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INCREMENTAL RETURNS TO CATTLE FEEDING FROM
ALTERNATIVE FEEDLOT PRACTICES

by

Ibrahim R. Hani

A thesis submitted in partial fulfillment of the
requirements for the degree

of

MASTER OF SCIENCE

in

Agricultural Economics

UTAH STATE UNIVERSITY
Logan, Utah

1989

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Ibrahim R. Hani

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ABSTRACT

Incremental Returns to Cattle Feeding From Alternative
Feedlot Practices

by

Ibrahim R. Hani, Master of Science
Utah State University, 1989Major Professor: Dr. Donald L. Snyder
Department: Economics

The main goals of this study are to: 1) identify the influence of various breeds, feeds, and hormone additives on the final weight or the rate of gain of feeder cattle; 2) determine the physical relationships among breeds, feeds, hormone additives, and other variables; and 3) estimate the costs and benefits associated with alternative feed and/or hormone additives and other variables to determine whether the benefits of using different breeds, feeds, and hormone additives exceed the costs. The linear model was initially chosen and showed that Rumensin additive and Angus and Simmental cross breeds were not significant on the basis of T test. The estimation, after excluding the nonsignificant variables, showed that Bovatec additive's impact on the total weight out was statistically negative and significant. Ralgro and Compudose hormones affected positively, and they were statistically significant, likewise breed (Tarantaise) affected positively on the total weight out and was statistically significant on the basis of T test.

The cost-benefit analyses explained that the values of the contribution of hormones Ralgro, Compudose and Tarantaise breed were exceed the cost of providing implants.

(64 pages)

CHAPTER I

INTRODUCTION

The production of livestock meats and related products is one of the largest industries in the world. Millions of producers and workers depend on raising livestock in both developed and developing countries (McCoy and Sarhan). While published data are not available on the number of people employed in the production, processing, and marketing of livestock and meat, nearly all farmers and ranchers have a hand in it. Most of those who do not produce livestock are involved to a greater or lesser degree in feed. In 1984 there were 3.5 million persons employed in farming in the United States (United States Department of Agriculture [USDA], 1986). According to USDA statistics, about 40% of the total labor hours spent in farm work are in livestock, feed, and hay production. Since a substantial part (more than 70%) of the remaining labor hours have some indirect input to enterprises related to livestock feed, it can be assumed that about 85% are in livestock or feed production. Thus, there are approximately 2.98 million persons (85% of 3.5 million) engaged in livestock production. In the agricultural industry, there are eight people in marketing for every six engaged in production. If that ratio holds true for the livestock sector, some 3.97 million people are engaged in the marketing of livestock and meat. In total, then, there would be 6.95 million people employed in production and marketing (McCoy and Sarhan).

The cattle-feeding sector comprises a large share of the livestock industry in the U.S. In 1986, there were 105,468,000 head of cattle and calves in the U.S. which comprised 63% of the total number of red-meat animals (i.e., cattle and calves, hogs, and sheep). The number of cattle and calves that were fed in feedlots in the U.S. are shown in table 1 below.

Table 1. The Cattle and Calves on Feed in the U.S., 1985-1986

Year	Number
1985	12,458,000
1986	11,412,000

During 1985 and 1986, more than 11 million cattle and calves were fed in more than 100,000 feedlots in the U.S. (USDA, 1986). The feed consumed per head and per unit of production, expressed in equivalent feeding value of corn, is given in table 2.

Table 2. Feed Consumed in U.S. Feedlots, 1981-1984 (Pounds of Corn Equivalent per Head)

Year	Cattle on Feed per Head	Other Beef Cattle per Head	All Beef Cattle per Head	Cattle/Calves per Head
1981	8,759	5,360	5,721	1,395
1982	8,988	5,395	5,829	1,432
1983	7,848	5,708	5,994	1,382
1984	9,307	5,914	6,346	1,422

The farm receipts in 1985 from sales of cattle, calves, beef, and veal in the U.S. were \$28,741,718,000, which is greater than for any other agricultural commodity (USDA, 1986). In addition, cattle feeding often provides a farmer with an alternative means of marketing grain (Kohls and Uhl). As a result of the rapid growth in demand for fed beef and economies of size associated with the cattle-feeding industry, large specialized feedlots were developed in 1950s through the 1970s (Kohls and Uhl). In 1980s the number of feedlots with 32,000 and over capacity increased, while the total number of feedlots decreased (Sands). Those that remain are located primarily in the Southwestern, Pacific, Western, Mountain, and Corn Belt regions of the U.S. Owners of these feeding operations typically purchase grains, roughage, and feeder animals for finishing cattle to market weights (Kohls and Uhl).

The meat production process generally consists of four stages: (1) a cow-calf phase, wherein the objective is to produce young calves through the breeding of mature cows; (2) a growth or backgrounding phase, in which the major objective is growth through liberal application of roughage and grass but a limited quantity of grain; (3) a finishing phase, where grains are heavily fed and the animals add condition in addition to muscle tissue; and (4) the slaughter phase, where the fattened animals are slaughtered. The first three stages are not necessarily separate and distinct since calves are sometimes fed grain even while nursing the mother cow or being pastured (McCoy and Sarhan).

Statement of the Problem

The overall purpose of this study is to examine the incremental benefits and costs associated with alternative feeding programs in the finishing or fattening stage of cattle production. More specifically, the two aspects of cattle feeding that will be examined are (1) the use of feed additives and (2) the use of hormone implants or treatments.

Many of the costs associated with cattle feeding, such as buildings and facilities, are largely fixed in a typical finishing period. Within the finishing period, even the cattle to be fed are relatively fixed. Still, it is possible that certain breeds of cattle may utilize feeds more efficiently. Except for the breed, the major variable in the feeding process is the combination of feedstuffs used. There are three things that can be adjusted relative to the feedstuffs used. First, it may be possible to adjust the actual type and relative proportion of feeds used. From an economic perspective, the selection and weighing of feeds could be based on a cost-minimization or profit-maximization approach. Second, the rate of pounds of feed required per pound of gain may be affected by the use of various feed additives. The economic question in this regard is whether or not the gains (benefits) resulting from the use of feed additives are sufficient to justify the expenditures. Third, feed to tissue conversion rates may be altered by implanting various growth hormones in the animals. Once again, the economic issue is whether or not the gain associated with the implants exceeds the cost of the implants.

Three questions are examined in this study. First, do differences in breeds account for changes in weight gained? Second, will the

inclusion of feed additives positively impact gains and is the cost associated with their use less than the benefits derived? Third, can increases in gains be attributed to hormone implants and does the return exceed the cost of implantation?

