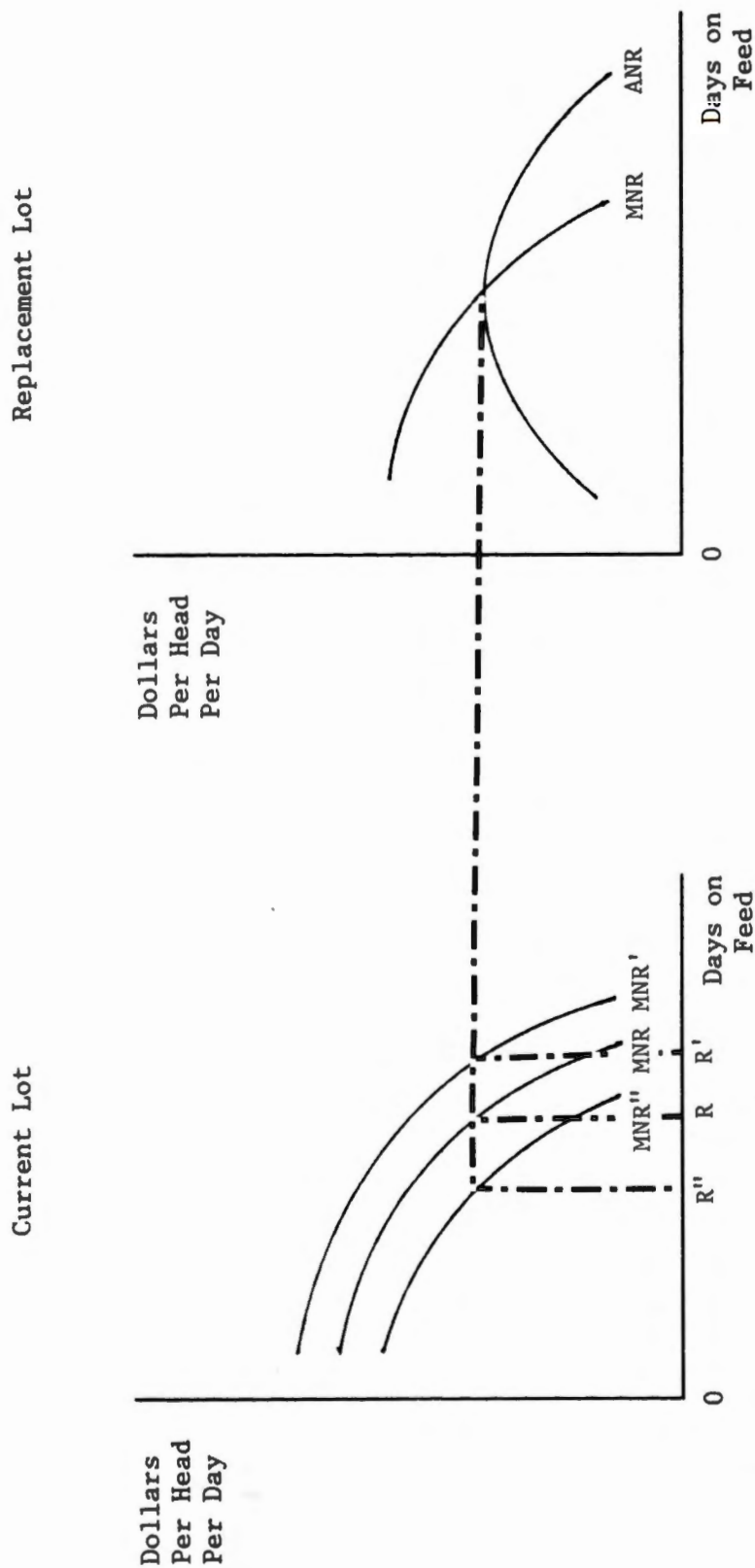


Figure 5. The Effects of Increases and Decreases in Carcass Price and Feed Cost on the Optimum Length of Feeding Period When Maximizing Net Revenue to the Feedlot Space.

price-cost condition. In Figure 5, MNR for the current lot represents the marginal net revenue associated with base prices and costs and, the optimum replacement date or length of feeding period for the base condition is represented by R. An increase in carcass price is illustrated by a positive shift in marginal net revenue for the current feedlot animal from MNR to MNR' and the optimum length of feeding period is extended from R to R'.

The results for the high carcass price condition indicate an extension of the mean optimal feeding period of approximately 25 days when compared to the base optimum length of feeding. Associated with this increase in the optimum length of feeding period were increases in the mean values for each of the important feedlot and carcass characteristics. The simulated animals were represented by a mean positive net return per day of \$0.29. The extended optimum feeding period resulted in a mean carcass yield grade of 3.18 which indicates that the premium price associated with Yield Grade 2 carcasses is not the primary influence on the optimum length of feeding for high carcass price conditions.

Low carcass price. A decrease in carcass price is represented in Figure 5 by a negative shift in the marginal net revenue for the current feedlot animal from MNR to MNR'' and a reduction in the optimum length of feeding period from R to R''. The low carcass price simulation results indicated that the mean optimum length of feeding period was reduced by approximately 32 days when compared to the base

results. Along with the reduction in the mean length of feeding period, each important feedlot and carcass characteristic decreased from its mean base values.

High feed cost. As with a decrease in carcass price, an increase in feed cost will result in a negative shift in the marginal net revenue curve for the current animal which reduces the optimum feeding length. When compared to the base results, the high feed cost condition reduced the mean optimum length of feeding period by approximately 26 days and, feed cost was the only characteristic which did not decrease from its base mean value.

Low feed cost. A decrease in feed cost is represented by a positive shift in marginal net revenue for the current feedlot animal and thus, extends the optimum feeding period. An extension in the mean optimum length of feeding period of about 31 days over the base date was produced by the low feed cost condition. Associated with this increase in the mean length of feeding was an increase in the mean value of each characteristic with the exception of feed cost.

Feeder Calf Characteristics

Each animal in the study was represented by an individual set of feeder cattle characteristics. These characteristics included the initial weight and fat thickness of the animal at the beginning of the feeding process, subjective scores for frame size and muscle thickness, diet, and breed. The means, standard deviations, minimum and maximum values for initial weight and fat thickness and subjective

frame size and muscle thickness scores are contained in Table 8. The 784 animals showed an average initial weight and fat thickness of 558.62 lbs. and 2.01mm, respectively. The mean subjective scores were 6.29 for frame size and 8.36 for muscle thickness. This frame size score places the mean animals in the study between Small and Medium U.S.D.A. frame size. The mean muscle thickness score indicates U.S.D.A. No. 1 muscling.⁶ The mean frame size score of 6.29 may explain the rather low average final live weights for the various cost-price conditions presented in the previous section.

Three hundred and eighty-eight of the simulated animals received the concentrate or high energy diet while 396 received the medium energy, silage-concentrate diet. The feeder calves consisted of 235 Angus, 223 Hereford, 237 Charolais-cross and 89 Angus-Hereford-cross.

Relationship Between Feeder Calf Characteristics and Important Feedlot and Carcass Characteristics

The primary objective of this study was to analyze the effect of individual feeder calf characteristics on important feedlot and carcass characteristics. The relationship between feeder calf characteristics and important feedlot and carcass characteristics was examined by means of multiple linear regressions. Each of the feedlot

⁶During the simulation routines, individual steers of No. 1 Muscle were represented by subjective scores of 6-15, while No. 2 Muscle related to scores of 3-5. Small Frame steers were depicted by scores of 1-6, while Medium and Large Frames were represented by subjective scores of 7-12 and 13-15, respectively.

Table 8. Means, Standard Deviations, Minimum and Maximum Values of Feeder Calf Characteristics.

Characteristic	Mean	Standard Deviation	Minimum Value	Maximum Value
Initial Weight (lbs.)	558.62	50.22	403.00	757.00
Initial Fat Thickness (mm)	2.01	1.03	1.00	6.00
Subjective Frame Size ^a	6.29	3.25	1.00	15.00
Subjective Muscle Thickness ^a	8.36	1.60	4.00	14.00

^aSubjective frame size and muscle thickness scores were assigned on a scale of 1 to 15, with higher scores reflecting greater manifestations of the trait.

and carcass characteristics for the 784 animals was regressed on the individual sets of feeder calf characteristics for each cost-price condition considered. The multiple linear regressions were of the following form:

$$DV = \alpha + \beta_1 IWT + \beta_2 IFT + \beta_3 DIET + \beta_4 BRD_A + \beta_5 BRD_H + \beta_6 BRD_{CX} \\ + \beta_7 BRD_{AH} + \beta_8 SFS + \beta_9 SMS$$

where

DV = dependent variable represented by either of the
feedlot or carcass characteristics

IWT = initial weight (lbs.) of the feeder animal

IFT = initial subcutaneous fat thickness (mm) of the
feeder animal

DIET = a zero-one dummy variable differentiating concentrate
(1) and silage-concentrate (0) diets

BRD_j = a set of zero-one-minus-one dummy variables
differentiating breed with A = Angus, H = Hereford,
CX = Charolais-cross, and AH = Angus-Hereford-cross

SFS = subjective frame size score (1-15) of the feeder
animal

SMS = subjective muscle thickness score (1-15) of the
feeder animal.

The complete results from these regressions for each cost-price condition when maximizing net revenue to the animal and to the feedlot space are summarized in the Appendix. The R^2 values for these regressions ranged from 0.028 to 0.445. The existence of some relatively low R^2 values suggest that one or more important explanatory variables

which influence the various dependent variables was omitted from the regression equations. While the R^2 values for some of the regressions were relatively low, extremely low values for R^2 were associated with the marbling score equations. This was particularly evident for the base, high carcass price, and low feed cost conditions when maximizing net revenue to the feedlot space and the high carcass price condition when maximizing net revenue to the animal.

In general, it was found that the equations overestimated the dependent variables at low values while they underestimated at high values of the dependent variables. It is important to note that the feeder calf characteristics examined in this study cannot be used alone to accurately predict important feedlot and carcass characteristics. However, the regression results can be utilized to identify those feeder calf characteristics which are important in explaining variations in feedlot and carcass characteristics.

It should also be noted that since carcass yield grade was determined as a linear function of subcutaneous fat thickness in the simulation model, the R^2 values for the equations predicting final fat thickness and yield grade will be identical. Also, the importance of the relationship between individual feeder calf characteristics and final fat thickness and yield grade will be the same.

The dependent variables in these regressions do not represent statistical data in the sense that they were not a collection of actual observations. The values of these variables were determined by the bioeconomic simulation model. Since the dependent variables do not represent statistical data, it may not be appropriate to discuss

the effects of the explanatory variables (feeder calf characteristics) on the dependent variables in terms of statistical significance. Thus, the results will be presented by identifying those feeder calf characteristics which have an important relationship to the feedlot and carcass characteristics considered. An individual feeder calf characteristic was identified as having an important relationship to a feedlot or carcass characteristic if the value of the regression coefficient was at least twice the size of the corresponding standard error. The results are presented for each cost-price condition considered when maximizing net revenue to the animal and to the feedlot space.

Initial Weight

Maximizing net revenue to the animal. The coefficients and corresponding standard errors associated with a one pound increase in initial weight when maximizing net revenue to the animal are summarized in Table 9. The coefficients are presented for each feedlot and carcass characteristic (dependent variables) and each cost-price condition considered. For example under the base prices and costs condition, a one pound increase in initial weight was associated with a \$0.0773 increase in net revenue from the feeding process.

For each cost-price condition, initial weight had an important effect on the number of days on feed (the values of the coefficients were at least twice the values of the corresponding standard errors). Initial weight was negatively related to days on feed which indicates

Table 9. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Initial Weight (lbs.) When Maximizing Net Revenue to the Animal.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	1/4" Trim Pricing
Days on Feed	-0.3101 (0.0343)	-0.2910 (0.0378)	-0.1960 (0.0226)	-0.2512 (0.0271)	-0.3002 (0.0374)	-0.2707 (0.0288)
Final Live Weight (lbs.)	0.2835 (0.0868)	0.3377 (0.0925)	0.4865 (0.0666)	0.3654 (0.0729)	0.3175 (0.0919)	0.3340 (0.0751)
Final Fat Thickness (mm)	-0.0048 (0.0027)	-0.0058 (0.0030)	0.0017 (0.0019)	-0.0012 (0.0021)	-0.0066 (0.0029)	-0.0019 (0.0022)
Yield Grade	-0.0007 (0.0004)	-0.0008 (0.0004)	0.0002 (0.0003)	-0.0002 (0.0003)	-0.0009 (0.0004)	-0.0003 (0.0003)
Marbling Score	-0.0030 (0.0004)	-0.0027 (0.0004)	-0.0017 (0.0003)	-0.0023 (0.0003)	-0.0028 (0.0004)	-0.0025 (0.0004)
Net Revenue (\$)	0.0773 (0.0291)	0.1102 (0.0357)	0.0368 (0.0244)	0.1174 (0.0280)	0.0359 (0.0314)	0.0765 (0.0280)
Feed Cost (\$)	-0.1985 (0.0400)	-0.1605 (0.0438)	-0.1040 (0.0269)	-0.1862 (0.0378)	-0.1377 (0.0349)	-0.1700 (0.0336)
Derived Feeder Value (\$/cwt.)	-0.0122 (0.0044)	-0.0429 (0.0057)	0.0141 (0.0033)	0.0070 (0.0042)	-0.0336 (0.0048)	-0.0077 (0.0041)

that heavier animals require less time to reach the optimal point of their feeding process.

Initial weight had an important effect on final live weight for all cost-price conditions and as expected, initial weight and final live weight were positively related. The results concerning the effect of initial weight on final live weight are consistent with the findings of Butts et al. [1] in which initial weight was positively related with carcass weight ($P < .001$).

The fat thickness regressions revealed a negative association with initial weight for all conditions with the exception of low carcass price. However, initial weight had an important effect on final fat thickness only for the low feed cost condition which implies that during periods of low feed prices, heavier animals tend to have lower fat thickness levels at the optimum days on feed.

A negative association was expressed between initial weight and carcass yield grade for each condition with the exception of low carcass price. However, only the yield grade coefficients associated with high carcass price and low feed cost were at least twice the size of their corresponding standard errors. Thus, heavier animals can be expected to produce lower optimal yield grades during high carcass price and low feed cost conditions, but the magnitudes of these negative relationships were relatively small.

Initial weight was related to carcass marbling score for each cost-price condition analyzed. A negative relationship existed between initial weight and marbling score which indicates that heavier animals will produce a carcass at the optimal endpoint of the feeding

process with a lower marbling score and thus a lower quality grade. This negative relationship was expected due to the fact that marbling score was dependent on final fat thickness and days on feed in the bioeconomic simulation model and initial weight had been found to be negatively related to both fat thickness and days on feed.

As for economic variables, initial weight was positively associated with net revenue from the feeding process for each cost-price condition. The coefficients associated with net revenue were twice the values of the corresponding standard errors for each condition with the exception of low carcass price and low feed cost.

The results indicated initial weight had an important effect on feed cost for each condition, and a negative relationship existed between initial weight and feed cost. This negative relationship can be expected since initial weight was found to be negatively related with optimum days on feed, and total feed cost is primarily dependent on the optimum number of days on feed.

A negative association was found to exist between initial weight and derived value of the feeder animal for each condition with the exceptions of low carcass price and high feed cost. Coefficients for initial weight were at least twice their standard errors for each condition with the exceptions of high feed cost and 1/4" trim pricing. These findings indicate that initially heavier animals showed lower derived values per hundredweight for base, high carcass price, and low feed cost conditions and higher derived feeder values for the low carcass price condition. Although the effect was unimportant, the positive association between initial weight and derived value of the

feeder animal for the high feed cost condition further validates the simulation model. During periods of high feed prices, the cost of weight gain through the feeding process is higher than during other cost-price conditions. It would be expected that heavier animals which reach their optimum at fewer days on feed would have a lower total cost of gain during the feeding process for periods of high feed cost, and thus, the positive association between initial weight and derived value of the feeder animal during high feed cost conditions would be expected. Actual observed market prices tend to confirm this result since higher feed costs tend to be associated with an increase in the market price of heavier feeder cattle relative to lighter feeder cattle.

It is interesting to note that initial weight was positively associated with net revenue for all conditions analyzed and negatively associated with derived feeder value per hundredweight for each condition except low carcass price and high feed cost. The positive association between initial weight and net revenue is caused by the fact that feeder animal prices used in the simulations declined as initial weight increased. The negative association between initial weight and derived feeder value is associated with the fact that cost of gain (determined primarily by feed cost) is relatively low even in the base price and cost condition. Thus, the derived value of the animal per hundredweight of initial weight would decline as initial weight increased.

Maximizing net revenue to the feedlot space. The coefficients and standard errors associated with a one pound increase in initial

weight when maximizing net revenue to the feedlot space are contained in Table 10. The directions of the associations between initial weight and the feedlot and carcass characteristics were inconsistent with the results obtained when maximizing net revenue to the animal for final fat thickness and yield grade for the low carcass price condition. Also, initial weight was positively associated with net revenue for all conditions when maximizing net revenue to the animal while a negative association existed between initial weight and net revenue per day for each condition except high carcass price and low feed cost when maximizing net revenue to the feedlot space.

Initial weight had an important effect on days on feed and final live weight for each cost-price condition. A negative relationship existed between initial weight and days on feed while initial weight was positively related to live weight for each condition.

The results indicated a negative association existed between initial weight and final fat thickness as well as carcass yield grade. Initial weight was related to final fat thickness and yield grade for each cost-price condition with the exception of high carcass price and low feed cost. The coefficients associated with marbling score indicated that a negative relationship existed between initial weight and carcass marbling score for all cost-price conditions analyzed.

A negative association existed between initial weight and net revenue per day from the feeding process for each condition with the exceptions of high carcass price and low feed cost. However, initial weight exhibited an important effect on net revenue per day only under high and low carcass price conditions. So during periods of high

Table 10. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Initial Weight (lbs.) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Cost-Price Conditions				
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost
Days on Feed	-0.2993 (0.0382)	-0.2497 (0.0420)	-0.3249 (0.0344)	-0.3333 (0.0352)	-0.2393 (0.0415)
Final Live Weight (lbs.)	0.3246 (0.0917)	0.4248 (0.0973)	0.2579 (0.0854)	0.2541 (0.0865)	0.4418 (0.0965)
Final Fat Thickness (mm)	-0.0060 (0.0030)	-0.0028 (0.0031)	-0.0061 (0.0027)	-0.0069 (0.0028)	-0.0021 (0.0030)
Yield Grade	-0.0008 (0.0004)	-0.0004 (0.0004)	-0.0008 (0.0004)	-0.0009 (0.0004)	-0.0003 (0.0004)
Marbling Score	-0.0028 (0.0004)	-0.0020 (0.0005)	-0.0032 (0.0004)	-0.0033 (0.0004)	-0.0019 (0.0005)
Net Revenue Per Day (\$)	-0.00004 (0.00016)	0.0008 (0.0002)	-0.0013 (0.0002)	-0.0002 (0.0002)	-0.00005 (0.00015)
Feed Cost (\$)	-0.1626 (0.0440)	-0.0954 (0.0479)	-0.2129 (0.0396)	-0.2587 (0.0486)	-0.0652 (0.0379)
Derived Feeder Value (\$/cwt.)	-0.0108 (0.0046)	-0.0426 (0.0059)	0.0189 (0.0038)	0.0107 (0.0046)	-0.0335 (0.0051)

(low) carcass price, initially heavier animals can be expected to generate increased (decreased) returns per day to the feeding process. A negative association existed between initial weight and feed cost for all conditions but the associations were important for only the base, low carcass price and high feed cost conditions.

Initial weight was negatively associated with the derived value per hundredweight of the feeder animal for each condition with the exceptions of low carcass price and high feed cost. The results indicated that initial weight had an important effect on derived value for each condition analyzed. These findings suggest that initially heavier animals are represented by lower (higher) derived feeder values for base, high carcass price, and low feed cost (low carcass price and high feed cost) conditions.

Initial Fat Thickness

Initial fat thickness (ultrasonic estimates) was selected, as opposed to subjective fat thickness, to represent the condition (fat cover) of the individual animals in the analysis. This selection was based on the findings of Butts et al. [II] which indicated that objective (ultrasonic) estimates of fat thickness were more effective than subjective estimates in relating to carcass weight and days on feed.

Maximizing net revenue to the animal. Table 11 contains the coefficients associated with a one millimeter increase in initial fat thickness when maximizing net revenue to the animal. Under base conditions, for example, a one millimeter increase in initial fat

Table 11. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Initial Fat Thickness (mm) When Maximizing Net Revenue to the Animal.

Dependent Variable	Cost-Price Conditions				
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost
					1/4" Trim Pricing
Days on Feed	-5.7180 (1.7565)	-8.9952 (1.9315)	-4.0161 (1.1562)	-5.0939 (1.3870)	-8.8604 (1.9136)
Final Live Weight (lbs.)	-20.5812 (4.4403)	-27.8397 (4.7310)	-15.4886 (3.4059)	-17.6038 (3.7302)	-27.9795 (4.6986)
Final Fat Thickness (mm)	0.6215 (0.1358)	0.4528 (0.1517)	0.6911 (0.0965)	0.6750 (0.1096)	0.4499 (0.1500)
Yield Grade	0.0855 (0.0186)	0.0623 (0.0208)	0.0950 (0.0133)	0.0928 (0.0150)	0.0618 (0.0206)
Marbling Score	-0.0014 (0.0213)	-0.0317 (0.0229)	0.0095 (0.0152)	-0.0019 (0.0176)	-0.0308 (0.0227)
Net Revenue (\$)	-5.0854 (1.4871)	-8.3148 (1.8285)	-2.5495 (1.2483)	-3.6935 (1.4334)	-6.8548 (1.6063)
Feed Cost (\$)	-6.2293 (2.0460)	-9.9170 (2.2422)	-4.3400 (1.3764)	-6.5476 (1.9340)	-7.8373 (1.7844)
Derived Feeder Value (\$/cwt.)	-0.8903 (0.2233)	-1.4653 (0.2937)	-0.4356 (0.1700)	-0.6426 (0.2125)	-1.2026 (0.2470)
					-4.0906 (1.4722)
					-16.6198 (3.8406)
					0.6851 (0.1108)
					0.0940 (0.0152)
					0.0117 (0.0185)
					-6.1408 (1.4307)
					-4.4614 (1.7185)
					-1.0785 (0.2097)

thickness is associated with an increase of 0.0855 in carcass yield grade and a reduction of \$5.0854 in net revenue from the feeding process.

Initial fat thickness had an important effect on days on feed and final live weight for all cost-price conditions, and initial fat was negatively related to both days on feed and final live weight. Thus, initially fatter animals would be expected to reach their optimum at fewer days on feed and at a lower final liveweight. These findings are consistent with those of Butts et al. [1] in which initial fat was negatively associated with days on feed ($P < .001$) and carcass weight ($P < .001$).

As expected, initial fat was positively related to final fat thickness as well as carcass yield grade for each cost-price condition analyzed which indicates that initially fatter animals are expected to have greater final fat thickness levels and yield grades. Initial fat was negatively associated with carcass marbling score for each condition with the exception of low carcass price and 1/4" trim pricing. However, initial fat was not important in predicting marbling score for any of the cost-price conditions considered.

A negative association existed between initial fat thickness and the economic variables, net revenue, feed cost and derived value of the feeder animal. Also, initial fat had an important effect on net revenue from feeding, feed cost, and the derived value per hundred-weight of the feeder animal for all cost-price conditions. The results indicate that initially fatter animals are expected to generate lower net returns to the feeding process. The negative

relationship between initial fat thickness and feed cost was expected due to the findings that initially fatter animals reached their optimum at fewer days on feed. The coefficients for derived value of the feeder animal indicate that initially fatter animals have lower derived values per hundredweight.

Maximizing net revenue to the feedlot space. The coefficients associated with a one millimeter increase in initial fat thickness when maximizing net revenue to the feedlot space are summarized in Table 12. The associations between initial fat thickness and the feedlot and carcass characteristics as well as the importance of the effect of initial fat on those characteristics were very similar to the results obtained when maximizing net revenue to the animal. In fact, the only inconsistencies were opposite directions of the association between initial fat thickness and marbling for low carcass price and low feed cost conditions.

Initial fat thickness was negatively related to days on feed and final live weight for each cost price condition examined. As expected, initial fat had an important effect on and was positively related to final fat thickness and carcass yield grade for each condition. Initial fat was negatively associated with carcass marbling score for each cost-price condition except low feed cost. However, initial fat thickness was unimportant in explaining the variation in marbling score for the conditions examined.

The results indicated that initial fat thickness had an important effect on net revenue per day from the feeding process. The negative relationship between initial fat and net revenue per day implies that

Table 12. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Initial Fat Thickness (mm) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Base Prices and Costs	Cost-Price Conditions			
		High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost
Days on Feed	-9.5150 (1.9534)	-6.9235 (2.1457)	-6.1588 (1.7587)	-6.7662 (1.7989)	-6.1177 (2.1225)
Final Live Weight (lbs.)	-29.0494 (4.6897)	-24.6631 (4.9766)	-21.6192 (4.3670)	-23.0487 (4.4218)	-24.2062 (4.9353)
Final Fat Thickness (mm)	0.4315 (0.1517)	0.5883 (0.1591)	0.6256 (0.1373)	0.5686 (0.1409)	0.6113 (0.1557)
Yield Grade	0.0593 (0.0208)	0.0810 (0.0219)	0.0860 (0.0189)	0.0782 (0.0194)	0.0841 (0.0214)
Marbling Score	-0.0337 (0.0227)	-0.0028 (0.0242)	-0.0027 (0.0210)	-0.0103 (0.0213)	0.0080 (0.0235)
Net Revenue Per Day (\$)	-0.0408 (0.0081)	-0.0321 (0.0088)	-0.0529 (0.0100)	-0.0434 (0.0089)	-0.0347 (0.0075)
Feed Cost (\$)	-10.4447 (2.2484)	-7.8582 (2.4500)	-6.6648 (2.0233)	-8.8764 (2.4849)	-5.7188 (1.9370)
Derived Feeder Value (\$/cwt.)	-0.8114 (0.2376)	-1.5664 (0.3029)	-0.3959 (0.1929)	-0.6055 (0.2329)	-1.3331 (0.2607)

initially fatter animals will generate less net returns per day during the feeding process. The coefficients associated with initial fat for feed cost and derived value of the feeder animal were at least twice the size of the corresponding standard errors for all cost-price conditions examined, and initial fat was negatively related to feed cost and derived value for all conditions.

Diet

Although an animal's diet should not be considered as a feeder calf characteristic, the binary variable was included in the regressions to account for variation caused by the differing diet treatments among the simulated animals. The binary explanatory variable was equal to 1 for the concentrate diet and 0 for the silage-concentrate diet.

Maximizing net revenue to the animal. The regression coefficients associated with diet when maximizing net revenue to the animal are summarized in Table 13. For example, under the base prices and costs condition the average animal receiving the concentrate diet showed an increase of 0.2316 in carcass yield grade and an increase of \$28.8431 in net revenue from the feeding process compared to an animal on the silage-concentrate diet.

Diet was negatively associated with days on feed for each cost-price condition analyzed, and diet had an important effect on days on feed for each cost-price condition except low carcass price. These findings indicate that concentrate-fed animals could be expected to reach their optimum slaughter point at fewer days on feed. Diet

Table 13. Regression Coefficients and Standard Errors Associated with the Binary Explanatory Variable Diet (1 = Concentrate Diet) When Maximizing Net Revenue to the Animal.

Dependent Variable	Base Prices and Costs	Cost-Price Conditions					1/4" Trim Pricing
		High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost		
Days on Feed	-21.5782 (3.2897)	-26.8021 (3.6175)	-3.2782 (2.1654)	-5.9122 (2.5976)	-25.2355 (3.5838)	-12.1199 (2.7572)	
Final Live Weight (lbs.)	23.1180 (8.3160)	20.1847 (8.8606)	48.9667 (6.3787)	45.0824 (6.9862)	22.0511 (8.8000)	36.8592 (7.1930)	
Final Fat Thickness (mm)	1.6859 (0.2543)	1.7990 (0.2840)	1.8722 (0.1807)	1.9389 (0.2052)	1.8447 (0.2810)	1.7402 (0.2075)	
Yield Grade	0.2316 (0.0349)	0.2472 (0.0390)	0.2571 (0.0248)	0.2664 (0.0282)	0.2536 (0.0386)	0.2391 (0.0285)	
Marbling Score	0.4144 (0.0399)	0.2685 (0.0428)	0.6746 (0.0284)	0.6432 (0.0329)	0.2922 (0.0425)	0.5616 (0.0346)	
Net Revenue (\$)	28.8431 (2.7852)	32.7468 (3.4245)	21.2696 (2.3378)	27.0363 (2.6847)	28.5652 (3.0085)	25.1985 (2.6795)	
Feed Cost (\$)	0.0217 (3.8319)	-4.2862 (4.1993)	17.6083 (2.5778)	18.3484 (3.6222)	-2.2338 (3.3419)	9.1230 (3.2186)	
Derived Feeder Value (\$/cwt.)	5.1052 (0.4182)	5.7712 (0.5500)	3.7921 (0.3183)	4.8300 (0.3979)	5.0193 (0.4625)	4.4541 (0.3927)	

had an important positive effect on final live weight and fat thickness, yield grade, and marbling score for each cost-price condition. These findings indicate that animals receiving a concentrate diet are associated with larger final live weights and fat thickness levels and higher measures of carcass yield grade and marbling score at their optimum slaughter points.

The results indicate that diet had an important positive effect on net revenue from feeding for each cost-price condition analyzed. The positive relationship between diet and net revenue from feeding indicates that higher returns can be expected from concentrate-fed animals. A positive association existed between diet and feed cost for each condition except high carcass price and low feed cost. However, diet had an important impact on feed cost for only the low carcass price, high feed cost and 1/4" trim pricing conditions. Diet had an important positive effect on the derived value per hundred-weight of the feeder animal for each condition. These findings indicate that animals receiving the concentrate diet showed higher derived feeder values per hundredweight compared to silage-concentrate-fed animals.

Maximizing net revenue to the feedlot space. Table 14 contains the coefficients associated with diet when maximizing net revenue to the feedlot space. The directions of the associations between diet and the feedlot and carcass characteristics were very similar to the results obtained when maximizing net revenue to the animal. The only inconsistencies were the associations between diet and feed cost for base and high feed cost conditions.

Table 14. Regression Coefficients and Standard Errors Associated with the Binary Explanatory Variable Diet (1 = Concentrate Diet) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	
Days on Feed	-29.0165 (3.6584)	-33.2942 (4.0186)	-21.6206 (3.2938)	-24.3347 (3.3690)	-34.9324 (3.9752)	
Final Live Weight (lbs.)	16.7428 (8.7833)	12.2595 (9.3206)	24.6032 (8.1788)	21.5854 (8.2814)	9.7743 (9.2431)	
Final Fat Thickness (mm)	1.7942 (0.2840)	1.9400 (0.2979)	1.8073 (0.2571)	1.7420 (0.2639)	1.8997 (0.2915)	
Yield Grade	0.2466 (0.0390)	0.2664 (0.0409)	0.2483 (0.0353)	0.2393 (0.0362)	0.2609 (0.0400)	
Marbling Score	0.2121 (0.0426)	0.0491 (0.0452)	0.4060 (0.0394)	0.3559 (0.0398)	0.0015 (0.0440)	
Net Revenue Per Day (\$)	0.1144 (0.0153)	0.1819 (0.0164)	0.0404 (0.0187)	0.1032 (0.0167)	0.1180 (0.0140)	
Feed Cost (\$)	-6.2714 (4.2109)	-10.3146 (4.5885)	0.2892 (3.7894)	-2.6654 (4.6538)	-9.6878 (3.6277)	
Derived Feeder Value (\$/cwt.)	5.3619 (0.4450)	5.9402 (0.5672)	4.3880 (0.3613)	5.3125 (0.4361)	5.2712 (0.4882)	

Diet had an important positive effect on days on feed for each cost-price condition considered. These findings indicate that concentrate-fed animals reached their optimum length of feeding points at fewer days on feed. A positive association existed between diet and final live weight. However, the coefficients for live weight were at least twice the value of the corresponding standard errors only for the low carcass price and high feed cost conditions. Diet was positively related to final fat thickness and carcass yield grade for each condition examined. While diet was positively associated with marbling score, the coefficients were at least twice the size of the corresponding standard errors for only the base, low carcass price, and high feed cost conditions.

Important positive effects existed between diet and net revenue per day from the feeding process. According to these findings, animals receiving the concentrate diet are associated with higher net returns to the feedlot facility. Diet was negatively associated to feed cost for each cost-price condition with the exception of low carcass price. However, diet had an important effect on feed cost only for high carcass price and low feed cost conditions. As when maximizing net revenue to the animal, diet had an important positive effect on the derived value per hundredweight of the feeder animal for all conditions analyzed.

Breed

The zero-one-minus-one explanatory variables representing breed were included in the regressions to account for the breed-related variation among Angus, Hereford, Charolais-cross, and Angus-Hereford-

cross animals in the study.