Objectives

The overall purpose of the research is to determine the effectiveness of certain feedlot feeding strategies. The specific objectives are to (1) identify the influence of breed, feed additives, and hormone implants on the rate of gain for feeder cattle and determine the physical relationship that exists between these and other production variables; (2) estimate the cost and benefits associated with alternative feed and/or hormone additives and other variable inputs; and (3) provide recommendations concerning the use of various feed and/or hormone additives based on a marginal analysis of costs and benefits derived under Objective #2.

Procedures and Methods

The specific procedures and methods required to meet each of the objectives given above are

Objective 1:

- (a) Identify a source of data that includes observations on the following variables: periodic cattle weights, rations fed, feed additives, hormone treatments, periods of time between weights/ration changes, etc.

- (b) Collect, transform, and enter data on variables listed above.
- (c) Prepare data for statistical analysis. In doing so, it is important that the spreadsheet or database program used be compatible with the statistical programs to be used.
- (d) Identify possible structural forms for estimation of the physical production function.
- (e) Prepare data consistent with the structural forms selected.
- (f) Select statistical software (program) suitable for production function estimation.
- (g) Estimate a physical production function for a select number of relevant functional forms.
- (h) Test coefficients and overall equation for statistical significance.
- (i) Select/modify functional form as appropriate.

Objective 2:

- (a) Given that a suitable functional form exists, calculate the marginal product associated with various breeds, feed additives, and hormones.
- (b) Identify cost of acquisition and use of various breeds, feed additives, and hormones.
- (c) Estimate the contribution for the various breeds, feed additives, and hormones.

Objective 3:

- (a) Identify those feed additives or hormone implants that are capable of adding weight (production) and specify those for which the value of the gain exceeds the cost.

CHAPTER II

LITERATURE REVIEW

The review of literature is divided into three major areas. First, the economic literature dealing with production economics will be reviewed. Second, the animal science literature dealing with the contribution or impact of various breeds, feed additives, and hormone implants will be briefly examined. Third, the economic literature dealing with applications of economic theory in the area of livestock feeding is discussed.

The Theory of Production

Production economics developed as a distinct field in the early part of this century in response to changing farm-household decision-making units. These changes created a need for additional research and education in firm-level decisions dealing with optimal resource use for the benefit of the producers and policy makers of agricultural programs. The impacts associated with alternative policies were examined; and traditional and developing economic theory, which deals with the technical and institutional changes of farm production and associated resource use, were developed.

In 1939 Hicks provided an analysis of the equilibrium of the firm by generating a mathematical model to represent the firm. Under certain conditions, Hicks determined equilibrium conditions that include (1) price of factor = value of marginal product; (2) diminishing marginal

productivity; and (3) diminishing average productivity, or, in other words, (1) price of product = marginal cost of product; (2) increasing marginal cost; and (3) increasing average cost.

In his classic work of 1939, Carlson provided a more definitive statement of production economics. The firm's primary focus, according to Carlson, is to plan its production such that (1) the discounted marginal cost of its output would be equal to the discounted marginal revenue of its output and (2) every productive service is employed until its discounted marginal value of productivity equals its discounted marginal cost. Carlson's contribution is his mathematical arrangement of production theory, which begins with the simplest setting of a single firm producing a single commodity in a single time period.

Many of the basic concepts of production economics were scattered throughout cost theory, capital and interest theory, and the theory of distribution. Carlson attempted to coordinate these relationships in a single and consistent body of theory and gave particular emphasis to the bearing of capital and interest theory on the cost and revenue calculations of a single firm. Carlson assumed that a business firm's production activity is so arranged that the production of one time period is entirely separated from the production of the preceding and subsequent time periods, or a mono-periodic production process.

The technical problems of production, i.e., those related to the relationship between inputs and outputs, are often expressed in a form suitable for economic analysis:

$$(1) \quad Y = Q(X_1, X_2, X_3, \dots, X_n)$$

where Y represents the physical quantity of some output, and X_1, \dots, X_n

represents n variable inputs used in the production process. It is important to recognize that a given amount of output may be produced from a number of different input combinations.

Carlson suggested two analytical concepts that greatly facilitate an analysis of the production function. The first is the concept of "marginal productivity," where the marginal product of any input is the partial derivative of production with respect to that input, or

$$(2) \quad \frac{dY}{dX} = Q_x$$

Stated somewhat differently, the marginal product of any input k is the change in the level of output that corresponds to an infinitesimal change in input, assuming the level of all other inputs remain constant.

Although there exists only one maximum output for any combination of variable inputs, a given output may be obtained from a series of different input combinations as noted above. Such a representation is generally called a production indifference curve or "isoquant."

The equation representing an isoquant is obtained directly from the previously developed production function, or

$$(3) \quad Y_0 = Q(X_1, X_2, X_3, \dots, X_n)$$

where Y_0 represents the constant output of each isoquant. In the case of two variable inputs or factors of production, the slope of the isoquant at any particular point is equal to the negative of the inverse of the ratio of marginal productivities at that same point.

Carlson's second concept is that of returns to scale. A production process will yield a constant or variable return to scale according to whether or not the output level does or does not vary in direct

proportion to the level of variable inputs or factors of production used. For example, if a proportional change in a given combination of inputs or factors increases output to a greater proportional degree, then the output coefficient is considered to be greater than unity and proportional returns will be increasing. After a particular level of inputs is reached, the function coefficient will fall below unity since production processes are subject to diminishing marginal productivities. Beyond this level of factor employment, output will cease to increase and the function coefficient will become zero or negative. An increase of the variable factors beyond this limit will not increase the output as long as the fixed factors remain constant. These three stages are illustrated in figure 1, which represents the classical three-stage production function.

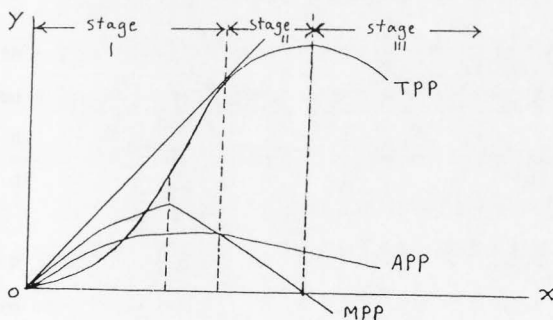


Figure 1. Classical three-stage production function and marginal and average curves for single factor variation

Production economics is concerned with the choice between alternative production processes, namely, enterprise selection and

resource allocation. How much and what to produce and the optimal combination of resources are key issues in any production problem. Regarding these issues, production economics provides answers to the following three questions:

(1) How much of a particular variable input does one employ?

(2) How much of each input should be employed in producing a given output?

(3) How much of each product should be produced?

The answer to the first question is in the factor-product relationship. The criterion for determining the optimum amount of input is derived from the slope of the total value product and total cost curves.