Maximizing net revenue to the animal. The regression coefficients associated with Angus, Hereford, Charolais-cross, and Angus-Hereford-cross when maximizing net revenue to the animal are summarized in Tables 15, 16, 17, and 18, respectively. For example, the coefficients in Table 15 indicate that under base conditions an Angus steer is associated with a reduction of 24.2364 pounds in final live weight and a decrease of \$6.6543 in net revenue from feeding at the optimum days on feed.

Angus and Hereford breeds were negatively associated with days on feed while Charolais-cross was positively associated for each cost-price condition examined. Angus-Hereford-cross was positively associated with days on feed for each cost-price condition with the exceptions of high carcass price and low feed cost. However, the only important effects of breed on days on feed were exhibited by Charolais-cross for high carcass price and low feed cost conditions. These findings imply that Charolais-cross steers are expected to reach their optimum slaughter points at a greater number of days on feed under high carcass price and low feed cost conditions.

The results indicated the Angus and Hereford were negatively associated with final live weight while Charolais-cross and Angus-Hereford-cross were positively associated with final live weight. Angus had an important effect on final live weight for each cost-price condition. Charolais-cross had an important effect on live weight for high carcass price and low feed cost conditions while Angus-Hereford-

Table 15. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Angus) When Maximizing Net Revenue to the Animal.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	1/4" Trim Pricing
Days on Feed	-4.6501 (2.8844)	-3.4781 (3.1718)	-3.6274 (1.8987)	-4.4082 (2.2776)	-3.7193 (3.1424)	-4.5868 (2.4175)
Final Live Weight (lbs.)	-24.2364 (7.2916)	-24.0793 (7.7691)	-20.0246 (5.5930)	-21.6809 (6.1256)	-23.9969 (7.7159)	-23.6733 (6.3069)
Final Fat Thickness (mm)	-0.0044 (0.2230)	0.0835 (0.2491)	-0.0252 (0.1585)	-0.0594 (0.1799)	0.0949 (0.2464)	-0.0328 (0.1820)
Yield Grade	-0.0007 (0.0306)	0.0111 (0.0342)	-0.0035 (0.0218)	-0.0082 (0.0247)	0.0127 (0.0338)	-0.0048 (0.0250)
Marbling Score	-0.0384 (0.0350)	-0.0249 (0.0375)	-0.0314 (0.0249)	-0.0432 (0.0288)	-0.0267 (0.0372)	-0.0360 (0.0304)
Net Revenue (\$)	-6.6543 (2.4421)	-10.2453 (3.0026)	-3.2664 (2.0498)	-5.1788 (2.3539)	-8.2916 (2.6379)	-6.5639 (2.3495)
Feed Cost (\$)	-7.0535 (3.3599)	-6.3874 (3.6820)	-5.6740 (2.2602)	-7.8125 (3.1760)	-5.2370 (2.9303)	-6.8012 (2.8221)
Derived Feeder Value (\$/cwt.)	-1.5047 (0.3667)	-2.1225 (0.4822)	-0.9125 (0.2791)	-1.2510 (0.3489)	-1.7803 (0.4056)	-1.4827 (0.3443)

Table 16. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Hereford) When Maximizing Net Revenue to the Animal.

Dependent Variable	Base Prices and Costs	Cost-Price Conditions				
		High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	1/4" Trim Pricing
Days on Feed	-4.4598 (2.9904)	-3.3066 (3.2884)	-2.9851 (1.9684)	-2.6007 (2.3613)	-3.9795 (3.2578)	-4.1708 (2.5064)
Final Live Weight (lbs.)	-11.0107 (7.5595)	-9.4512 (8.0545)	-8.8233 (5.7984)	-7.0633 (6.3506)	-10.6948 (7.9994)	-9.4255 (6.5386)
Final Fat Thickness (mm)	0.3487 (0.2312)	0.5198 (0.2582)	0.1964 (0.1643)	0.3110 (0.1866)	0.4652 (0.2555)	0.2912 (0.1886)
Yield Grade	0.0481 (0.0317)	0.0717 (0.0355)	0.0271 (0.0226)	0.0428 (0.0256)	0.0642 (0.0351)	0.0402 (0.0259)
Marbling Score	-0.0396 (0.0363)	-0.0015 (0.0389)	-0.0134 (0.0258)	-0.0146 (0.0299)	-0.0095 (0.0386)	-0.0345 (0.0315)
Net Revenue (\$)	-2.0856 (2.5318)	-3.3088 (3.1129)	-1.1842 (2.1251)	-1.4942 (2.4404)	-2.9656 (2.7348)	-3.0980 (2.4358)
Feed Cost (\$)	-5.1078 (3.4833)	-3.8391 (3.8173)	-3.3291 (2.3433)	-3.5776 (3.2927)	-3.7071 (3.0379)	-4.4751 (2.9258)
Derived Feeder Value (\$/cwt.)	-0.1366 (0.3801)	-0.3834 (0.4999)	0.0419 (0.2894)	-0.0209 (0.3617)	-0.3127 (0.4205)	-0.3171 (0.3570)

Table 17. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Charolais-Cross) When Maximizing Net Revenue to the Animal.

Dependent Variable	Base Prices and Costs	Cost-Price Conditions					1/4" Trim Pricing
		High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost		
Days on Feed	7.1924 (3.7063)	11.4213 (4.0756)	4.9629 (2.4397)	3.9600 (2.9266)	11.8278 (4.0377)	4.5633 (3.1064)	
Final Live Weight (lbs.)	11.6333 (9.3692)	21.0026 (9.9828)	6.4473 (7.1866)	4.1886 (7.8709)	21.1627 (9.9144)	6.9539 (8.1039)	
Final Fat Thickness (mm)	-1.3073 (0.2865)	-1.1779 (0.3200)	-1.1643 (0.2036)	-1.3185 (0.2312)	-1.1369 (0.3166)	-1.3064 (0.2338)	
Yield Grade	-0.1792 (0.0393)	-0.1613 (0.0440)	-0.1596 (0.0280)	-0.1808 (0.0318)	-0.1556 (0.0435)	-0.1789 (0.0321)	
Marbling Score	-0.0195 (0.0450)	0.0041 (0.0482)	-0.0404 (0.0320)	-0.0554 (0.0371)	0.0128 (0.0479)	-0.0494 (0.0390)	
Net Revenue (\$)	-5.1266 (3.1379)	-3.3507 (3.8582)	-5.3478 (2.6339)	-5.8040 (3.0247)	-3.2161 (3.3895)	-1.7525 (3.0189)	
Feed Cost (\$)	6.3238 (4.3172)	10.9335 (4.7312)	3.8834 (2.9042)	3.2484 (4.0809)	9.1316 (3.7652)	3.5861 (3.6262)	
Derived Feeder Value (\$/cwt.)	-0.6032 (0.4711)	-0.2600 (0.6196)	-0.6700 (0.3587)	-0.7357 (0.4483)	-0.2497 (0.5211)	-0.0052 (0.4424)	

Table 18. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Angus-Hereford-Cross) When Maximizing Net Revenue to the Animal.

Dependent Variable	Base Prices and Costs	Cost-Price Conditions				1/4" Trim Pricing
		High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	
Days on Feed	1.9175 (4.0304)	-4.6365 (4.4320)	1.6496 (2.6530)	3.0489 (3.1825)	-4.1290 (4.3908)	4.1943 (3.3780)
Final Live Weight (lbs.)	23.6138 (10.1885)	12.5279 (10.8557)	22.4006 (7.8150)	24.5557 (8.5592)	13.5290 (10.7814)	26.1449 (8.8126)
Final Fat Thickness (mm)	0.9629 (0.3116)	0.5746 (0.3480)	0.9931 (0.2214)	1.0668 (0.2514)	0.5768 (0.3443)	1.0480 (0.2543)
Yield Grade	0.1317 (0.0428)	0.0785 (0.0478)	0.1360 (0.0304)	0.1462 (0.0345)	0.0787 (0.0473)	0.1435 (0.0349)
Marbling Score	0.0975 (0.0489)	0.0224 (0.0524)	0.0852 (0.0348)	0.1132 (0.0403)	0.0235 (0.0520)	0.1199 (0.0424)
Net Revenue (\$)	13.8665 (3.4123)	16.9048 (4.1955)	9.7984 (2.8642)	12.4769 (3.2891)	14.4733 (3.6858)	11.4143 (3.2829)
Feed Cost (\$)	5.8375 (4.6947)	-0.7070 (5.1449)	5.1197 (3.1582)	8.1417 (4.4378)	-0.1875 (4.0944)	7.6901 (3.9433)
Derived Feeder Value (\$/cwt.)	2.2444 (0.5123)	2.7659 (0.6738)	1.5406 (0.3900)	2.0075 (0.4876)	2.3426 (0.5667)	1.8051 (0.4811)

cross was important in explaining the variation in live weight for each condition with the exceptions of high carcass price and low feed cost. Hereford was unimportant in explaining final live weight for all conditions considered.

Angus was negatively associated with final fat thickness for each cost-price condition except high carcass price and low feed cost. Hereford and Angus-Hereford-cross were positively associated with final fat thickness while Charolais-cross was negatively associated with final fat. However, Angus was unimportant in explaining the variation in final fat, and Hereford was important for only the high carcass price condition. Charolais-cross had an important effect on final fat for each condition while Angus-Hereford-cross was important for each condition with the exception of high carcass price and low feed cost.

A negative association existed between Angus and carcass yield grade for each cost-price condition except high carcass price and low feed cost. Hereford and Angus-Hereford-cross were positively associated with yield grade while Charolais-cross was negatively associated. As with final fat thickness, Angus was unimportant in determining carcass yield grade while Hereford was important for the high carcass price condition. Also, Charolais-cross was important in explaining the variation in yield grade for each condition while Angus-Hereford-cross was important for each condition except high carcass price and low feed cost. These findings indicate that Charolais-cross steers are represented by lower carcass yield grades as well as lower levels of fat thickness at their optimum slaughter points. Also, Angus-

Hereford-cross steers are associated with higher yield grades and fat thickness levels for each cost-price condition with the exceptions of high carcass price and low feed cost while Hereford steers are represented by higher yield grades and fat thickness levels for high carcass price conditions.

Angus and Hereford were negatively associated with carcass marbling score for each cost-price condition. Also, Charolais-cross was negatively associated with marbling score for each condition with the exceptions of high price carcass and low feed cost. However, none of the coefficients associated with Angus, Hereford, or Charolais-cross for marbling score were at least twice the size of the corresponding standard errors. A positive association existed between Angus-Hereford-cross and carcass marbling score, and Angus-Hereford-cross had an important effect on marbling score for low carcass price, high feed cost, and 1/4" trim pricing conditions. These findings suggest that under low carcass price, high feed cost, and 1/4" trim pricing conditions, Angus-Hereford-cross steers are represented by higher carcass marbling scores (thus, higher quality grades) at the optimum slaughter points.

Angus, Hereford, and Charolais-cross were negatively associated with net revenue from feeding while Angus-Hereford-cross was positively associated. Angus had an important effect on net revenue for each cost-price condition except low carcass price. Hereford had an unimportant effect on net revenue from feeding while Charolais-cross had an important impact on net revenue only for the low carcass price condition. These results imply that Angus steers can be expected to

generate lower returns from feeding for each condition except low carcass price while Charolais-cross steers are associated with lower returns under low carcass price conditions. For each cost-price condition, Angus-Hereford-cross was important in explaining the variation in net revenue from feeding. It is interesting to note that these findings indicate that Angus-Hereford-cross steers are associated with an increase in net revenue at their optimum slaughter points for all cost-price conditions.

Angus and Hereford were negatively associated with feed cost for each cost-price condition analyzed. Charolais-cross was positively associated with feed cost for each condition, and Angus-Hereford-cross was positively associated with feed cost for each condition with the exceptions of high carcass price and low feed cost. Angus and Charolais-cross were the only breeds which had an important effect on feed cost. Angus was important in describing the variation in feed cost for each cost-price condition with the exceptions of high carcass price and low feed cost while Charolais-cross had an important effect on feed cost for high carcass price and low feed cost conditions. It is interesting to note that the later maturing Charolais-cross steers had an important positive effect on feed cost for the two cost-price conditions which are characterized by the greatest mean optimum number of days on feed.

The results indicated that Angus and Charolais-cross were negatively associated with the derived value per hundredweight of the feeder animal for each cost-price condition while Hereford was negatively associated with derived value for each condition except low

carcass price. Angus-Hereford-cross steers were positively associated with the derived value per hundredweight of the feeder animal for each condition. Angus and Angus-Hereford-cross were important in explaining the variation in derived value for each condition while Hereford and Charlois-cross were unimportant.

Maximizing net revenue to the feedlot space. The impact of breed on the important feedlot and carcass characteristics when maximizing net revenue to the feedlot space are summarized in Tables 19, 20, 21, and 22 which represent Angus, Hereford, Charolais-cross, and Angus-Hereford-cross, respectively. Of particular interest was the lack of importance of Hereford in explaining the variation in any of the feedlot and carcass characteristics analyzed when examining the maximization of net revenue to the feedlot facility.

The directions of the associations between Angus and the feedlot and carcass characteristics were very similar to the results obtained when maximizing net revenue to the animal. The only inconsistencies were associated with final fat thickness and yield grade for base and high feed cost conditions. Opposite directions of the associations were revealed between Hereford and marbling score for the base condition and between Hereford and derived feeder value for the high feed cost condition. An inconsistency in association was identified between Charolais-cross and marbling score for the base condition. Also, Charolais-cross was positively associated with net revenue per day for the low carcass price condition while a negative association existed between Charolais-cross and net revenue for that condition when maximizing net revenue to the animal. Inconsistencies were

Table 19. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Angus) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	
Days on Feed	-2.3034 (3.2077)	-1.8135 (3.5235)	-6.5630 (2.8880)	-4.3850 (2.9540)	-2.1122 (3.4855)	
Final Live Weight (lbs.)	-23.0429 (7.7013)	-24.1277 (8.1724)	-27.5895 (7.1712)	-24.3437 (7.2612)	-24.9885 (8.1045)	
Final Fat Thickness (mm)	0.1363 (0.2491)	0.0720 (0.2612)	-0.1442 (0.2254)	0.0071 (0.2314)	0.0266 (0.2556)	
Yield Grade	0.0185 (0.0342)	0.0098 (0.0359)	-0.0199 (0.0310)	0.0007 (0.0318)	0.0038 (0.0351)	
Marbling Score	-0.0148 (0.0374)	-0.0116 (0.0397)	-0.0611 (0.0345)	-0.0307 (0.0349)	-0.0197 (0.0386)	
Net Revenue Per Day (\$)	-0.0389 (0.0134)	-0.0414 (0.0144)	-0.0495 (0.0164)	-0.0401 (0.0146)	-0.0366 (0.0123)	
Feed Cost (\$)	-5.3398 (3.6922)	-5.2592 (4.0233)	-8.9985 (3.3226)	-8.2567 (4.0805)	-4.6833 (3.1808)	
Derived Feeder Value (\$/cwt.)	-1.6226 (0.3902)	-2.1451 (0.4973)	-0.7986 (0.3168)	-1.2969 (0.3824)	-1.7883 (0.4280)	

Table 20. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Hereford) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	
Days on Feed	-3.6427 (3.3256)	-6.3559 (3.6530)	-3.0833 (2.9941)	-3.4683 (3.0625)	-6.4631 (3.6135)	
Final Live Weight (lbs.)	-10.7238 (7.9842)	-14.8710 (8.4726)	-8.8708 (7.4347)	-10.6050 (7.5280)	-15.6094 (8.4022)	
Final Fat Thickness (mm)	0.5005 (0.2582)	0.4323 (0.2708)	0.4611 (0.2337)	0.4352 (0.2399)	0.4333 (0.2650)	
Yield Grade	0.0687 (0.0355)	0.0596 (0.0372)	0.0635 (0.0321)	0.0600 (0.0329)	0.0598 (0.0364)	
Marbling Score	0.0005 (0.0387)	-0.0223 (0.0411)	-0.0150 (0.0358)	-0.0157 (0.0362)	-0.0180 (0.0400)	
Net Revenue Per Day (\$)	-0.0153 (0.0139)	-0.0084 (0.0150)	-0.0225 (0.0170)	-0.0171 (0.0151)	-0.0134 (0.0128)	
Feed Cost (\$)	-4.2798 (3.8278)	-7.0061 (4.1711)	-3.6310 (3.4447)	-5.0103 (4.2304)	-5.7632 (3.2977)	
Derived Feeder Value (\$/cwt.)	-0.1208 (0.4045)	-0.2960 (0.5156)	0.0798 (0.3284)	0.0307 (0.3964)	-0.2220 (0.4438)	

Table 21. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Charolais-Cross) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	
Days on Feed	13.2963 (4.1217)	16.7633 (4.5275)	8.6506 (3.7109)	8.9313 (3.7957)	17.3819 (4.4786)	
Final Live Weight (lbs.)	24.2194 (9.8956)	30.2334 (10.5010)	14.0454 (9.2146)	15.6595 (9.3302)	31.6503 (10.4137)	
Final Fat Thickness (mm)	-1.1188 (0.3200)	-1.0459 (0.3357)	-1.2424 (0.2897)	-1.2300 (0.2973)	-1.0245 (0.3285)	
Yield Grade	-0.1534 (0.0439)	-0.1434 (0.0461)	-0.1704 (0.0398)	-0.1684 (0.0408)	-0.1409 (0.0451)	
Marbling Score	0.0216 (0.0480)	0.0440 (0.0510)	-0.0072 (0.0444)	-0.0109 (0.0449)	0.0487 (0.0496)	
Net Revenue Per Day (\$)	-0.0194 (0.0172)	-0.0366 (0.0185)	0.0060 (0.0210)	-0.0145 (0.0188)	-0.0142 (0.0158)	
Feed Cost (\$)	13.0179 (4.7442)	16.5812 (5.1696)	7.5996 (4.2693)	9.7546 (5.2432)	13.9781 (4.0872)	
Derived Feeder Value (\$/cwt.)	-0.7857 (0.5014)	-0.3737 (0.6390)	-0.9028 (0.4070)	-0.9253 (0.4913)	-0.3975 (0.5500)	

Table 22. Regression Coefficients and Standard Errors Associated with the Zero-One-Minus-One Explanatory Variable Breed (1 = Angus-Hereford-Cross) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Base Prices and Costs	Cost-Price Conditions			
		High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost
Days on Feed	-7.3502 (4.4821)	-8.5938 (4.9234)	0.9957 (4.0354)	-1.0779 (4.1276)	-8.8065 (4.8702)
Final Live Weight (lbs.)	9.5473 (10.7609)	8.7653 (11.4192)	22.4150 (10.0203)	19.2892 (10.1460)	8.9476 (11.3243)
Final Fat Thickness (mm)	0.4820 (0.3480)	0.5417 (0.3650)	0.9254 (0.3150)	0.7877 (0.3233)	0.5646 (0.3572)
Yield Grade	0.0662 (0.0478)	0.0740 (0.0501)	0.1267 (0.0433)	0.1078 (0.0444)	0.0773 (0.0491)
Marbling Score	-0.0073 (0.0522)	-0.0101 (0.0554)	0.0834 (0.0482)	0.0573 (0.0488)	-0.0110 (0.0540)
Net Revenue Per Day (\$)	0.0736 (0.0187)	0.0863 (0.0202)	0.0660 (0.0229)	0.0718 (0.0204)	0.0641 (0.0172)
Feed Cost (\$)	-3.3984 (5.1590)	-4.3159 (5.6217)	5.0299 (4.6426)	3.5124 (5.7017)	-3.5317 (4.4446)
Derived Feeder Value (\$/cwt.)	2.5291 (0.5452)	2.8147 (0.6949)	1.6215 (0.4426)	2.1915 (0.5343)	2.4078 (0.5981)

identified for Angus-Hereford-cross and days on feed, marbling score, and feed cost for the base condition. Also, opposite signs of direction were revealed between Angus-Hereford-cross and days on feed for the high feed cost condition and between Angus-Hereford-cross and marbling score for high carcass price and low feed cost conditions.

Angus and Hereford were negatively associated with days on feed for each cost-price condition while a negative association existed between Angus-Hereford-cross and days on feed for each condition except low carcass price. A positive association existed between Charolais-cross and days on feed for each condition. Charolais-cross had an important impact on days on feed for each cost-price condition, and Angus had an important impact on the number of days on feed for the low carcass price condition. These findings indicate that for each cost-price condition examined, Charolais-cross steers were associated with an increase in the number of days on feed required to reach optimum feeding points while Angus steers were associated with increased days on feed for the low carcass price condition.

The results indicated that Angus and Hereford were negatively associated with final live weight while Charolais-cross and Angus-Hereford-cross were positively associated with live weight. Angus had an important effect on final live weight for all cost-price conditions while the effect of Charolais-cross on live weight was important for each condition with the exceptions of low carcass price and high feed cost. For the low carcass price condition, Angus-Hereford-cross was important in explaining the variation in final live weight.

A positive association existed between Angus and final fat thickness for each cost-price condition except low carcass price, and Hereford was also positively associated with fat thickness for all conditions. However, none of the coefficients associated with Angus or Hereford were at least twice the value of the corresponding standard errors. Charolais-cross had an important effect on and was negatively related to final fat thickness for each condition examined. A positive association existed between Angus-Hereford-cross and final fat for each condition, but Angus-Hereford-cross had an important effect on fat thickness for only low carcass price and high feed cost conditions.

As with fat thickness, Hereford and Angus-Hereford-cross were positively associated with yield grade for all cost-price conditions while Angus and yield grade were positively associated for each condition except low carcass price. Also, a negative association existed between Charolais-cross and carcass yield grade. Charolais-cross was important in explaining the variation in yield grade for each condition while Angus-Hereford-cross was important for low carcass price and low feed cost conditions.

Angus was negatively associated with carcass marbling score for each cost-price condition while Hereford was negatively associated for each condition except base prices and costs. A negative association existed between Angus-Hereford-cross and marbling score for each condition with the exceptions of low carcass price and high feed cost. Charolais-cross was positively associated to marbling score for each condition with the exception of low carcass price and high feed cost.

However, none of the breeds was important in explaining the variation in carcass marbling score for any of the cost-price conditions analyzed.

The associations between the various breeds and marbling score when maximizing net revenue to either the animal or the feedlot facility are influenced by the number of days on feed due to the manner in which marbling score was estimated during the simulation. Marbling score was expressed as a nonlinear function of fat thickness level and days of feed at slaughter, and increased days on feed resulted in higher marbling scores. Thus, the breeds which were associated with mean increases (decreases) in optimum days on feed would be expected to be positively (negatively) associated with carcass marbling score.

Angus and Hereford were negatively associated with net revenue per day from feeding for all cost-price conditions while Charolais-cross was negatively associated for each condition except low carcass price. A positive association existed between Angus-Hereford-cross and net revenue per day for each condition. Angus and Angus-Hereford-cross had important effects on net revenue per day from feeding for all conditions while Hereford and Charolais-cross were unimportant. These findings indicate that Angus steers are associated with decreased returns to the feedlot facility when slaughtered at their optimum length of feeding periods while Angus-Hereford-cross steers are associated with increased returns.

The results indicated that Angus and Hereford were negatively associated with feed cost for all cost-price conditions, and a

negative association existed between Angus-Hereford-cross and feed cost for each condition with the exceptions of low carcass price and high feed cost. Charolais-cross was positively associated with feed cost for each cost-price condition analyzed. The important breed effects on feed cost were Angus for low carcass price and high feed cost conditions and Charolais-cross for each condition with the exceptions of low carcass price and high feed cost.

A negative association existed between Angus and Charolais-cross and the derived value per hundredweight of the feeder animal for each cost-price condition examined. Hereford was negatively associated with derived value for each condition except low carcass price and high feed cost while Angus-Hereford-cross was positively associated with derived value for all conditions. All coefficients associated with Angus and Angus-Hereford-cross for derived value were at least twice the size of the corresponding standard errors while the Charolais-cross coefficient for low carcass price was greater than twice the value of the corresponding standard error. These findings imply that when operators are maximizing net revenue to the feedlot facility, Angus steers can be expected to have lower derived values per hundredweight at their optimum feeding points while Angus-Hereford-cross steers are associated with higher derived values at their optimums. Also, Charolais-cross animals were associated with lower derived feeder values for the low carcass price condition.

Subjective Frame Size Score

It should be noted that subjective frame score was selected, as opposed to initial wither height, to represent the structural

dimension of the individual animals in this analysis. This selection was base on the fact that subjective frame size is a criterion for the U.S.D.A. feeder cattle grading system.

Maximizing net revenue to the animal. The coefficients associated with a one unit increase in subjective frame size score (range 1-15) when maximizing net revenue to the animal are summarized in Table 23. Under base prices and costs, for example, a unit increase in subjective frame size is associated with an increase of 9.8434 pounds in final live weight and with a decrease of \$4.8363 in net revenue from feeding.

Subjective frame size had an important positive effect on days on feed for all cost-price conditions analyzed. These results indicate that larger framed animals are expected to reach their optimum slaughter points at a greater number of days on feed. These findings are consistent with the general findings of Butts et al. [II] in which frame size was positively related to days on feed. When accounting for breed differences, Butts et al. [II] reported that frame size was related ($P < .01$) to days on feed among calves receiving a high energy diet but, frame was not related ($P > .05$) to days of feed among calves receiving a medium energy diet.

A positive relationship existed between frame size and final live weight for all cost-price conditions. These results were expected since higher scores for frame size were associated with increases in anticipated slaughter weight. These findings are also consistent with the findings of Butts et al. [II] in which frame size was positively related ($P < .001$) with carcass weight. Other studies have revealed

Table 23. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Subjective Frame Size Score (1-15) When Maximizing Net Revenue to the Animal.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	1/4" Trim Pricing
Days on Feed	2.6638 (0.6957)	3.4329 (0.7650)	1.2836 (0.4579)	1.7537 (0.5493)	3.3879 (0.7579)	1.9733 (0.5831)
Final Live Weight (lbs.)	9.8434 (1.7586)	12.1933 (1.8738)	5.6654 (1.3489)	7.1254 (1.4774)	12.1818 (1.8609)	7.7634 (1.5211)
Final Fat Thickness (mm)	-0.0971 (0.0538)	-0.0645 (0.0601)	-0.1516 (0.0382)	-0.1246 (0.0434)	-0.0627 (0.0594)	-0.1301 (0.0439)
Yield Grade	-0.0134 (0.0074)	-0.0089 (0.0082)	-0.0209 (0.0052)	-0.0172 (0.0060)	-0.0087 (0.0081)	-0.0180 (0.0060)
Marbling Score	0.0157 (0.0084)	0.0211 (0.0091)	0.0057 (0.0060)	0.0105 (0.0070)	0.0203 (0.0090)	0.0116 (0.0073)
Net Revenue (\$)	-4.8363 (0.5890)	-3.3966 (0.7242)	-5.8676 (0.4944)	-5.4271 (0.5677)	-4.0085 (0.6362)	-4.7030 (0.5666)
Feed Cost (\$)	3.2795 0.8103	4.2907 (0.8880)	1.6463 (0.5451)	2.6295 (0.7660)	3.3854 (0.7067)	2.4559 (0.6806)
Derived Feeder Value (\$/cwt.)	0.2881 (0.0884)	0.5487 (0.1163)	0.0987 (0.0673)	0.1783 (0.0842)	0.4385 (0.0978)	0.3099 (0.0830)

that tall or rangy calves, which were represented by higher scores for frame in this study, produced heavier carcasses than did small framed animals [Butts et al., II].

The results indicated that frame size was negatively associated with final fat thickness and carcass yield grade. However, frame size had an important effect on fat thickness and yield grade for only low carcass price, high feed cost, and 1/4" trim pricing conditions. For those cost-price conditions, the findings indicate that larger framed animals are associated with lower fat thickness levels and yield grades at their optimum slaughter points.

A positive association existed between frame size and carcass marbling score for all cost-price conditions, but frame size was an important determinant of marbling score for only high carcass price and low feed cost conditions. These findings indicate that larger framed animals are associated with higher marbling scores and thus more desirable quality grades under high carcass price and low feed cost conditions. These results seem to be inconsistent with other studies which reported that in general large framed calves produced heavier carcasses with less fat and lower quality grades than small framed, compact animals [Butts et al., II]. However, the animals analyzed in the previous studies were slaughtered at equal ages or weights. The positive relationship between frame size and marbling score obtained in this study may be due to the fact that the simulated animals reached their optimum at various lengths of the feeding process and in general, those animals with higher frame size scores were characterized by an increase in the optimum number of days on

feed. Since days on feed was a primary determinant of marbling score in the feeding simulation model, it would be expected that larger animals which optimized at longer lengths of days on feed would be associated with higher marbling scores at optimum days on feed.

Subjective frame size had an important negative effect on net revenue from feeding for all cost-price conditions. These results suggest that large framed animals are associated with decreased returns to the feeding process for all the conditions analyzed.

A positive relationship existed between frame size and feed cost for each cost-price condition examined. These findings may be explained by the increase in the optimum number of days on feed associated with large framed animals, as well as the higher daily feed intake of those animals which would increase feed cost.

Frame size had an important positive effect on the derived value per hundredweight of the feeder animal for each cost-price condition analyzed with the exception of low carcass price. These findings indicate that larger framed animals are associated with increases in the derived value per hundredweight of the animal for the remaining conditions examined.

It is important to note that the negative relationship between frame size and net revenue was a result of the prices paid for feeder animals in the analysis. Medium framed animals were associated with lower net revenue from feeding because they were generally priced higher than smaller framed animals. Medium Frame animals were priced from \$8.84 to \$10.63 per hundredweight higher than Small Frame animals. Although Large Frame animals were priced below Medium Frame,

the smaller number of animals in the Large Frame category apparently did not offset the negative relationship between frame size and net revenue resulting from Medium Frames priced considerably higher than Small Frames. However, it should be noted that frame size was positively related to derived value per hundredweight for each condition except low carcass price which indicates that larger framed animals were associated with higher derived values for the remaining conditions analyzed.

Maximizing net revenue to the feedlot space. Table 24 contains the coefficients associated with subjective frame size when maximizing net revenue to the feedlot space. The directions of the associations between subjective frame score and the feedlot and carcass characteristics were identical to the results obtained when maximizing net revenue to the animal.

A positive relationship existed between frame size score and days on feed for all cost-price conditions. Subjective frame size was also positively related to final live weight for all conditions. A negative association existed between frame size and final fat thickness and carcass yield grade for each condition, but none of the coefficients for fat thickness or yield grade were at least twice the size of the corresponding standard errors. The results indicated that frame size was positively associated with carcass marbling score for all conditions analyzed. However, frame size was important in describing the variation in marbling score for only the high feed cost condition.

Table 24. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Subjective Frame Size Score (1-15) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Cost-Price Conditions			
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost Low Feed Cost
Days on Feed	3.1309 (0.7736)	3.4061 (0.8498)	2.6408 (0.6965)	3.0368 (0.7125) 3.4234 (0.8406)
Final Live Weight (lbs.)	11.9605 (1.8574)	12.6691 (1.9710)	9.8713 (1.7296)	10.9786 (1.7513) 12.6719 (1.9546)
Final Fat Thickness (mm)	-0.0941 (0.0601)	-0.1001 (0.0630)	-0.0977 (0.0544)	-0.0794 (0.0558) -0.1090 (0.0616)
Yield Grade	-0.0129 (0.0082)	-0.0138 (0.0087)	-0.0135 (0.0075)	-0.0110 (0.0077) -0.0150 (0.0085)
Marbling Score	0.0162 (0.0090)	0.0150 (0.0096)	0.0150 (0.0083)	0.0186 (0.0084) 0.0137 (0.0093)
Net Revenue Per Day (\$)	-0.0209 (0.0032)	-0.0200 (0.0035)	-0.0232 (0.0040)	-0.0240 (0.0035) -0.0173 (0.0030)
Feed Cost (\$)	3.9844 (0.8905)	4.4146 (0.9703)	3.2644 (0.8013)	4.4620 (0.9841) 3.5382 (0.7672)
Derived Feeder Value (\$/cwt.)	0.2850 (0.0941)	0.5481 (0.1199)	0.0588 (0.0764)	0.1394 (0.0922) 0.4370 (0.1032)

Frame size had an important negative effect on net revenue per day from feeding for all cost-price conditions analyzed. These findings indicate that larger framed animals are associated with lower returns to the feedlot facility. Again, this negative relationship was due to higher purchase prices associated with Medium Frame compared to Small Frame animals in the analysis.

Frame size was positively related to feed cost for each cost-price condition indicating that larger framed animals are associated with higher costs of feeding at their optimum length of feeding period. A positive association existed between frame size and the derived value per hundredweight of the feeder animal for all conditions. Frame size was important in describing the variation in derived value for base, high carcass price, and low feed cost conditions. For those cost-price conditions, the results indicate that larger framed animals are associated with higher derived values of the feeder animal.