Let a profit function be represented by

$$(4) \quad \pi = P_y f(X) - P_x X - TFC$$

To maximize this function with respect to the variable input, the first derivative would be set to zero to obtain

$$(5) \quad \frac{d\pi}{dX} = P_y \frac{dy}{dx} - P_x = 0$$

or

$$(6) \quad P_y MPP_x = P_x$$

where the term on the left side of equation (6) represents the slope of the total value product (TVP) curve and is called the value of the marginal production (VMP). The term on the right side of equation (6) is known as the marginal factor cost (MFC) or the cost of the input.

In order to determine how much of each input should be used, the factor-factor relationship must be examined. The factor-factor

relationship, earlier referred to as an isoquant, reflects substitution possibilities among factors of production. Algebraically, the least-cost combination is attained where the ratio of marginal productivity to price for each input is the same for all inputs used, or

$$(7) \quad \frac{MP_{x_1}}{P_{x_1}} = \frac{MP_{x_2}}{P_{x_2}} \quad \text{or} \quad \frac{MP_{x_1}}{MP_{x_2}} = \frac{P_{x_1}}{P_{x_2}}$$

where the left side of the last expression represents the slope of the isoquant; the right side the slope of the iso-cost line. Thus, the number of units from each variable input used to meet the least cost for a given output is attained at the point where the iso-cost line is tangent to the isoquant, as illustrated in figure 2 below, given that the isoquant is convex to the origin.

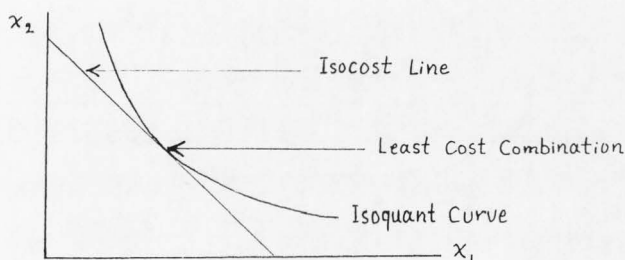


Figure 2. Determining the combination of inputs to produce output at a minimum cost

The answer to the question of how much of each product to produce can best be answered by examining the relationship between products, which is represented by a production possibilities curve. The primary use of the production possibility curve is to determine the most

profitable combination of products for a limited quantity of inputs for factors of production. The production possibility curve represents all possible combinations of production that can be produced from a given input level. Thus, while many combinations of products could be produced from the same bundle of inputs, generally only one combination of two products will provide the greatest return. The maximum revenue combination of outputs is determined using the concept of marginal rate of product substitution (MRPS), which is similar to that defined in factor-factor relationships. The MRPS refers to the amount by which one product changes in quantity when the other output is also changed. The MRPS is defined as the slope of the production possibility curve, or

$$(8) \quad \text{MRPS of } Y_1 \text{ for } Y_2 = (dY_1/dY_2)$$

where Y_1 and Y_2 represent the total amount of two products that can be produced from a given and fixed set of inputs or factors of production. From the prices of Y_1 and Y_2 , total revenue can be estimated for every combination of the two products that represents the iso-revenue curve. The maximum revenue combination of outputs on a production possibility curve can be determined using the criterion

$$(9) \quad \text{MRPS of } Y_1 \text{ for } Y_2 = - P_{Y1}/P_{Y2} \text{ or } dY_2/dY_1 = - P_{Y1}/P_{Y2}.$$

The left side of equation (9) represents the slope of the production possibility curve and the right side the slope of the iso-revenue line. The maximum revenue point is that point in figure 3 below which the iso-revenue line is tangent to the production possibility curve. The point of tangency represents the profit-maximizing level of output for both goods.

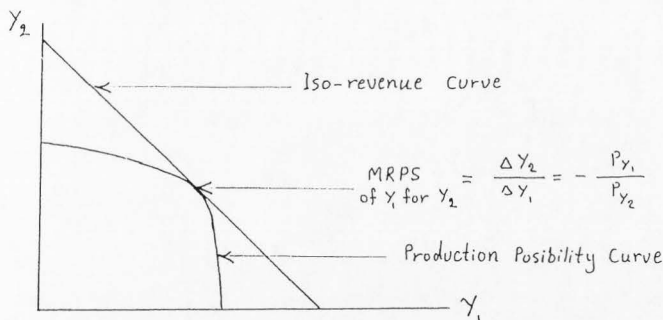


Figure 3. The maximum revenue combination of products on a production possibility curve

Production and Cost

There is a relationship between the characteristics of a production function and a corresponding cost function. The cost function is the dual of the production function and vice versa. In the traditional analysis of production, the application of a variable input or factor of production will initially increase production at an increasing rate. This corresponds to the portion of the cost function that increases at a decreasing rate. In other words, marginal productivity increases and marginal cost decreases. As more of the variable input is added, marginal productivity begins to decline (i.e., total product increases at a decreasing rate) and marginal cost increases (i.e., total costs increase at an increasing rate), as illustrated in figure 4. This relationship is important because data limitations often preclude the estimation of the physical production function.

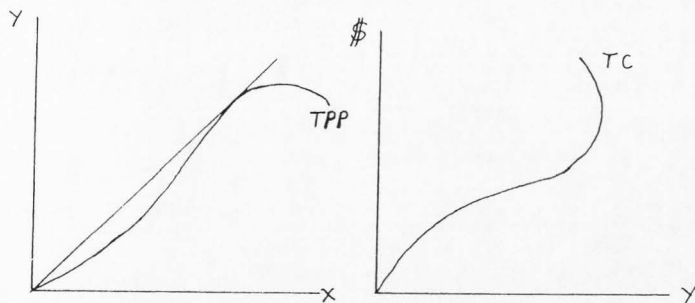


Figure 4. The linkage between production function and cost-output relationship

Empirical Development of Production Economics

Since the development of the Cobb-Douglas production function in 1928, agricultural economists have been concerned with the analysis of productivity. There were many problems linked with productivity analysis, which encouraged empirical work, particularly in the post-World War II period. For example, Halter et al. pointed to the advantage of the flexible transcendental predicting function. Vandenborre and McCarthy wrote on the matter of comparing marginal value productivities with individual factor prices in Cobb-Douglas analysis. Productivity estimation was the main objective in other studies. Heady and Shaw illustrated the use of a Cobb-Douglas production function and estimated the marginal value of productivity of resource levels in different farming locations in the U.S. Heady and Strand examined production efficiency by using average productivity measurements as a major goal of economic organization.

Application of Production Economics

The first empirical estimates of production functions for agricultural firms in the U.S. were made in the Iowa studies. Heady (1946) derived production functions for a 1939 random sample of 738 Iowa farms. Functions were derived both for (1) types of farms and (2) average of the state. In all cases, the inputs were land, labor, power and equipment, livestock and feed, and operating expenses, all measured in dollar terms. Output was also measured in dollar terms. A Cobb-Douglas function, without the constraint of constant returns to scale, was employed. Some of the estimated elasticities were negative, though all such were insignificant at the 5% probability level. In every case, the sum of the elasticities was less than one, indicating diminishing returns to scale.

Management was not included as an input, primarily because no objective measure was available. Had such data been available, the results may well have been different. Heady (1946) identified a number of limitations, including the aggregation problem, lack of homogeneity in farms sampled for estimation purposes, the use of labor availability instead of labor used, the method of measuring capital inputs, a lack of measurable management, and the form of the function selected.

In 1945, Nelson conducted a livestock study inspired by wartime food shortages and the need for basic data in determining livestock feeding and price policy. The studies of animal gain and feed intake for calves, yearlings, and two-year-old beef animals were also based on feeding experiments. The experiments were conducted a number of years prior to the analysis and were not designed specifically for production

function estimation. A single-variable production function was derived for the several classes of cattle with the various grains, protein supplements, and forages converted to a single category measured as total digestible nutrients. Estimates were derived for both live and dressed weight of the cattle. The live-weight regressions indicate diminishing marginal and average productivity of feed from the outset of the feeding period. The dressed-weight regressions indicate ranges of both increasing and decreasing marginal productivity of feed, primarily because the dressing percentage of animals increases with weight. In this study, neither the productivity coefficients nor marginal rates of substitution could be specified for different feed categories.

Tintner and Brownlee derived a Cobb-Douglas function for 468 Iowa farms that kept records in 1939. They derived mean marginal productivities, where inputs and product were measured in dollars. Tintner derived a similar production function for 609 Iowa farms that kept records in 1942.

In the Heady (1946) and Tintner studies, livestock products were aggregated into a single output. Inputs were aggregated largely on the basis of accounting procedures of the time. Also, the inputs were not always measured in a logical fashion and may have given rise to low or negative productivities.

Many other economists made important contributions in the economic applications of production functions. Tolley, Black, and Ezekiel examined inputs as related to output in farm organization and cost of production studies and actually made an attempt to fit production functions to farm data. As cited by Heady and Dillon in Agricultural

Production Functions, Heady and Olson studied the marginal rates of substitution and uncertainty in the utilization of feed resources with particular emphasis on forage crops. Heady (1952) later examined the use and estimation of input-output relationships, or productivity coefficients. Heady also dealt with the choice of the functional form in estimating input-output relationships within the farm sector. Darcovich (as cited by Heady and Dillon) used production functions in the study of resource productivity in some of the beef-producing areas of Alberta, Canada. Based on a review of traditional and popular literature, Griffen, Montgomery, and Rister provided an excellent summary of available functional forms and their corresponding properties for production analysis.

Animal Science Production Literature

The scientific effects of feed additives and hormone implants are identified in many studies. For example, the feed additive Monensin (Rumensin), a biologically active compound produced by a strain of Streptomyces Cinnamonesis, is effective in preventing coccidiosis in poultry with moderate in vitro activity against gram-positive organisms (Richardson et al.). The other feed additive, Bovatec, is a lasalocid antibiotic agent used as an anticoccidial. Both compounds have been observed to increase the feed efficiency of cattle fed finishing rations in the feedlot. This increased efficiency is the result of modifying and manipulating the rumen fermentation process so that propionic acid comprises a larger proportion of the total volatile fatty acids (Potter et al., 1974). The propionic acid is used more efficiently for

production by the animal than is acetic acid. This increase in propionic acid changes the form of energy available for metabolism by the animal and has resulted in an improvement in feed efficiency (Oliver).

The compound in Ralgro hormone that stimulates weight gain is Zeranol, while the basic ingredient in the Compudose hormone, estradiol, releases a controlled level of a natural steroid, estradiol-17B. The two hormones stimulate the animal's pituitary gland to increase production of somatotrophin which is commonly referred to as the growth hormone. Presence of the extra growth hormone in the animal's system results in increased tissue and skeletal growth, thereby creating extra weight (Neel).

Some animal science literature has dealt with the impact of feed and hormone additives on average daily gain and feed efficiency in feedlot cattle. For instance, Potter et al. (1985) studied the effects of feeding Momensin at 33 ppm alone, Tylosin at 11 ppm alone, and the two feed additives in combination on the average daily gain, average daily feed intake, feed gain ratio, and the incidence of liver abscesses in feedlot cattle. They found that Momensin reduced feed intake and improved feed efficiency and had an effect on liver abscess incidence, while Tylosin reduced abscess incidence from 17% to 9%.

Zinn studied the influence of dietary Salinomycin levels of 0, 5.5, 11, 16.5, and 22 milligrams per kilogram, respectively, on rate and efficiency of gain. The base diet to which the ionophore was added was composed largely of steam-processed grains and contained 3% supplemental fat. Performance responses to Salinomycin supplementation were similar for steers and heifers. Rate of gain was not influenced. However, feed

conversion was improved by an average of 5% at the 11 to 22 milligrams per kilograms levels of Salinomycin. This improvement in feed conversion could be accounted for as either a 5% increase in the net energy value of the diet or a 10% reduction in maintenance requirement.

Horton evaluated the effects of adding Lasalocid or Momensin to a high-silage diet for growing steers. The results showed that 33 milligrams Lasalocid per kilogram feed significantly improved feedlot performance of these animals.

Rumsey studied the effects of implants of Synovex-S and of a diet containing kiln dust on the composition of tissue gain by Hereford steers. He found Synovex-S implanted steers consumed more feed dry matter in the 126-day trial, gained weight faster and were more efficient than non-implanted steers.

Schake et al. studied the effect of reimplanted DES or Synovex-S in crossbred beef steers obtained from either a drylot feeding program (Source I) or from oat pasture (Source II). Half of the steers from each source were reimplanted with DES and the other half with Synovex-S. They found steers from Source I gained more than those from Source II. Feed efficiency, final weight, and sale prices of steers were not significantly influenced by type of reimplant.

Potter et al. (1985) evaluated the effects of feeding Monensin at 33 ppm alone, Tylosin at 11 ppm alone, and the two feed additives in combination on the average daily gain, average daily feed intake, feed, gain ratio, and the incidence of liver abscesses in feedlot cattle. They found Monensin reduced feed intake and improved feed efficiency and had no effect on average daily gain. Tylosin improved average daily gain and

had no effect on daily feed intake. The effect of Tylosin on feed efficiency approached significance. The interaction of Monensin and Tylosin was insignificant for daily gain, daily feed intake and feed gain ratio. Monensin had no effect on liver abscess incidence, while Tylosin reduced abscess incidence from 27 to 9%.