Subjective Muscle Thickness Score

Maximizing net revenue to the animal. The regression coefficients associated with a one unit increase in subjective muscle thickness score when maximizing net revenue to the animal are summarized in Table 25. For example under base prices and costs, a unit increase in subjective muscle thickness is associated with a reduction in final live weight of 5.8796 pounds and a reduction of \$2.3845 in net revenue from feeding.

Table 25. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Subjective Muscle Thickness Score (1-15) When Maximizing Net Revenue to the Animal.

Dependent Variable	Base Prices and Costs	Cost-Price Conditions				
		High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	1/4" Trim Pricing
Days on Feed	-1.7349 (1.0812)	-1.4251 (1.1890)	-0.6343 (0.7117)	-0.9498 (0.8538)	-1.4681 (1.1779)	-1.5385 (0.9062)
Final Live Weight (lbs.)	-5.8796 (2.7332)	-5.7463 (2.9122)	-3.1819 (2.0965)	-3.9043 (2.2962)	-5.4538 (2.8923)	-4.7255 (2.3641)
Final Fat Thickness (mm)	-0.1270 (0.0836)	-0.1057 (0.0934)	-0.0482 (0.0594)	-0.0628 (0.0675)	-0.1025 (0.0924)	-0.1089 (0.0682)
Yield Grade	-0.0175 (0.0115)	-0.0146 (0.0128)	-0.0068 (0.0082)	-0.0087 (0.0093)	-0.0142 (0.0127)	-0.0151 (0.0094)
Marbling Score	-0.0224 (0.0131)	-0.0154 (0.0141)	-0.0092 (0.0093)	-0.0146 (0.0108)	-0.0162 (0.0140)	-0.0230 (0.0114)
Net Revenue (\$)	-2.3845 (0.9154)	-3.1105 (1.1255)	-1.8786 (0.7684)	-2.0195 (0.8824)	-2.9205 (0.9888)	-1.9616 (0.8807)
Feed Cost (\$)	-2.6323 (1.2594)	-2.4896 (1.3802)	-1.3408 (0.8472)	-2.0444 (1.1905)	-1.9894 (1.0984)	-2.3139 (1.0579)
Derived Feeder Value (\$/cwt.)	-0.1346 (0.1374)	-0.2704 (0.1808)	-0.0397 (0.1046)	-0.0664 (0.1308)	-0.2332 (0.1520)	-0.0561 (0.1291)

Subjective muscle thickness was negatively associated with days on feed for all cost-price conditions analyzed. However, muscle thickness was not important in explaining the variation in days on feed for all conditions. A negative association existed between muscle thickness and final live weight, but muscle thickness had an important effect on live weight for only the base prices and costs condition. These findings indicate that under base conditions, heavier muscled steers are associated with lower final live weights at their optimum feeding points. Butts et al. [II] reported that muscle thickness was unrelated ($P > .05$) to days on feed as well as carcass weight.

The results indicated that muscle thickness was negatively associated with final fat thickness, as well as carcass yield grade, for each cost-price condition. However, none of the coefficients for either fat thickness or yield grade were at least twice the size of the corresponding standard errors. A negative association also existed between muscle thickness and carcass marbling score for each condition, but muscle thickness had an important impact on marbling score only for the 1/4" trim pricing condition.

A negative relationship existed between subjective muscle thickness score and net revenue from feeding for all cost-price conditions analyzed. These results indicate the heavier muscled steers are associated with lower net returns from feeding at their optimum slaughter points. Muscle thickness and feed costs were negatively associated for each condition, but muscle thickness was related to feed cost only for the base and 1/4" trim pricing conditions. A

negative association existed between muscle thickness and the derived value per hundredweight of the feeder animal. However, none of the coefficients for derived value were at least twice the size of the corresponding standard error.

Maximizing net revenue to the feedlot space. Table 26 contains the regression coefficients associated with subjective muscle thickness score when maximizing net revenue to the feedlot space. The direction (negative) of the associations between subjective muscle thickness and the feedlot and carcass characteristics was identical to the results obtained when maximizing net revenue to the animal.

A negative association existed between muscle thickness and days on feed for all cost-price conditions, but muscle thickness was unimportant in explaining the variation in days on feed for each condition. Muscle thickness was negatively associated with final live weight for all conditions. However, muscle thickness had an important effect on live weight for only the high feed cost condition. Subjective muscle thickness was negatively associated with final fat thickness, yield grade, and marbling score, but none of the coefficients for these characteristics were at least twice the size of the corresponding standard errors.

A negative association existed between muscle thickness and net revenue per day, and muscle thickness had an important effect on net revenue per day for each condition analyzed except high carcass price. These findings indicate that heavier muscled steers are associated with lower returns to the feedlot facility when slaughtered at their optimum length of feeding for base, low carcass price, and high and

Table 26. Regression Coefficients and Standard Errors Associated with the Explanatory Variable Subjective Muscle Thickness Score (1-15) When Maximizing Net Revenue to the Feedlot Space.

Dependent Variable	Cost-Price Conditions					
	Base Prices and Costs	High Carcass Price	Low Carcass Price	High Feed Cost	Low Feed Cost	
Days on Feed	-1.0162 (1.2024)	-1.0189 (1.3208)	-1.3664 (1.0826)	-1.4340 (1.1073)	-1.1813 (1.3065)	
Final Live Weight (lbs.)	-4.8579 (2.8868)	-5.0824 (3.0634)	-5.3119 (2.6881)	-5.8047 (2.7219)	-5.4008 (3.0380)	
Final Fat Thickness (mm)	-0.0767 (0.0934)	-0.0729 (0.0979)	-0.1128 (0.0845)	-0.1165 (0.0867)	-0.0834 (0.0958)	
Yield Grade	-0.0106 (0.0128)	-0.0101 (0.0135)	-0.0156 (0.0116)	-0.0161 (0.0119)	-0.0115 (0.0132)	
Marbling Score	-0.0111 (0.0140)	-0.0086 (0.0149)	-0.0190 (0.0129)	-0.0196 (0.0131)	-0.0094 (0.0145)	
Net Revenue Per Day (\$)	-0.0126 (0.0050)	-0.0107 (0.0054)	-0.0162 (0.0061)	-0.0138 (0.0055)	-0.0118 (0.0046)	
Feed Cost (\$)	-2.0837 (1.3840)	-2.0747 (1.5081)	-2.2920 (1.2455)	-2.9546 (1.5296)	-1.7835 (1.1923)	
Derived Feeder Value (\$/cwt.)	-0.1518 (0.1463)	-0.2805 (0.1864)	-0.0039 (0.1187)	-0.0461 (0.1433)	-0.2328 (0.1604)	

low feed cost conditions. Muscle thickness was negatively associated with feed cost and the derived value per hundredweight of the feeder animal for all cost-price conditions. However, muscle thickness was unimportant in explaining the variation in either feed cost or derived value for all conditions analyzed.

Comparisons of Results from Base and 1/4" Trim Pricing Conditions

Comparison of results from the base and 1/4" trim pricing conditions is of interest due to the emerging consumer preference for leaner beef. Of particular interest is the comparison of the effects of feeder calf characteristics on net revenue and derived feeder value per hundredweight for the two cost-price conditions.

The positive effect of initial weight on net revenue was approximately the same for the two conditions. However, the negative association of initial weight with derived feeder value for the 1/4" trim pricing condition was smaller in magnitude than the negative effect of initial weight in derived value for the base condition.

Initial fat thickness had a stronger negative effect on net revenue and derived feeder value for the 1/4" trim pricing condition than for the base results. These findings indicate that initially fatter animals would be expected to generate lower returns to the feeding process and have lower derived values per hundredweight if the 1/4" trim pricing structure was adopted.

As for breed effects, the negative effects of Angus on net revenue and derived feeder value were approximately the same for the two conditions. Hereford had a stronger negative association with net

revenue and derived value per hundredweight for the 1/4" trim pricing condition than for the base results. The negative association between Charolais-cross and net revenue and derived feeder value was considerably smaller in magnitude for the 1/4" trim condition. The positive effect of Angus-Hereford-cross on net revenue and derived feeder value was smaller in magnitude for the 1/4" trim pricing condition. From these findings, it would be expected that Angus-Hereford-cross animals would generate lower returns from feeding and have lower derived values per hundredweight if the 1/4" trim pricing structure was adopted.

Subjective frame size had a weaker negative effect on net revenue for the 1/4" trim pricing condition when compared to the base results. The positive effect of frame size on derived feeder value was larger in magnitude for the 1/4" trim condition. These findings indicate that larger framed animals would be expected to generate higher returns to the feeding process and have higher derived values per hundredweight if the 1/4" trim pricing structure was adopted.

The negative effect of subjective muscle thickness on net revenue from feeding was smaller in magnitude for the 1/4" trim pricing condition which indicates that heavier muscled animals will generate higher returns if the 1/4" trim price structure was adopted. The negative association between muscle thickness and derived feeder value was also of smaller magnitude for the 1/4" trim pricing condition.

CHAPTER 4

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary and Conclusions

The primary objective of this study was to analyze the effect of feeder calf characteristics on important feedlot and carcass characteristics. The feeder calf characteristics examined in the study were initial weight and fat thickness, diet, breed, and subjective frame size and muscle thickness scores. Individual effects of these observable feeder calf characteristics on the length of the feeding process, final live weight and fat thickness, carcass yield grade and marbling score, feed cost, profitability of the feeding process, and derived value of the feeder animal were examined for animals fed to their individually optimal slaughter point. The analysis included separate results for maximizing net revenue to the animal and to the feedlot facility for differing cost-price scenarios.

In order to accomplish the primary objective, a bioeconomic simulation model was developed to represent animals individually during the feedlot finishing process. The set of mathematical equations included in the model described the purchase, feeding, growth and selling process for the 784 individual animals in the study. Regression analysis was utilized to generate coefficients for growth, in terms of weight, fat thickness, feed consumption, yield and quality grades, and salable carcass weight.

The simulation model was designed to allow the optimization of selling dates for individual animals by calculating the maximum net

returns to an individual animal or to the feedlot space which the animal occupies. Net returns to the animal and to the feedlot space were calculated every five days (from 100 to 340) on feed and the optimum selling point was determined. An individual animal's important feedlot and carcass characteristics which were utilized to meet the primary objective correspond to the animal's optimum selling point.

The base models for maximizing net revenue to the animal and to the feedlot space included costs and prices representative of 1985, with the exception of carcass price which was based on 1983-1984 prices. Also, additional simulations were conducted to evaluate the effects of changes in feed costs and carcass prices and the emerging preference for leaner beef on the relationship between feeder animal characteristics and feedlot and carcass characteristics. The effect of individual feeder calf characteristics at optimum slaughter points was analyzed by regressing each important feedlot and carcass characteristic for the 784 animals on the observable feeder calf characteristics. The R^2 values for some of these regressions were relatively low which indicates the existence of other factors which have important effects on the feedlot and carcass characteristics analyzed. A feeder calf characteristic was identified as having an important effect on a feedlot or carcass characteristic if the coefficient associated with the feeder calf characteristic was at least twice the size of the corresponding standard error.

Applicability of the Simulation Model

The results indicated that the bioeconomic simulation model developed for this study responded predictably to differing cost-price conditions. As expected, increases in carcass price and decreases in feed cost resulted in increases in the mean optimum number of days on feed and in mean net returns from feeding when maximizing net revenue to the animal and to the feedlot facility. Also, decreases in carcass price and increases in feed cost resulted in reductions in the optimum mean number of days on feed and net returns from the feeding process.

The results of this study revealed that individual feeder calf characteristics had important effects on the feedlot and carcass characteristics analyzed. The identification of these important effects allows several conclusions to be drawn concerning the effect of individual feeder calf characteristics on important feedlot and carcass characteristics. However, due to the relatively low R^2 values associated with some of the regressions and the existence of other factors affecting feedlot and carcass characteristics, it cannot be concluded that the feeder calf characteristics examined in this study can be used alone to accurately predict important feedlot and carcass characteristics.

Maximizing Net Revenue to the Animal

A relationship was identified between initial weight and days on feed, final live weight, marbling score, and feed cost for each cost-price condition. Initial weight was negatively related to days on feed, marbling score, and feed cost while a positive relationship existed between initial weight and final live weight. From these

findings, it can be concluded that initially heavier animals can be expected to reach their optimum slaughter points at fewer days on feed with lower marbling scores and feed costs and higher final live weights. Initial weight was positively related to net revenue from feeding for all conditions with the exceptions of low carcass price and low feed cost indicating initially heavier animals were associated with higher net returns from feeding for the remaining conditions analyzed. A negative relationship existed between initial weight and derived value of the feeder animal for base, high carcass price, and low feed cost conditions indicating that initially heavier animals were associated with lower derived feeder values for those conditions. However, initial weight was positively related to derived feeder value for the low carcass price condition which indicates that initially heavier animals were associated with higher derived values for that condition. Initial weight was negatively related to yield grade for only high carcass price and low feed cost conditions and to final fat thickness for only the low feed cost condition. Thus during periods of low feed cost, initially heavier animals can be expected to have lower fat thickness levels and yield grades, and during periods of high carcass price, initially heavier animals are associated with lower yield grades.

Initial fat thickness was positively related to final fat thickness and yield grade and negatively related to days on feed, final live weight, net revenue, feed cost, and derived value of the feeder animal for all cost-price conditions. Thus, it can be concluded that initially fatter steers can be expected to reach their optimum

slaughter points at fewer days on feed with higher final fat thickness levels and yield grades, and lower final live weights, net returns from feeding, feed costs, and derived feeder animal values per hundredweight.

Diet was positively related to final live weight and fat thickness, yield grade, marbling score, net revenue, and derived value of the feeder animal for all conditions examined. These findings indicate that concentrate-fed steers had higher final live weights and fat thickness levels, yield grades, marbling scores, net returns from feeding, and derived feeder values at their optimum slaughter points. Diet was negatively related to days on feed for each cost-price condition except low carcass price indicating that concentrate-fed animals could be expected to reach their optimum slaughter points at fewer days on feed for the remaining conditions. Also, diet was positively related to feed cost for low carcass price, high feed cost, and 1/4" trim pricing conditions, and thus, concentrate-fed animals can be expected to have lower feed cost for those conditions.

As for breed effects, Angus was negatively related to final live weight and derived value of the feeder animal for each cost-price condition indicating Angus steers were represented by lower final weights and derived values at their optimum slaughter points. The findings revealed a negative relationship between Angus and net revenue for each condition except low carcass price indicating Angus animals can be expected to generate lower returns to the feeding process for the remaining conditions analyzed. Also, Angus and feed cost were negatively related for each condition with the exceptions of

high carcass price and low feed cost which indicates that Angus animals are associated with lower feed costs for the remaining conditions.

Hereford was positively related to final fat thickness and yield grade for only the high carcass price condition. From these findings, it can be concluded that Hereford animals can be expected to have higher fat thickness levels and yield grades at their optimum slaughter points during periods of high carcass price.

Charolais-cross was negatively related to final fat thickness and yield grade for all conditions, and it can be concluded that Charolais-cross animals reached their optimum slaughter points at lower fat thickness levels and yield grades. Charolais-cross was positively related to days on feed, final live weight, and feed cost for only high carcass price and low feed cost conditions. These findings indicate that during high carcass price and low feed cost conditions, Charolais-cross animals reached their optimum slaughter points at a greater number of days on feed with higher live weights and feed costs. A negative relationship existed between Charolais-cross and net revenue from feeding for only the low carcass price condition indicating that Charolais-cross animals can be expected to generate lower returns during periods of low carcass price.

The results revealed that Angus-Hereford-cross was positively related to net revenue and derived value of the feeder animal for all cost-price conditions. From these findings, it can be concluded that Angus-Hereford-cross animals were associated with higher net returns

from feeding and higher derived feeder values at their optimum slaughter points. A positive relationship existed between Angus-Hereford-cross and final live weight, fat thickness, and yield grade for each condition with the exceptions of high carcass price and low feed cost. Thus, it can be concluded that Angus-Hereford-cross animals were associated with higher live weights, fat thickness levels, and yield grades at their optimum slaughter points for the remaining conditions analyzed. Also, Angus-Hereford-cross was positively related to marbling score for low carcass price, high feed cost, and 1/4" trim pricing conditions indicating that Angus-Hereford-cross animals can be expected to have higher marbling scores at their optimum points during those conditions.

The findings of this study indicated that subjective frame size score was positively related to days on feed, final live weight, feed cost, and derived value of the feeder animal and negatively related to net revenue for each cost-price condition. Thus, it can be concluded that larger framed animals reached their optimum slaughter points at a greater number of days on feed with higher final live weights, feed costs, and derived feeder values and lower returns from feeding. Subjective frame size score was negatively related to final fat thickness and yield grade for only low carcass price, high feed cost, and 1/4" trim pricing conditions which indicates that larger framed animals were associated with lower fat thickness levels and yield grades at their optimum slaughter points for those conditions. Also, frame size was positively related to marbling score for only high carcass price and low feed cost conditions which indicates that larger

framed animals can be expected to have higher marbling scores at their optimum points for those conditions.

It should be noted that the conclusions concerning net revenue as well as net revenue per day when maximizing net revenue to the feedlot space are dependent on the prices paid for the feeder animal. For example, a negative relationship existed between frame size and net revenue when maximizing net revenue to the animal. This relationship was due to the fact that Medium Frame animals were priced higher than the Small Frame animals in the simulations (\$8.84 to \$10.63 per cwt.). It is important to note that while the relationship between frame size and net revenue was negative, larger framed animals were related to higher derived values per hundredweight for the feeder animal.

The results indicated that subjective muscle thickness score was negatively related to net revenue from feeding for all cost-price conditions. These findings indicate that heavier muscled animals are expected to generate lower net returns when slaughtered at their optimum points. Muscle thickness was negatively related to feed cost for only the base and 1/4" trim pricing conditions which indicates that heavier muscled animals were associated with lower costs of feeding at their optimum slaughter points for those conditions. A negative relationship existed between muscle thickness and final live weight for only the base condition indicating that heavier muscled animals were associated with lower live weights at their optimum points for that condition. Also, muscle thickness was negatively related to marbling score for only the 1/4" trim pricing condition

which indicates that heavier muscled animals reached their optimum points at lower marbling scores for that condition.

It should be noted that the effect of subjective muscle thickness was limited to the variation in muscle thickness exhibited by only beef breeds in this study. No observations were available for animals representing No. 3 Muscle. Thus, the associations and relationships concerning muscle thickness which were identified in this study may not be applicable if No. 3 muscled animals were considered.

Maximizing Net Revenue to the Feedlot Space

When maximizing net revenue to the feedlot space, initial weight was negatively related to days on feed and marbling score and positively related to final weight for all cost-price conditions analyzed (1/4" trim pricing was not included when maximizing net revenue to the feedlot space). From these findings, it can be concluded that initially heavier animals reached their optimum length of feeding period at fewer days on feed with heavier final live weights and lower marbling scores. Also, initial weight was related to the derived value per hundredweight of the feeder animal for all conditions. A negative relationship existed between initial weight and derived value for base, high carcass price, and low feed cost conditions indicating that initially heavier animals were associated with lower derived values for those conditions. For low carcass price and high feed cost conditions, initial weight was positively related to derived value indicating initially heavier animals were associated with higher derived values. Initial weight was negatively related to final fat thickness, yield grade, and feed cost for base, low carcass price, and

high feed cost conditions indicating that initially heavier animals can be expected to have lower fat thickness levels, yield grades, and feed costs at their optimum points for those conditions. Initial weight was positively related to net revenue per day for the high carcass price condition and negatively related to net revenue per day for the low carcass price condition. These findings indicate that initially heavier animals are expected to generate higher (lower) net returns per day for the high (low) carcass price condition.

Initial fat thickness was related to each of the feedlot and carcass characteristics analyzed, except marbling score, for all cost-price conditions. A negative relationship existed between initial fat thickness and days on feed, final live weight, net revenue per day, feed cost, and derived value of the feeder animal while initial fat thickness was positively related to final fat thickness and yield grade. From these findings, it can be concluded that initially fatter animals reached their optimum length of feeding period at fewer days on feed with higher fat thickness levels and yield grades and lower final live weights, net returns per day from feeding, feed costs, and derived feeder values per hundredweight.

Diet was positively related to final fat thickness, yield grade, net revenue per day, and derived feeder value and negatively related to days on feed for each cost-price condition examined. These findings indicate that concentrate-fed animals can be expected to reach their optimum length of feeding points at fewer days on feed with higher fat thickness levels, yield grades, net returns per day, and derived values per hundredweight. A positive relationship existed

between diet and marbling score for base, low carcass price, and high feed cost conditions which indicates that concentrate-fed animals are associated with higher marbling scores at their optimum points for those conditions. Diet was positively related to final live weight for low carcass price and high feed cost conditions indicating that concentrate-fed animals were associated with higher live weights at their optimum length of feeding period for those conditions. A negative relationship existed between diet and feed cost for only high carcass price and low feed cost conditions which indicates that concentrate-fed animals can be expected to have higher feed costs at their optimum points for those conditions.

As for breed effects, Angus was negatively related to final live weight, net revenue per day, and derived value of the feeder animal for each cost-price condition. These findings indicate that Angus animals were associated with lower live weights, net returns per day, and derived feeder values at their optimum length of feeding period. Also, Angus was negatively related to feed cost for only low carcass price and high feed cost conditions and to days on feed for only the low carcass price condition. From these findings, it can be concluded that at their optimum points Angus animals were associated with lower feed costs for low carcass price and high feed cost conditions and with fewer days on feed for the low carcass price condition. Hereford was not related to any of the feedlot and carcass characteristics when maximizing net revenue to the feedlot space.

Charolais-cross was positively related to days on feed and negatively related to final fat thickness and yield grade for all

conditions. These findings indicate that Charolais-cross animals are expected to reach their optimum length of feeding period at a greater number of days on feed with lower fat thickness levels and yield grades. Charolais-cross was positively related to final live weight and feed cost for each condition with the exceptions of low carcass price and high feed cost which indicates that Charolais-cross animals can be expected to have higher live weights and feed costs at their optimum points for the remaining conditions analyzed. Also, a negative relationship existed between Charolais-cross and derived feeder value for only the low carcass price condition indicating that Charolais-cross animals were associated with lower derived values per hundredweight at their optimum length of feeding period for that condition.

Angus-Hereford-cross was positively related to net revenue per day and derived value of the feeder animal for each condition analyzed. From these findings, it can be concluded that Angus-Hereford-cross animals could be expected to generate higher net returns to the feedlot facility with higher derived feeder values at their optimum length of feeding period. Also, Angus-Hereford-cross was positively related to final fat thickness and yield grade for only low carcass price and high feed cost conditions and to final live weight for only the low carcass price condition. From these findings, it can be concluded that Angus-Hereford-cross animals could be expected to have higher fat thickness levels and yield grades for low carcass price and high feed cost conditions and to have lower final live weights for the low carcass price condition at their optimum points.

Subjective frame size score was positively related to days on feed, final live weight, and feed cost and negatively related to net revenue per day for each cost-price condition. These findings indicated that larger framed animals reached their optimum length of feeding period at a greater number of days on feed with higher live weights and feed costs and lower net returns to the feedlot facility. A positive relationship existed between frame size and derived feeder value for each condition with the exceptions of low carcass price and high feed cost which indicates that larger framed animals were associated with higher derived values of the feeder animal for the remaining conditions analyzed. Also, frame size was positively related to marbling score for only the high feed cost condition indicating that larger framed animals were associated with higher marbling scores for that condition.

Subjective muscle thickness was negatively related to net revenue per day for each condition examined except high carcass price. From these findings, it can be concluded that heavier muscled animals were associated with lower net returns to the feedlot facility for the remaining conditions analyzed. The only remaining identifiable effect of muscle thickness was a negative relationship between muscle thickness and final live weight for the high feed cost condition which indicates that heavier muscled animals could be expected to have lower feed costs for that condition.

Implications

The results of this analysis imply that feeder calf characteristics have important identifiable effects on the optimal length of the feeding process, the profitability and derived value of the feeder animal, as well as important feedlot and carcass characteristics. However, the general lack of importance of subjective muscle thickness in describing the variation of the feedlot and carcass characteristics examined indicates that the current feeder cattle grading system should be reevaluated.

The U.S.D.A. identified muscle thickness as an indicator of a feeder animal's potential carcass yield grade [U.S.D.A. Federal Register]. However, this study implies that the feeder animal's initial fat thickness or condition is a better indicator of carcass yield grade at optimal feeding points.

The results imply that for feedlot managers who intend to maximize net revenue to the animal, the feeder animal which is most profitable under price and costs conditions simulated is characterized by an Angus-Hereford-cross steer with an initially heavier weight and lower subcutaneous fat thickness. Also, lower subjective scores for frame size and muscle thickness were associated with increased returns to the animal.

When maximizing net revenue to the feedlot space, the results implied that the most profitable animal was an Angus-Hereford-cross steer with lower initial fat thickness levels. Lower subjective scores for frame size and muscle thickness were also associated with increased returns to the feedlot facility. Again, it should be noted

that the larger framed animals were associated with lower returns to the feeding process because Medium Frame animals were priced higher than Small Frame animals in the study.

The results imply that for maximization of net revenue to the animal, the feeder animal which has the highest derived value per hundredweight is typically characterized by an Angus-Hereford-cross steer with an initially lighter weight (heavier weight for low carcass price and high feed cost conditions) and lower subcutaneous fat thickness levels. Also, higher subjective frame size scores were associated with increases in derived feeder animal value.

When maximizing net revenue to the feedlot space, the results imply that the feeder animal which had the highest derived value per hundredweight was an Angus-Hereford-cross steer with an initially lighter weight (heavier weight for low carcass price and high feed cost conditions) and lower fat thickness levels. Higher subjective scores for frame size were also associated with increases in derived feeder value.

The comparisons of the important effects of feeder calf characteristics on feedlot and carcass characteristics when maximizing net revenue to the animal for the base and 1/4" trim pricing conditions allows several implications to be drawn if the 1/4" trim pricing structure was adopted. Of particular interest is the effect of such a change in the price structure on net revenue from feeding and derived feeder value. If the 1/4" trim price structure was adopted, initial weight would be expected to have approximately the same positive effect on net revenue. However the results implied that initially

fatter and Angus-Hereford-cross animals would be less profitable under the new pricing structure. Also, larger framed and heavier muscled animals were associated with increased returns for the 1/4" trim pricing structure.

As for the derived value of the feeder animal, the results imply that initially fatter and Angus-Hereford-cross animals would be associated with decreases in the derived value per hundredweight for the 1/4" trim pricing structure while Angus animals would be expected to have approximately the same negative effect on derived feeder value. Also, larger framed animals were associated with increased derived value per hundredweight for the new price structure.

If feedlot managers attempt to maximize net returns either to the animal or the feedlot facility by feeding those animals which possess the profit-indicating feeder calf characteristics, the commercial cow-calf producers can then adjust their operations to produce feeder calves with those characteristics desired by feedlot operations. This should result in an improvement in the efficiency of this marketing link of the beef industry, and increased net returns should be shared within the industry. It is important to note that the cost of production of the feeder animal has not been analyzed in this study. Thus, the analysis did not include the adjustments which the cow-calf producer would have to make to produce feeder animals possessing the desired characteristics.

As a suggestion for further research, the bioeconomic simulation model developed in this study could be expanded to include heifers and additional breeds as well as cross-breds. Consideration of heifers

and additional breeds should add more information concerning the optimal feeding point of the feeder animal.

Further applications of the model would be to examine the effects of additional changes in the premiums and discounts associated with carcass yield and quality grades on important feedlot and carcass characteristics. Also, maximizing net revenue to the feedlot space could be examined for conditions in which the expectations associated with the replacement animals differed from the expectations associated with this study. For example during high carcass price conditions, the optimum length of the feeding period could be analyzed when higher prices were expected for the replacement animals.

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APPENDIX

REGRESSION EQUATIONS FOR SEPARATE COST-PRICE CONDITIONS

Multiple linear regressions were utilized to examine the impact of feeder calf characteristics on the optimal length and profitability of the feeding process, derived value per hundredweight of the feeder animal and on other economically important feedlot and carcass characteristics. The selected dependent variables which were regressed on feeder cattle characteristics were days on feed, final live weight, final fat thickness, carcass yield grade, marbling score, net revenue or net revenue per day, feed cost, and feeder animal value per hundredweight of initial weight. The dependent variables for the 784 individual animals in the study were observed at the optimal point at which net revenue to either the animal or the feedlot space was maximized. The individual animal feeder calf characteristics (explanatory variables) were initial weight and fat thickness, diet, breed, and subjective scores for frame size and muscle thickness.

The results of these multiple regressions are presented for separate cost-price conditions when maximizing net revenue to the animal and to the feedlot space. The selected dependent variables are represented in the following manner:

DOF = number of days on feed

FWT = final live weight (lbs.)

FFT = final subcutaneous fat thickness (mm)

YG = carcass yield grade

MS = carcass marbling score

NR = net revenue (\$) associated with maximizing net revenue to the animal

NRPD = net revenue per day (\$) associated with maximizing net revenue to the feedlot space

FC = feed cost (\$)

V/IWT = derived feeder animal value per hundredweight of initial weight (\$/cwt.).

The feeder calf characteristics (explanatory variables) are represented by the following:

IWT = initial weight (lbs.)

IFT = initial subcutaneous fat thickness (mm)

DIET = animal's diet (1 if concentrate, 0 if silage-concentrate)

A, H, CX, and AH = a set of zero-one-minus-one dummy variables representing Angus, Hereford, Charolais-cross, and Angus-Hereford-cross, respectively

SFS = subjective frame size score (1-15)

SMS = subjective muscle thickness score (1-15).

The results of the multiple regressions of important feedlot and carcass characteristics on feeder calf characteristics are summarized in Tables A-1 through A-11.

Table A-1. Regression Equations for Base Prices and Costs When Maximizing Net Revenue to the Animal.

DOF = 369.0122 - 0.3101IWT - 5.7180IFT - 21.5782DIET - 4.6501A - 4.4598H + 7.1924CX + 1.9175AH (20.5317) (0.0343) (1.7565) (3.2897) (2.8844) (2.9904) (3.7063) (4.0304)	
+ 2.6638SFS - 1.7349SMS (0.6957) (1.0812)	R ² = 0.208
FWT = 792.0442 + 0.2835IWT - 20.5812IFT + 23.1180DIET - 24.2364A - 11.0107H + 11.6333CX + 23.6138AH (51.9016) (0.0868) (4.4403) (8.3160) (7.2916) (7.5595) (9.3692) (10.1885)	
+ 9.8434SFS - 5.8796SMS (1.7586) (2.7332)	R ² = 0.193
FFT = 12.7031 - 0.0048IWT + 0.6215IFT + 1.6859DIET - 0.0044A + 0.3487H - 1.3073CX + 0.9629AH (1.5871) (0.0027) (0.1358) (0.2543) (0.2230) (0.2312) (0.2865) (0.3116)	
- 0.0971SFS - 0.1270SMS (0.0538) (0.0836)	R ² = 0.190
YG = 2.9544 - 0.0007IWT + 0.0855IFT + 0.2316DIET - 0.0007A + 0.0481H - 0.1792CX + 0.1317AH (0.2180) (0.0004) (0.0186) (0.0349) (0.0306) (0.0317) (0.0393) (0.0428)	
- 0.0134SFS - 0.0175SMS (0.0074) (0.0115)	R ² = 0.190
MS = 6.6775 - 0.0030IWT - 0.0014IFT + 0.4144DIET - 0.0384A - 0.0396H - 0.0195CX + 0.0975AH (0.2490) (0.0004) (0.0213) (0.0399) (0.0350) (0.0363) (0.0450) (0.0489)	
+ 0.0157SFS - 0.0224SMS (0.0084) (0.0131)	R ² = 0.187

Table A-1 (Continued)

NR = - 36.3186 + 0.0773IWT - 5.0854IFT + 28.8431DIET - 6.6543A - 2.0856H - 5.1266CX + 13.8665AH (17.3826) (0.0291) (1.4871) (2.7852) (2.4421) (2.5318) (3.1379) (3.4123)	
- 4.8363SFS - 2.3845SMS (0.5890) (0.9154)	R ² = 0.250
FC = 308.8769 - 0.1985IWT - 6.2293IFT + 0.0217DIET - 7.0535A - 5.1078H + 6.3238CX + 5.8375AH (23.9155) (0.0400) (2.0460) (3.8319) (3.3599) (3.4833) (4.3172) (4.6947)	
+ 3.2795SFS - 2.6323SMS (0.8103) (1.2594)	R ² = 0.120
V/IWT = 55.9231 - 0.0122IWT - 0.8903IFT + 5.1052DIET - 1.5047A - 0.1366H - 0.6032CX + 2.2444AH (2.6100) (0.0044) (0.2233) (0.4182) (0.3667) (0.3801) (0.4711) (0.5123)	
+ 0.2881SFS - 0.1346SMS (0.0884) (0.1374)	R ² = 0.230

Table A-2. Regression Equations for Base Prices and Costs When Maximizing Net Revenue to the Feedlot Space.