Potter et al. (1974) examined the effect of different Monensin dosages on weight gain of pasture cattle. Monensin levels of 100 and 200 milligrams per day (PC.01) significantly increased gain. The response at 200 milligrams per day was slightly more than that at the 100 milligrams per day dose.

Grueter et al. studied the effect of Rumensin on feed efficiency of lightweight cattle started on high-roughage rations and finished on high-concentrate rations. During the growing phase (high roughage) 30 grams of Rumensin per ton of feed increased feed efficiency 9%. During the finishing period, feed efficiency was increased 11%. Cattle fed Rumensin consumed less feed and gained at a rate equal to or slightly faster than that of the control groups. Ten grams Rumensin per ton of feed increased daily gain by 5%.

In 1982, Brandt evaluated the treatment of feeding cattle with Bovatec (Lasalocide) at a different level (gram per ton) of complete feed. He found that Bovatec improved performance of feedlot cattle. Bovatec at levels of 10 to 30 grams per ton improved feed conversion. At 30 grams per ton, Bovatec significantly increased gain by 5.24% (PC.01) compared to nonmedicated control and increased feed conversion.

In 1982, Stuart studied the effect of Bovatec (Lasalocid) on the rate of gain and feed conversion of feeder cattle. He found that Bovatec

at 30 grams per ton of feed increased average daily by 7.2% (PC.01) and improved feed conversion by 9.7% (PC.01) over nonmedicated controls.

Loy, Harpster, and Cash studied the effect of reimplanted growth stimulants in feedlot steers on the rate of gain, composition, and efficiency of growth. The study examined the effects of reimplantation of 36 milligrams of Zeranol (Ralgro) or 200 milligrams of progesterone plus 20 milligrams estradiol benzoate (one kind of Compudose), referred to as (Synovex-S). The implants (Ralgro and Synovex-S) increased daily gains by 11.5% and 25.2%, respectively.

In 1987, Williams et al. studied the influence of frame size and Zeranol (Ralgro) on growth, compositional growth, and plasma hormone characteristics. Angus, Charolais X Hereford and Hereford X Angus yearling steers (34 steers averaging 270 kilograms body weight) were randomly assigned to treatments by small and large frame. The steers showed an improvement in daily gain regardless of frame size for the total trial and were more efficient in converting dry matter to gain than the steers not implanted with hormones (nonmedicated control).

Basson et al. evaluated the comparison of the performance of estradiol (Compudose) silicone-rubber-implant-treated steer to that of Zeranol or Estradiol plus progesterone. They found the performance (average daily gain and feed conversion) of all implant treatments was significantly improved over the control group. The single-implant treatment showed gains significantly less than the reimplant treatment.

Borger et al. tested the effects of Zeranol (Ralgro) implants and dietary protein level on line performance, carcass, merit, certain endocrine factors, and blood metabolite levels. They found over the 169-day trial that Zeranol-implanted cattle gained significantly faster (7-8%) than non-implanted steers (1-24 vs. 1-15 kilograms per day).

From the animal science literature it appears that feed and hormone additives do have an impact on weight gain and efficiency of digestibility in cattle. However, none of these authors specifically evaluated the costs and benefits derived from the application of these additives and hormones.

Economic Literature Research

Virtually all of the recent economic literature involving cattle has focussed on the relationship between the size of the feedlot and the cost of operation. As examples, Irrer and Jones examined the relationships between size and average total nonfeed costs of a beef-feeding enterprise. Hunter and Madden analyzed the internal physical economies associated with the size of the cattle-feeding industry. McCoy and Wakefield examined the relationship between costs per unit of output to various degrees to which the capacity of a given size feedlot is utilized and the relationship of costs to various sizes of feedlots.

None of the current economic literature deals with the cost effectiveness of feed additives and/or hormone implants. Unlike previous analyses, the specific purpose of this study is to quantify the influence

that feed and hormone additives has on the rate of gain in feeder cattle and to determine the cost effectiveness of their use in feeding cattle for slaughter.

CHAPTER III

DATA AND ANALYSIS

Data on several groups of cattle were made available by Dr. Norris Stenquist of the Animal Science Department at Utah State University. The data included information on periodic cattle weights, rations fed, feed additives given, hormone treatments administered, the period of time between weight and ration changes, breed, medical care, and feed costs. The data consisted of four consecutive feeding trials over the interval 1983 through 1986. There were seven weighing periods for each of the 32 animals in Group 1; six such periods for the 31 animals in Group 2, eight weighing periods for the 32 animals in Group 3, and seven for the 33 animals in Group 4.

Feeding periods are the intervals within the feeding trial in which the cattle are fed a certain ration, generally 28 days. The feeding trials were conducted on an individual animal basis. While most of the data were entered directly from actual feeding records, net energy for maintenance and gain were estimated from the data contained in the actual feeding records. The data were entered on a spreadsheet to provide a uniform basis for data entry and manipulation. The list of variables and their corresponding definitions is included in Appendix A.

Analytical Procedures

The data were prepared for statistical analysis using a spreadsheet program. Each of the variables was entered and matched to specific animals. The data were arranged such that all observations for the same

animal were listed consecutively. Statistical analyses were performed using two microcomputer programs, MicroTSP and Statgraphics. The statistical analyses primarily consisted of the estimation of physical production functions. The production functions included many explanatory variables, with the animal's weight after each feeding interval as the dependent variable.

The hypotheses to be tested were: (1) Feed additives have no discernible impact on the weight out and rate of gain; (2) hormone implants have no discernible impact on the weight out and rate of gain; and (3) animal breed does not have an impact on the weight out and rate of gain. In general form, the null hypothesis can be stated formally as

$$(10) \quad H_0: B_i = 0$$

$$H_1: B_i \neq 0$$

where H_0 is the null hypothesis, and H_1 is the alternative hypothesis. The null hypothesis states that the slope coefficient of any special feed or hormone additive is zero against an alternative hypotheses, which is assumed not equal to zero. If the null hypothesis is rejected, then one can conclude that the additive or hormone does have some effect on weight out with some degree of confidence. In this analysis, the dummy variable technique was used to determine the impact, if any, of various feed additives, hormone treatments, and cattle breeds. The models were estimated using ordinary least squares (OLS).

The Model

The formal model included weight-in (WI), net energy for gain (NEG), total days for the feeding interval (TOTDAY), dummy variables for

each of the feed additives tested (DADD1 and DADD2), dummy variables for each of the hormone implants (DHOR1 and DHOR2), and dummy variables for three of the four breeds examined (DBRE1, DBRE2, and DBRE3). The units and measurement and a brief description of the variable are included below.

WTOUT = animal's weight out measured in pounds

WTIN = animal's weight in measured in pounds

NEG = net energy for gain measured in megacalories

TOTDAY = total days on feed

DADD1 = Rumensin feed additive

DADD2 = Bovatec feed additive

DHOR1 = Ralgro hormone implant

DHOR2 = Compudose hormone implant

DBRE1 = Angus breed

DBRE2 = Tarantaise breed

DBRE3 = Simmental-cross breed

Following the dummy variable approach (Kmenta), one less dummy variable is used than available alternatives. For instance, if there are three alternatives with respect to feed additives, i.e., (a) no additive, (b) Rumensin, and (c) Bovatec, then two dummy variables are used and the base case is excluded. In the case of feed additives and hormones, the case not included is the base situation in which no feed additives or hormones are given. In the case of the breed comparison, the base is the Hereford breed.

The method of OLS provides efficient and unbiased estimates of the parameters under certain conditions. Consequently, OLS is often used in

estimating the coefficients corresponding to the independent (exogenous) variables. The conditions imposed include (a) normal distribution of error terms, (b) zero mean of error terms, (c) a constant variance of the error terms (homoskedasticity), (d) error terms from one observation (time period or data point) are uncorrelated with the error terms for all other observations (nonautocorrelation), and (e) nonstochastic independent (exogenous) variables. Since this analysis was done using OLS procedures, it is necessary to discuss some of the potential problems in more detail.

Multicollinearity: The term multicollinearity refers to the existence of an exact or approximately exact linear relationship among some or all explanatory variables of a regression model. In the classical linear regression model, excessive multicollinearity leads to indeterminate variable coefficients and infinite standard errors. In the event of near perfect or high collinearity, many problems occur using the OLS technique. For example, the variances and covariances of these estimators will be increased if the partial correlation coefficient is increased. In the cases of high collinearity, the estimated standard errors increase dramatically, thereby reducing the t-values. Consequently, acceptance of the null hypothesis will be increased, i.e., a failure to reject the null hypothesis even though properly warranted.

In linear regression models with more than two explanatory variables under the case of high collinearity, it is possible to find that one or more of the partial slope coefficients are individually statistically insignificant on the basis of the t test. However, the F statistic and R^2 are generally significant.

Autocorrelation: The term autocorrelation can be defined as correlation between members of series of observations over time, such as time-series data, or space, such as cross-section data. In the classical linear model, it is assumed that such autocorrelation does not exist in the disturbance terms over time or space.

In the presence of autocorrelation, the OLS estimators are still consistent and linearly unbiased but no longer efficient. The existence of autocorrelation may inflate the precision or accuracy of the estimators. As a result, the usual OLS variance of the estimators may understate the true variance and overestimate R^2 .

Autocorrelation may be tested through the use of the Durbin-Watson statistic. The Durbin-Watson statistic is simply the ratio of the sum of squared differences in successive residuals to the residual sum of squares. The advantage of the Durbin-Watson d statistic is that it is based on the estimated residuals, which are routinely computed in regression analysis. This test will be efficient under the following assumptions: (1) The regression model includes an intercept; (2) the explanatory variables are nonstochastic (fixed in repeated samples); (3) the disturbance terms, U_t , are generated by the first-order autoregressive scheme. That is,

$$(11) \quad U_t = \rho U_{t-1} + \varepsilon_t \text{ and } -1 < \rho < 1$$

where ρ is the first-order coefficient of autocorrelation; (4) the regression model does not include lagged value(s) of the dependent variable(s) as one of the explanatory variables; and (5) there are no missing observations in the data (Gujarati).

With the Durbin-Watson statistic, there is no unique critical value that will lead to the rejection or the acceptance of the null hypothesis concerning first-order serial correlation in the disturbances U_i ; but an upper and lower bound can be calculated such that if the computed "d" lies outside these critical values, a decision can be made regarding the presence of positive or negative serial correlation. These limits depend only upon the number of observations (n) and the number of explanatory variables.

R squared: The value of R^2 represents the proportion of the variability in the dependent (endogenous) variable that can be explained by changes in the one or more independent (exogenous) variables. The higher the value of R^2 , the greater the explanatory power of the independent variables.

t statistic: The t statistic can be used to determine whether specific coefficients are significantly different from zero. The t statistic represents the value of the estimator divided by its standard error. For large data series, a t statistic above 2.0 suggests that the coefficient is significantly different from zero.

F statistic: The F statistic provides a test of overall equation significance. The F statistic is to the overall equation what the t statistic is to each coefficient.

CHAPTER IV

STUDY RESULTS

Both linear and multiplicative (power) models were used in the estimation of coefficients. The linear model was chosen because the results were nearly identical in both models, and data manipulation and interpretation is often easier in the linear model.

During the initial analysis, both of the feed additives were included in the production equation. However, the feed additives Rumensin, and breeds (breed₁ = Angus, and breed₂ = Simmental-cross) had insignificant, negative effects on the dependent variable (WTOUT) (table 3). After discarding the dummy variables for Rumensin, Angus breed, and Simmental-cross breed, the equation was reestimated (table 4). The estimated parameters of the resulting linear regression model are shown below:

$$\begin{aligned}
 (12) \quad WTOUT = & 48.284 + .939 \, WTIN + .198 \, NEG \\
 & (5.539) \, (.009) \quad (.0016) \\
 & + .141 \, TOTDAYS - 9.654 \, DADD2 + 10.973 \, DHOR1 \\
 & (.029) \quad (2.642) \quad (2.420) \\
 & + 6.815 \, DHOR2 + 17.226 \, DBRE2 \\
 & (2.871) \quad (2.642)
 \end{aligned}$$

$R^2 = .986006$; F-statistic: 8817.721; D-W Statistic: 1.904

The figures in parentheses are the estimated standard errors.

The value of R^2 in this model is .986 which suggests that more than 98% of the variation in weight out of each feeding period can be

Table 3. Independent Variables and Their Coefficients for the Initial Regression Estimation

VARIABLE	COEFFICIENT	STD. ERROR	T STAT.	2-TAIL SIG.
C	50.563512	6.5145327	7.7616483	0.000
WTIN	0.9358223	0.0096128	97.351380	0.000
NEG	0.1970172	0.0118223	16.664837	0.000
TOTDAYS	0.1493433	0.0313567	4.7627228	0.000
RUMND	-0.6345583	1.9846910	-0.3197265	0.749
BOVAD	-9.6253786	2.9393427	-3.2746704	0.001
HORM1D	10.599210	2.5929935	4.0876347	0.000
HORM2D	6.2695593	3.0375739	2.0640022	0.039
BREED1	-0.6763323	2.1010488	-0.3219022	0.748
BREED2	17.126188	2.6984583	6.3466566	0.000
BREED3	-3.0513641	3.5781111	-0.8527863	0.394
R squared	0.986020	Mean of dependent var		856.6029
Adjusted R squared	0.985860	S.D. of dependent var		179.2901
S.E. of regression	21.31964	Sum of squared resid		396802.0
Durbin-Watson stat	1.901204	F statistic		6157.433
Log likelihood	-3953.519			

Notes: Dependent Variable is WTOUT; SMPL range is 1 - 884; Number of observations is 844.