DOF = 400.1911 - 0.2993IWT - 9.5150IFT - 29.0165DIET - 2.3034A - 3.6427H + 13.2963CX - 7.3502AH (22.8325) (0.0382) (1.9534) (3.6584) (3.2077) (3.3256) (4.1217) (4.4821)	
+ 3.1309SFS - 1.0162SMS (0.7736) (1.2024)	R ² = 0.246
FWT = 828.3777 + 0.3246IWT - 29.0494IFT + 16.7428DIET - 23.0429A - 10.7238H + 24.2194CX + 9.5473AH (54.8176) (0.0917) (4.6897) (8.7833) (7.7013) (7.9842) (9.8956) (10.7609)	
+ 11.9605SFS - 4.8579SMS (1.8574) (2.8868)	R ² = 0.259
FFT = 15.5036 - 0.0060IWT + 0.4315IFT + 1.7942DIET + 0.1363A + 0.5005H - 1.1188CX + 0.4820AH (1.7727) (0.0030) (0.1517) (0.2840) (0.2491) (0.2582) (0.3200) (0.3480)	
- 0.0941SFS - 0.0767SMS (0.0601) (0.0934)	R ² = 0.135
YG = 3.3398 - 0.0008IWT + 0.0593IFT + 0.2466DIET + 0.0185A + 0.0687H - 0.1534CX + 0.0662AH (0.2434) (0.0004) (0.0208) (0.0390) (0.0342) (0.0355) (0.0439) (0.0478)	
- 0.0129SFS - 0.0106SMS (0.0082) (0.0128)	R ² = 0.135
MS = 7.0504 - 0.0028IWT - 0.0337IFT + 0.2121DIET - 0.0148A + 0.0005H 0.0216CX - 0.0073AH (0.2659) (0.0004) (0.0227) (0.0426) (0.0374) (0.0387) (0.0480) (0.0522)	
+ 0.0162SFS - 0.0111SMS (0.0090) (0.0140)	R ² = 0.092

Table A-2 (Continued)

$\text{NRPD} = 0.0697 - 0.00004\text{IWT} - 0.0408\text{IFT} + 0.1144\text{DIET} - 0.0389\text{A} - 0.0153\text{H} - 0.0194\text{CX} + 0.0736\text{AH}$	
(0.0952)	(0.00016) (0.0081) (0.0153) (0.0134) (0.0139) (0.0172) (0.0187)
$- 0.0209\text{SFS} - 0.0126\text{SMS}$	
(0.0032)	(0.0050)
$R^2 = 0.178$	
$\text{FC} = 329.1207 - 0.1626\text{IWT} - 10.4447\text{IFT} - 6.2714\text{DIET} - 5.3398\text{A} - 4.2798\text{H} + 13.0179\text{CX} - 3.3984\text{AH}$	
(26.2808)	(0.0440) (2.2484) (4.2109) (3.6922) (3.8278) (4.7442) (5.1590)
$+ 3.9844\text{SFS} - 2.0837\text{SMS}$	
(0.8905)	(1.3840)
$R^2 = 0.163$	
$\text{V/IWT} = 54.0191 - 0.0108\text{IWT} - 0.8114\text{IFT} + 5.3619\text{DIET} - 1.6226\text{A} - 0.1208\text{H} - 0.7857\text{CX} + 2.5291\text{AH}$	
(2.7773)	(0.0046) (0.2376) (0.4450) (0.3902) (0.4045) (0.5014) (0.5452)
$+ 0.2850\text{SFS} - 0.1518\text{SMS}$	
(0.0941)	(0.1463)
$R^2 = 0.217$	

Table A-3. Regression Equations for High Carcass Price When Maximizing Net Revenue to the Animal.

DOF = 386.1626 - 0.2910IWT - 8.9952IFT - 26.8021DIET - 3.4781A - 3.3066H + 11.4213CX - 4.6365AH (22.5771) (0.0378) (1.9315) (3.6175) (3.1718) (3.2884) (4.0756) (4.4320)	
+ 3.4329SFS - 1.4251SMS (0.7650) (1.1890)	R ² = 0.239
FWT = 808.7890 + 0.3377IWT - 27.8397IFT + 20.1847DIET - 24.0793A - 9.4512H + 21.0026CX + 12.5279AH (55.3005) (0.0925) (4.7310) (8.8606) (7.7691) (8.0545) (9.9828) (10.8557)	
+ 12.1933SFS - 5.7463SMS (1.8738) (2.9122)	R ² = 0.251
FFT = 14.8621 - 0.0058IWT + 0.4528IFT + 1.7990DIET + 0.0835A + 0.5198H - 1.1779CX + 0.5746AH (1.7727) (0.0030) (0.1517) (0.2840) (0.2491) (0.2582) (0.3200) (0.3480)	
- 0.0645SFS - 0.1057SMS (0.0601) (0.0934)	R ² = 0.133
YG = 3.2516 - 0.0008IWT + 0.0623IFT + 0.2472DIET + 0.0111A + 0.0717H - 0.1613CX + 0.0785AH (0.2435) (0.0004) (0.0208) (0.0390) (0.0342) (0.0355) (0.0440) (0.0478)	
- 0.0089SFS - 0.0146SMS (0.0082) (0.0128)	R ² = 0.133
MS = 6.9068 - 0.0027IWT - 0.0317IFT + 0.2685DIET - 0.0249A - 0.0015H + 0.0041CX + 0.0224AH (0.2671) (0.0004) (0.0229) (0.0428) (0.0375) (0.0389) (0.0482) (0.0524)	
+ 0.0211SFS - 0.0154SMS (0.0091) (0.0141)	R ² = 0.109

Table A-3 (Continued)

NR = 57.5892 + 0.1102IWT - 8.3148IFT + 32.7468DIET - 10.2453A - 3.3088H - 3.3507CX + 16.9048AH (21.3726) (0.0357) (1.8285) (3.4245) (3.0026) (3.1129) (3.8582) (4.1955)	
- 3.3966SFS - 3.1105SMS (0.7242) (1.1255)	R ² = 0.173
FC = 317.9523 - 0.1605IWT - 9.9170IFT - 4.2862DIET - 6.3874A - 3.8391H + 10.9335CX - 0.7070AH (26.2087) (0.0438) (2.2422) (4.1993) (3.6820) (3.8173) (4.7312) (5.1449)	
+ 4.2907SFS - 2.4896SMS (0.8880) (1.3802)	R ² = 0.160
V/IWT = 93.3696 - 0.0429IWT - 1.4653IFT + 5.7712DIET - 2.1225A - 0.3834H - 0.2600CX + 2.7659AH (3.4325) (0.0057) (0.2937) (0.5500) (0.4822) (0.4999) (0.6196) (0.6738)	
+ 0.5487SFS - 0.2704SMS (0.1163) (0.1808)	R ² = 0.276

Table A-4. Regression Equations for High Carcass Price When Maximizing Net Revenue to the Feedlot Space.

DOF = 392.3295 - 0.2497IWT - 6.9235IFT - 33.2942DIET - 1.8135A - 6.3559H + 16.7633CX - 8.5938AH (25.0805) (0.0420) (2.1457) (4.0186) (3.5235) (3.6530) (4.5275) (4.9234)	
+ 3.4061SFS - 1.0189SMS (0.8498) (1.3208)	R ² = 0.218
FWT = 802.0884 + 0.4248IWT - 24.6631IFT + 12.2595DIET - 24.1277A - 14.8710H + 30.2334CX + 8.7653AH (58.1710) (0.0973) (4.9766) (9.3206) (8.1724) (8.4726) (10.5010) (11.4192)	
+ 12.6691SFS - 5.0824SMS (1.9710) (3.0634)	R ² = 0.254
FFT = 15.0606 - 0.0028IWT + 0.5883IFT + 1.9400DIET + 0.0720A + 0.4323H - 1.0459CX + 0.5417AH (1.8594) (0.0031) (0.1591) (0.2979) (0.2612) (0.2708) (0.3357) (0.3650)	
- 0.1001SFS - 0.0729SMS (0.0630) (0.0979)	R ² = 0.134
YG = 3.2781 - 0.0004IWT + 0.0810IFT + 0.2664DIET + 0.0098A + 0.0596H - 0.1434CX + 0.0740AH (0.2554) (0.0004) (0.0219) (0.0409) (0.0359) (0.0372) (0.0461) (0.0501)	
- 0.0138SFS - 0.0101SMS (0.0087) (0.0135)	R ² = 0.134
MS = 6.9496 - 0.0020IWT - 0.0028IFT + 0.0491DIET - 0.0116A - 0.0223H + 0.0440CX - 0.0101AH (0.2824) (0.0005) (0.0242) (0.0452) (0.0397) (0.0411) (0.0510) (0.0554)	
+ 0.0150SFS - 0.0086SMS (0.0096) (0.0149)	R ² = 0.033

Table A-4 (Continued)

$\text{NRPD} = 0.0603 + 0.0008\text{IWT} - 0.0321\text{IFT} + 0.1819\text{DIET} - 0.0414\text{A} - 0.0084\text{H} - 0.0366\text{CX} + 0.0863\text{AH}$ $(0.1027) (0.0002) (0.0088) (0.0164) (0.0144) (0.0150) (0.0185) (0.0202)$		
$- 0.0200\text{SFS} - 0.0107\text{SMS}$ $(0.0035) (0.0054)$		
$R^2 = 0.220$		
$\text{FC} = 312.7073 - 0.0954\text{IWT} - 7.8582\text{IFT} - 10.3146\text{DIET} - 5.2592\text{A} - 7.0061\text{H} + 16.5812\text{CX} - 4.3159\text{AH}$ $(28.6375) (0.0479) (2.4500) (4.5885) (4.0233) (4.1711) (5.1696) (5.6217)$		
$+ 4.4145\text{SFS} - 2.0747\text{SMS}$ $(0.9703) (1.5081)$		
$R^2 = 0.148$		
$\text{V/IWT} = 92.3924 - 0.0426\text{IWT} - 1.5664\text{IFT} + 5.9402\text{DIET} - 2.1451\text{A} - 0.2960\text{H} - 0.3737\text{CX} + 2.8147\text{AH}$ $(3.5400) (0.0059) (0.3029) (0.5672) (0.4973) (0.5156) (0.6390) (0.6949)$		
$+ 0.5481\text{SFS} - 0.2805\text{SMS}$ $(0.1199) (0.1864)$		
$R^2 = 0.271$		

Table A-5. Regression Equations for Low Carcass Price When Maximizing Net Revenue to the Animal.

DOF = 252.5522 - 0.1960IWT - 4.0161IFT - 3.2782DIET - 3.6274A - 2.9851H + 4.9629CX + 1.6496AH (13.5147) (0.0226) (1.1562) (2.1654) (1.8987) (1.9684) (2.4397) (2.6530)	
+ 1.2836SFS - 0.6343SMS (0.4579) (0.7117)	R ² = 0.158
FWT = 581.0210 + 0.4865IWT - 15.4886IFT + 48.9667DIET - 20.0246A - 8.8233H + 6.4473CX + 22.4006AH (39.8107) (0.0666) (3.4059) (6.3787) (5.5930) (5.7984) (7.1866) (7.8150)	
+ 5.6654SFS - 3.1819SMS (1.3489) (2.0965)	R ² = 0.236
FFT = 6.3315 + 0.0017IWT + 0.6911IFT + 1.8722DIET - 0.0252A + 0.1964H - 1.1643CX + 0.9931AH (1.1279) (0.0019) (0.0965) (0.1807) (0.1585) (0.1643) (0.2036) (0.2214)	
- 0.1516SFS - 0.0482SMS (0.0382) (0.0594)	R ² = 0.334
YG = 2.0769 + 0.0002IWT + 0.0950IFT + 0.2571DIET - 0.0035A + 0.0271H - 0.1596CX + 0.1360AH (0.1549) (0.0003) (0.0133) (0.0248) (0.0218) (0.0226) (0.0280) (0.0304)	
- 0.0209SFS - 0.0068SMS (0.0052) (0.0082)	R ² = 0.334
MS = 5.2472 - 0.0017IWT + 0.0095IFT + 0.6746DIET - 0.0314A - 0.0134H - 0.0404CX + 0.0852AH (0.1774) (0.0003) (0.0152) (0.0284) (0.0249) (0.0258) (0.0320) (0.0348)	
+ 0.0057SFS - 0.0092SMS (0.0060) (0.0093)	R ² = 0.445

Table A-5 (Continued)

NR = - 113.5991 + 0.0368IWT - 2.5495IFT + 21.2696DIET - 3.2664A - 1.1842H - 5.3478CX + 9.7984AH	
(14.5907) (0.0244) (1.2483) (2.3378) (2.0498) (2.1251) (2.6339) (2.8642)	
- 5.8676SFS - 1.8786SMS	R ² = 0.336
(0.4944) (0.7684)	
FC = 200.3854 - 0.1040IWT - 4.3400IFT + 17.6083DIET - 5.6740A - 3.3291H + 3.8834CX + 5.1197AH	
(16.0882) (0.0269) (1.3764) (2.5778) (2.2602) (2.3433) (2.9042) (3.1582)	
+ 1.6463SFS - 1.3408SMS	R ² = 0.140
(0.5451) (0.8472)	
V/IWT = 23.2388 + 0.0141IWT - 0.4356IFT + 3.7921DIET - 0.9125A + 0.0419H - 0.6700CX + 1.5406AH	
(1.9868) (0.0033) (0.1700) (0.3183) (0.2791) (0.2894) (0.3587) (0.3900)	
+ 0.0987SFS - 0.0397SMS	R ² = 0.192
(0.0673) (0.1046)	

Table A-6. Regression Equations for Low Carcass Price When Maximizing Net Revenue to the Feedlot Space.

DOF =	379.7130 - 0.3249IWT - 6.1588IFT - 21.6206DIET - 6.5630A - 3.0833H + 8.6506CX + 0.9957AH	
	(20.5568) (0.0344) (1.7587) (3.2938) (2.8880) (2.9941) (3.7109) (4.0354)	
	+ 2.6408SFS - 1.3664SMS	$R^2 = 0.233$
	(0.6965) (1.0826)	
FWT =	810.3896 + 0.2579IWT - 21.6192IFT + 24.6032DIET - 27.5895A - 8.8708H + 14.0454CX + 22.4150AH	
	(51.0449) (0.0854) (4.3670) (8.1788) (7.1712) (7.4347) (9.2146) (10.0203)	
	+ 9.8713SFS - 5.3119SMS	$R^2 = 0.207$
	(1.7296) (2.6881)	
FFT =	13.5139 - 0.0061IWT + 0.6256IFT + 1.8073DIET - 0.1442A + 0.4611H - 1.2424CX + 0.9254AH	
	(1.6046) (0.0027) (0.1373) (0.2571) (0.2254) (0.2337) (0.2897) (0.3150)	
	- 0.0977SFS - 0.1128SMS	$R^2 = 0.193$
	(0.0544) (0.0845)	
YG =	3.0650 - 0.0008IWT + 0.0860IFT + 0.2483DIET - 0.0199A + 0.0635H - 0.1704CX + 0.1267AH	
	(0.2204) (0.0004) (0.0189) (0.0353) (0.0310) (0.0321) (0.0398) (0.0433)	
	- 0.0135SFS - 0.0156SMS	$R^2 = 0.193$
	(0.0075) (0.0116)	
MS =	6.8157 - 0.0032IWT - 0.0027IFT + 0.4060DIET - 0.0611A - 0.0150H - 0.0072CX + 0.0834AH	
	(0.2457) (0.0004) (0.0210) (0.0394) (0.0345) (0.0358) (0.0444) (0.0482)	
	+ 0.0150SFS - 0.0190SMS	$R^2 = 0.194$
	(0.0083) (0.0129)	

Table A-6 (Continued)

NRPD = 0.2524 - 0.0013IWT - 0.0529IFT + 0.0404DIET - 0.0495A - 0.0225H + 0.0060CX + 0.0660AH (0.1166) (0.0002) (0.0100) (0.0187) (0.0164) (0.0170) (0.0210) (0.0229)	
- 0.0232SFS - 0.0162SMS (0.0040) (0.0061)	R ² = 0.183
FC = 319.5192 - 0.2129IWT - 6.6648IFT + 0.2892DIET - 8.9985A - 3.6310H - 7.5996CX + 5.0299AH (23.6502) (0.0396) (2.0233) (3.7894) (3.3226) (3.4447) (4.2693) (4.6426)	
+ 3.2644SFS - 2.2920SMS (0.8013) (1.2455)	R ² = 0.135
V/IWT = 18.7681 + 0.0189IWT - 0.3959IFT + 4.3880DIET - 0.7986A + 0.0798H - 0.9028CX + 1.6215AH (2.2547) (0.0038) (0.1929) (0.3613) (0.3168) (0.3284) (0.4070) (0.4426)	
+ 0.0588SFS - 0.0039SMS (0.0764) (0.1187)	R ² = 0.194

Table A-7. Regression Equations for High Feed Cost When Maximizing Net Revenue to the Animal.