Table 4. Independent Variables and Their Coefficients After the Nonsignificant Variables are Excluded

VARIABLE	COEFFICIENT	STD. ERROR	T STAT.	2-TAIL SIG.
C	48.283868	5.5393263	8.7165596	0.000
WTIN	0.9386774	0.0088618	105.92442	0.000
NEG	0.1978758	0.0116165	17.033983	0.000
TOTDAYS	0.1405942	0.0287614	4.8882934	0.000
BOVAD	-9.6538287	2.2893330	-4.2168740	0.000
HORM1D	10.973007	2.4203327	4.5336770	0.000
HORM2D	6.8153966	2.8708478	2.3740014	0.018
BREED2	17.225548	2.6418192	6.5203357	0.000
R squared	0.986006	Mean of dependent var		856.6029
Adjusted R squared	0.985895	S.D. of dependent var		179.2901
S.E. of regression	21.29361	Sum of squared resid		397194.2
Durbin-Watson stat	1.904301	F statistic		8817.721
Log likelihood	-3953.955			

Notes: Dependent Variable is WTOUT; SMPL range is 1 - 884; Number of observations is 884.

explained by the independent variables included in the model. The t statistics are significant for each of the estimated coefficients. The null hypothesis, i.e., $B_i = 0$, can be rejected with 99% confidence.

The interpretation of this regression equation is as follows. First, the intercept form is virtually meaningless in this application because it lies outside the range of values used in the analysis. Second, if all factors except one were to be held constant, the contribution of the remaining variable can be determined.

It should be noted that except for WTIN, NEG, and TOTDAYS, marginal analysis cannot be applied to the included variables. Only the impact of the existence of feed additives and/or hormone implants can be examined. For instance, if the DHOR1 is implanted, then the contribution of that implant is approximately 10.973 pounds of gain per feeding period. Similarly, the existence of the second hormone implant, DHOR2, contributes approximately 6.815 pounds of beef for each feeding period. Continuing, the existence of the second feed additive, DADD2 = Bovatec, suggests that production may be retarded if fed. The Tarantaise breed does appear to have a significant impact on the production of beef as revealed in its coefficient of + 17.226.¹ This suggests that the Tarantaise breed does gain faster than the other breeds under consideration in this analysis.

The estimated d value obtained from the computer printout, which is routinely computed by the regression program, was approximately 1.904. Using the Durbin-Watson d -statistic table for testing the serial

¹There was a limited number of Tarantaise animals included in the study. Therefore, it is possible that the effects may be overrated.

correlation between the disturbances, U_i , for instance, in our model with seven explanatory variables, the $"d"_L = 1.603$, and $"d"_u = 1.746$. For testing the null hypothesis that there is no autocorrelation, the estimated d value should be between the following limits.

$$(13) \quad "d"_u < "d" < 4 - "d"_u$$

where $"d"_u$ is the upper limit and $"d"$ is the estimated $"d"$ statistic.

Substituting the d statistic in the identity above, we get

$$(14) \quad 1.746 < 1.904 < 2.254$$

These results of the Durbin-Watson test suggest that the null hypothesis, i.e., there is no serial correlation between the disturbances, U_i , cannot be rejected.

The dummy variable technique enables us to differentiate between intercepts of the base case and the cases of using or implanting feed and hormone additives. The average weight out of each animal can be determined given the specific values for the coefficients, which can be shown as below. There are several possible scenarios, including the base case, that can be examined.

Case 1: Starting from the base category E(WTOUT/DBovatec = 0, DHOR1 = 0, DHOR2 = 0, and DBRE2 = 0, given all other variables in the Model):

$$= 48.284 + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

This equation represents the base case (no additives or hormones are used or implanted into the animal during each feeding period).

Case II: Using FADD2 (= Bovatec) in the ration and E(WTOUT/DBovatec = 1, DHOR1 = 0, DHOR2 = 0, and DBRE2 = 0, given all other variables in the Model):

$$= (48.284 - 9.654) + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

$$= 38.630 + .939 \text{ WTIN} + .198 \text{ ENG} + .141 \text{ TOTDAYS}$$

Case III: Using HOR1 implant (= Ralgro) and E(WTOUT/DBovatec = 0, DHOR1 = 1, DHOR2 = 0, and DBRE2 = 0, given other variables in the Model):

$$= (48.284 + 10.973) + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

$$= 59.256 + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

Case IV: Using HOR2 implant = Compudose and E(WTOUT/DBovatec = 0, DHOR1 = 0, DHOR2 = 1, and DBRE2 = 0, given all other variables in the Model):

$$= (48.284 + 6.815) + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

$$= 55.099 + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

Case V: Selecting breed = Tarantaise and E(WTOUT/DBovatec = 0, DHOR1 = 0, DHOR2 = 0, and DBRE2 = 1, given all other variables in the Model):

$$= (48.284 + 17.226) + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

$$= 65.51 + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

Case VI: Implanting Ralgro hormone with alternative breed2 (Tarantaise) and E(WTOUT/DBovatec = 0, DHOR1 = 1, DHOR2 = 0, and DBRE2 = 1, given all other variables in the Model):

$$= (48.284 + 10.973 + 17.226) + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

$$= 76.483 + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS}$$

Case VII: Implanting Compudose hormone with alternative breed2 (Tarantaise) and

E(WTOUT/DBovatec = 0, DHOR1 = 0, DHOR2 = 1, and DBRE2 = 1, given all other variables in the Model):

$$\begin{aligned} &= (48.284 + 6.815 + 17.226) + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS} \\ &= 72.325 + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS} \end{aligned}$$

Cases II, III, and IV reflect the impact of using FADD2 = Bovatec and hormone implant (Ralgro and Compudose) on the mean WTOUT of the animals separately with base category breed (Hereford). Equations 6 and 7 quantify the impact of hormone 1 (Ralgro) and hormone 2 (Compudose) on the mean WTOUT with alternative breed (Tarantaise). Note that the intercept of the mean weight out of equations 6 and 7 differ from the mean weight out of the base category (equation 1).