DOF = 298.7086 - 0.2512IWT - 5.0939IFT - 5.9122DIET - 4.4082A - 2.6007H + 3.9600CX + 3.0489AH (16.2122) (0.0271) (1.3870) (2.5976) (2.2776) (2.3613) (2.9266) (3.1825)	
+ 1.7537SFS - 0.9498SMS (0.5493) (0.8538)	R ² = 0.171
FWT = 676.3680 + 0.3654IWT - 17.6038IFT + 45.0824DIET - 21.6809A - 7.0633H + 4.1886CX + 24.5557AH (43.6018) (0.0729) (3.7302) (6.9862) (6.1256) (6.3506) (7.8709) (8.5592)	
+ 7.1254SFS - 3.9043SMS (1.4774) (2.2962)	R ² = 0.206
FFT = 8.5296 - 0.0012IWT + 0.6750IFT + 1.9389DIET - 0.0594A + 0.3110H - 1.3185CX + 1.0668AH (1.2808) (0.0021) (0.1096) (0.2052) (0.1799) (0.1866) (0.2312) (0.2514)	
- 0.1246SFS - 0.0628SMS (0.0434) (0.0675)	R ² = 0.289
YG = 2.3800 - 0.0002IWT + 0.0928IFT + 0.2664DIET - 0.0082A + 0.0428H - 0.1808CX + 0.1462AH (0.1759) (0.0003) (0.0150) (0.0282) (0.0247) (0.0256) (0.0318) (0.0345)	
- 0.0172SFS - 0.0087SMS (0.0060) (0.0093)	R ² = 0.289
MS = 5.7915 - 0.0023IWT - 0.0019IFT + 0.6432DIET - 0.0432A - 0.0146H - 0.0554CX + 0.1132AH (0.2053) (0.0003) (0.0176) (0.0329) (0.0288) (0.0299) (0.0371) (0.0403)	
+ 0.0105SFS - 0.0146SMS (0.0070) (0.0108)	R ² = 0.369

Table A-7 (Continued)

NR = - 94.8537 + 0.1174IWT - 3.6935IFT + 27.0363DIET - 5.1788A - 1.4942H - 5.8040CX + 12.4769AH (16.7554) (0.0280) (1.4334) (2.6847) (2.3539) (2.4404) (3.0247) (3.2891)	
- 5.4271SFS - 2.0195SMS (0.5677) (0.8824)	R ² = 0.280
FC = 294.0712 - 0.1862IWT - 6.5476IFT + 18.3484DIET - 7.8125A - 3.5776H + 3.2484CX + 8.1417AH (22.6067) (0.0378) (1.9340) (3.6222) (3.1760) (3.2927) (4.0809) (4.4378)	
+ 2.6295SFS - 2.0444SMS (0.7660) (1.1905)	R ² = 0.132
V/IWT = 38.6061 + 0.0070IWT - 0.6426IFT + 4.8300 DIET - 1.2510A - 0.0209H - 0.7357CX + 2.0075AH (2.4836) (0.0042) (0.2125) (0.3979) (0.3489) (0.3617) (0.4483) (0.4876)	
+ 0.1783SFS - 0.0664SMS (0.0842) (0.1308)	R ² = 0.196

Table A-8. Regression Equations for High Feed Cost When Maximizing Net Revenue to the Feedlot Space.

DOF =	391.2549 - 0.3333IWT - 6.7662IFT - 24.3347DIET - 4.3850A - 3.4683H + 8.9313CX - 1.0779AH	
	(21.0267) (0.0352) (1.7989) (3.3690) (2.9540) (3.0625) (3.7957) (4.1276)	
	+ 3.0368SFS - 1.4340SMS	R ² = 0.237
	(0.7125) (1.1073)	
FWT =	825.4020 + 0.2541IWT - 23.0487IFT + 21.5854DIET - 24.3437A - 10.6050H + 15.6595CX + 19.2892AH	
	(51.6853) (0.0865) (4.4218) (8.2814) (7.2612) (7.5280) (9.3302) (10.1460)	
	+ 10.9786SFS - 5.8047SMS	R ² = 0.224
	(1.7513) (2.7219)	
FFT =	14.3993 - 0.0069IWT + 0.5686IFT + 1.7420DIET + 0.0071A + 0.4352H - 1.2300CX + 0.7877AH	
	(1.6468) (0.0028) (0.1409) (0.2639) (0.2314) (0.2399) (0.2973) (0.3233)	
	- 0.0794SFS - 0.1165SMS	R ² = 0.170
	(0.0558) (0.0867)	
YG =	3.1872 - 0.0009IWT + 0.0782IFT + 0.2393DIET + 0.0007A + 0.0600H - 0.1684CX + 0.1078AH	
	(0.2262) (0.0004) (0.0194) (0.0362) (0.0318) (0.0329) (0.0408) (0.0440)	
	- 0.0110SFS - 0.0161SMS	R ² = 0.170
	(0.0077) (0.0119)	
MS =	6.9890 - 0.0033IWT - 0.0103IFT + 0.3559DIET - 0.0307A - 0.0157H - 0.0109CX + 0.0573AH	
	(0.2485) (0.0004) (0.0213) (0.0398) (0.0349) (0.0362) (0.0449) (0.0488)	
	+ 0.0186SFS - 0.0196SMS	R ² = 0.172
	(0.0084) (0.0131)	

Table A-8 (Continued)

NRPD = - 0.0232 - 0.0002IWT - 0.0434IFT + 0.1032DIET - 0.0401A - 0.0171H - 0.0145CX + 0.0718AH (0.1039) (0.0002) (0.0089) (0.0167) (0.0146) (0.0151) (0.0188) (0.0204)	
- 0.0240SFS - 0.0138SMS (0.0035) (0.0055)	
$R^2 = 0.168$	
FC = 394.8198 - 0.2587IWT - 8.8764IFT - 2.6654DIET - 8.2567A - 5.0103H + 9.7546CX + 3.5124AH (29.0452) (0.0486) (2.4849) (4.6538) (4.0805) (4.2304) (5.2432) (5.7017)	
+ 4.4620SFS - 2.9546SMS (0.9841) (1.5296)	
$R^2 = 0.145$	
V/IWT = 35.2067 + 0.0107IWT - 0.6055IFT + 5.3125DIET - 1.2969A + 0.0307H - 0.9253CX + 2.1915AH (2.7218) (0.0046) (0.2329) (0.4361) (0.3824) (0.3964) (0.4913) (0.5343)	
+ 0.1394SFS - 0.0461SMS (0.0922) (0.1433)	
$R^2 = 0.190$	

Table A-9. Regression Equations for Low Feed Cost When Maximizing Net Revenue to the Animal.

DOF =	389.0726 - 0.3002IWT - 8.8604IFT - 25.2355DIET - 3.7193A - 3.9795H + 11.8278CX - 4.1290AH	
	(22.3673) (0.0374) (1.9136) (3.5838) (3.1424) (3.2578) (4.0377) (4.3908)	
	+ 3.3879SFS - 1.4681SMS	$R^2 = 0.240$
	(0.7579) (1.1779)	
FWT =	813.9871 + 0.3175IWT - 27.9795IFT + 22.0511DIET - 23.9969A - 10.6948H + 21.1627CX + 13.5290AH	
	(54.9218) (0.0919) (4.6986) (8.8000) (7.7159) (7.9994) (9.9144) (10.7814)	
	+ 12.1818SFS - 5.4538SMS	$R^2 = 0.254$
	(1.8609) (2.8923)	
FFT =	15.1053 - 0.0066IWT + 0.4499IFT + 1.8447DIET + 0.0949A + 0.4652H - 1.369CX + 0.5768AH	
	(1.7539) (0.0029) (0.1500) (0.2810) (0.2464) (0.2555) (0.3166) (0.3443)	
	- 0.0627SFS - 0.1025SMS	$R^2 = 0.135$
	(0.0594) (0.0924)	
YG =	3.2851 - 0.0009IWT + 0.0618IFT + 0.2536DIET + 0.0127A + 0.0642H - 0.1556CX + 0.0787AH	
	(0.2409) (0.0004) (0.0206) (0.0386) (0.0338) (0.0351) (0.0435) (0.0473)	
	- 0.0087SFS - 0.0142SMS	$R^2 = 0.135$
	(0.0081) (0.0127)	
MS =	6.9432 - 0.0028IWT - 0.0308IFT + 0.2922DIET - 0.0267A - 0.0095H + 0.0128CX + 0.0235AH	
	(0.2651) (0.0004) (0.0227) (0.0425) (0.0372) (0.0386) (0.0479) (0.0520)	
	+ 0.0203SFS - 0.0162SMS	$R^2 = 0.122$
	(0.0090) (0.0140)	

Table A-9 (Continued)

NR = 30.7517 + 0.0359IWT - 6.8548IFT + 28.5652DIET - 8.2916A - 2.9656H - 3.2161CX + 14.4733AH	
(18.7762) (0.0314) (1.6063) (3.0085) (2.6379) (2.7348) (3.3895) (3.6858)	
- 4.0085SFS - 2.9205SMS	R ² = 0.196
(0.6362) (0.9888)	
FC = 257.5518 - 0.1377IWT - 7.8373IFT - 2.2338DIET - 5.2370A - 3.7071H + 9.1316CX - 0.1875AH	
(20.8576) (0.0349) (1.7844) (3.3419) (2.9303) (3.0379) (3.7652) (4.0944)	
+ 3.3854SFS - 1.9894SMS	R ² = 0.162
(0.7067) (1.0984)	
V/IWT = 75.8573 - 0.0336IWT - 1.2026IFT + 5.0193DIET - 1.7803A - 0.3127H - 0.2497CX + 2.3426AH	
(2.8868) (0.0048) (0.2470) (0.4625) (0.4056) (0.4205) (0.5211) (0.5667)	
+ 0.4385SFS - 0.2332SMS	R ² = 0.271
(0.0978) (0.1520)	

Table A-10. Regression Equations for Low Feed Cost When Maximizing Net Revenue to the Feedlot Space.

DOF = 392.8254 - 0.2393IWT - 6.1177IFT - 34.9324DIET - 2.1122A - 6.4631H + 17.3819CX - 8.8065AH (24.8095) (0.0415) (2.1225) (3.9752) (3.4855) (3.6135) (4.4786) (4.8702)	
+ 3.4234SFS - 1.1813SMS (0.8406) (1.3065)	R ² = 0.224
FWT = 803.1263 + 0.4418IWT - 24.2062IFT + 9.7743DIET - 24.9885A - 15.6094H + 31.6503CX + 8.9476AH (57.6877) (0.0965) (4.9353) (9.2431) (8.1045) (8.4022) (10.4137) (11.3243)	
+ 12.6719SFS - 5.4008SMS (1.9546) (3.0380)	R ² = 0.261
FFT = 15.2044 - 0.0021IWT + 0.6113IFT + 1.8997DIET + 0.0266A + 0.4333H - 1.0245CX + 0.5646AH (1.8195) (0.0030) (0.1557) (0.2915) (0.2556) (0.2650) (0.3285) (0.3572)	
- 0.1090SFS - 0.0834SMS (0.0616) (0.0958)	R ² = 0.140
YG = 3.2976 - 0.0003IWT + 0.0841IFT + 0.2609DIET + 0.0038A + 0.0598H - 0.1409CX + 0.0773AH (0.2499) (0.0004) (0.0214) (0.0400) (0.0351) (0.0364) (0.0451) (0.0491)	
- 0.0150SFS - 0.0115SMS (0.0085) (0.0132)	R ² = 0.140
MS = 6.9597 - 0.0019IWT + 0.0080IFT + 0.0015DIET - 0.0197A - 0.0180H + 0.0487CX - 0.0110AH (0.2749) (0.0005) (0.0235) (0.0440) (0.0386) (0.0400) (0.0496) (0.0540)	
+ 0.0137SFS - 0.0094SMS (0.0093) (0.0145)	R ² = 0.028

Table A-10 (Continued)

NRPD = 0.1716 + 0.00005IWT - 0.0347IFT + 0.1180DIET - 0.0366A - 0.0134H - 0.0142CX + 0.0641AH (0.0876) (0.00015) (0.0075) (0.0140) (0.0123) (0.0128) (0.0158) (0.0172)	
- 0.0173SFS - 0.0118SMS (0.0030) (0.0046)	R ² = 0.172
FC = 249.6036 - 0.0652IWT - 5.7188IFT - 9.6878DIET - 4.6833A - 5.7632H + 13.9781CX - 3.5317AH (22.6412) (0.0379) (1.9370) (3.6277) (3.1808) (3.2977) (4.0872) (4.4446)	
+ 3.5382SFS - 1.7835SMS (0.7672) (1.1923)	R ² = 0.153
V/IWT = 74.7187 - 0.0335IWT - 1.3331IFT + 5.2712DIET - 1.7883A - 0.2220H - 0.3975CX + 2.4078AH (3.0468) (0.0051) (0.2607) (0.4882) (0.4280) (0.4438) (0.5500) (0.5981)	
+ 0.04370SFS - 0.2328SMS (0.1032) (0.1604)	R ² = 0.262

Table A-11. Regression Equations for $\frac{1}{4}$ " Trim Pricing When Maximizing Net Revenue to the Animal.

DOF = 324.6330 - 0.2707IWT - 4.0906IFT - 12.1199DIET - 4.5868A - 4.1708H + 4.5633CX + 4.1943AH (17.2081) (0.0288) (1.4722) (2.7572) (2.4175) (2.5064) (3.1064) (3.3780)	
+ 1.9733SFS - 1.5385SMS (0.5831) (0.9062)	$R^2 = 0.180$
FWT = 718.4627 + 0.3340IWT - 16.6198IFT + 36.8592DIET - 23.6733A - 9.4255H + 6.9539CX + 26.1449AH (44.8925) (0.0751) (3.8406) (7.1930) (6.3069) (6.5386) (8.1039) (8.8126)	
+ 7.7634SFS - 4.7255SMS (1.5211) (2.3641)	$R^2 = 0.198$
FFT = 9.9599 - 0.0019IWT + 0.6851IFT + 1.7402DIET - 0.0328A + 0.2912H + 1.3064CX + 1.0480AH (1.2952) (0.0022) (0.1108) (0.2075) (0.1820) (0.1886) (0.2338) (0.2543)	
- 0.1301SFS - 0.1089SMS (0.0439) (0.0682)	$R^2 = 0.279$
YG = 2.5780 - 0.0003IWT + 0.0940IFT + 0.2391DIET - 0.0048A + 0.0402H - 0.1789CX + 0.1435AH (0.1778) (0.0003) (0.0152) (0.0285) (0.0250) (0.0259) (0.0321) (0.0349)	
- 0.0180SFS - 0.0151SMS (0.0060) (0.0094)	$R^2 = 0.279$
MS = 6.1314 - 0.0025IWT + 0.0117IFT + 0.5616DIET - 0.0360A - 0.0345H - 0.0494CX + 0.1199AH (0.2161) (0.0004) (0.0185) (0.0346) (0.0304) (0.0315) (0.0390) (0.0424)	
+ 0.0116SFS - 0.0230SMS (0.0073) (0.0114)	$R^2 = 0.304$

Table A-11 (Continued)

NR = - 50.9839 + 0.0765IWT - 6.1408IFT + 25.1985DIET - 6.5639A - 3.0980H - 1.7525CX + 11.4143AH			
(16.7234)	(0.0280)	(1.4307)	(2.6795) (2.4358) (3.0189) (3.2829)
- 4.7030SFS - 1.9616SMS			
(0.5666)	(0.8807)		R ² = 0.219
FC = 268.9620 - 0.1700IWT - 4.4614IFT + 9.1230DIET - 6.8012A - 4.4751H + 3.5861CX + 7.6901AH			
(20.0877)	(0.0336)	(1.7185)	(3.2186) (2.8221) (2.9258) (3.6262) (3.9433)
+ 2.4559SFS - 2.3139SMS			
(0.6806)	(1.0579)		R ² = 0.113
V/IWT = 50.6978 - 0.0077IWT - 1.0785IFT + 4.4541DIET - 1.4827A - 0.3171H - 0.0052CX + 1.8051AH			
(2.4509)	(0.0041)	(0.2097)	(0.3927) (0.3443) (0.3570) 0.4424 (0.4811)
+ 0.3099SFS - 0.0561SMS			
(0.0830)	(0.1291)		R ² = 0.236

VITA

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