Comparing these results with the other studies, the feed additive (Rumensin) was negatively but insignificantly effected; this result is different from the evaluation of Potter et al. (1974) and Grueter et al. (1976). For the Bovatec feed additive, this study showed a negative and significant effect on the average weight out, while the studies of Brandt and Stuart showed this additive affected positively on the performance of the animal.²

Growth hormone results (Ralgro and Compudose) were consistent with evaluations done by Loy, Harpster, and Cash (1988); Williams et al. (1987); Basson et al. (1985); and Borger et al (1973). These hormones positively impacted average daily gain and improved feed conversion.

²These results are inconsistent with results reported elsewhere. One possible explanation is that the animals refused to eat Bovatec since it was available on a "free-consumption basis," i.e., the animals were not required to consume the feed additives.

CHAPTER V

COST AND BENEFIT ESTIMATION

Estimated Benefits

The estimated regression model is:

$$\begin{aligned} \text{WTOUT} = & 48.284 + .939 \text{ WTIN} + .198 \text{ NEG} + .141 \text{ TOTDAYS} \\ & - 9.654 \text{ DADD2} + 10.973 \text{ DHOR1} + 6.815 \text{ DHOR2} \\ & + 17.226 \text{ DBRE2} \end{aligned}$$

The marginal product or contribution for each explanatory variable, i.e., a change in weight out for the change in these variables holding all other variables in the model constant, in this model can be explained by examining their coefficients. The marginal product of variables WTIN, NEG, and TOTDAYS equals .939 lb., .198 lb., and .141 lb., respectively.

The estimated contributions of feed additive (Bovatec), hormones (Ralgro, Compudose), and breed (Tarantaise) can be explained as follows. The contribution of DADD2 (Bovatec) can be computed from the estimated regression equation above holding all other factors constant and examining the change in weight out for the existence of additive 2 as equal to -9.654 pounds. The contributions of hormone 1 (Ralgro) and hormone 2 (Compudose) can be computed from the same regression equation. These contributions equal 10.973 pounds and 6.815 pounds, respectively. The contribution of the alternative breed, Tarantaise, increased the average weight out by 17.226 pounds per feeding period.

Estimated Cost

The estimated cost of implanting Ralgro and Compudose are calculated as follows:

In order to be effective, the animal must be implanted with Ralgro hormone every 90 days. Over all feeding periods each animal was treated with two implants. The cost of one implant is \$.91, excluding labor cost, in 1986 terms. The total cost of the Ralgro hormone is as follows

$$$.91 \times 2 = \$1.82$$

Thus, the cost of the Ralgro hormone per feeding period is

$$\begin{array}{r} \$1.82 \\ \hline 6 \end{array} = \$.303$$

since there were six feeding periods for each animal.

Unlike Ralgro, the Compudose hormone must be implanted only once every 200 days. Each animal in this experiment was treated with only one implant. The cost, excluding labor, of one implant of Compudose equals \$1.90. The cost of hormone per feeding period is

$$\begin{array}{r} \$1.90 \\ \hline 6 \end{array} = \$.317$$

Estimated Benefits

Since the contribution of hormone 1 (Ralgro) equals 10.973 pounds and the price of beef (live) is \$54.9/cwt (fifty-four dollars and ninety cents per hundred pounds), the value of the contribution of Ralgro hormone is

$$10.973 \text{ lb.} \times \$54.9/\text{lb.} = \$6.024$$

The contribution of hormone 2 (Compudose) equals 6.815 pounds, and the value of this contribution is

$$6.815 \text{ lb.} \times \$0.549/\text{lb.} = \$3.741$$

While it appears that the Ralgro implant provides a larger positive benefit than Compudose, it should be noted that Ralgro must be implanted twice while Compudose is implanted only once. Therefore, the disparity in net returns between the two hormones is not as strong as indicated by the cost of the respective hormone.

Finally, the contribution of selective breed (Tarantaise) equals $17.226 \text{ lb.} \times \$0.549/\text{lb} = \$9.457$.

CHAPTER VI

SUMMARY, CONCLUSION, AND RECOMMENDATION

Summary

More than 800 observations of eight variables were gathered and arranged for statistical analysis. Because of the size of the data base, data were prepared for statistical analysis using a spreadsheet program. Each of the variables were entered and matched to specific animals. The data were arranged such that all observations for the same animal were listed consecutively.

The results of this analysis indicate that there is a significant negative effect on the average weight out from adding a certain amount of Bovatec to the ration of an animal at the end of the feeding period. Implanting Ralgro hormone increased the average WTOUT of the animal by about 10.973 pounds. Likewise, the effect of implanting Compudose hormone into the animal added an extra amount of weight, about 6.815 pounds to the average weight out at the end of each feeding period. The selective breed Tarantaise increased the average WTOUT of the animal by about 17.226 pounds at the end of the feeding period. The test for autocorrelation shows that there is no serial correlation between the disturbances U_i .

Conclusions

The growth hormone Ralgro will add a benefit (i.e., its value of contribution) that exceeds the cost incurred from purchasing this hormone. As an illustration, the benefit in dollar value equals \$6.024,

while the cost of this hormone for each feeding period equals about (\$303). The difference between the cost and benefit equals \$5.721.

The benefit of the Compudose hormone exceeds its cost during the feeding period. The difference between the value of contribution of Compudose hormone (\$3.741) and the cost of implanting this hormone (\$.317) equals \$3.424. Each hormone implant provides positive net returns and differences in weight gained were shown for the various breeds included in this study.

The contribution value of Tarantaise breed is

$$17.226 \text{ lb.} \times \$549/\text{lb.} = \$9.457$$

This suggests that the typical feedlot operator could afford to pay more for feeder cattle of the Tarantaise breed.

Recommendations

Further analysis should be made with respect to the functional form. Linear and multiplication forms were used in this study, but many other functional forms are available. While providing an adequate fit of the data, both linear and multiplicative forms impose restrictions that may or may not conform to the data. In addition, an analysis of the change in weight gain for costs incurred should be examined.

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APPENDICES

Appendix A. Guidelines for Reading Feedlot Data

1. Column 1: Animal

Each animal has been identified by a whole number with the first animal being given the number one, the second animal number two, etc. Every feeding period has been designated by .1 for the first, .2 for the second, and so on. For instance, 18.2 represents animal 18 in the second feeding period. The animals are numbered consecutively from one feeding trial to the next. If there are 32 animals in trial one, the first animal in trial two would be number 33. The feeding periods are the intervals within the feeding trial in which the cattle are fed a certain ration, generally 28 days. The feeding trials include different cattle.

2. Weight in (WTIN):

Gives the animal's weight in pounds at the beginning of feeding period.

3. Weight out (WTOUT):

Gives the animal's weight in pounds at the end of feeding period.

4. Gain: (GAIN)

Gives the total animal's gain in pounds over the feeding period.

5. Gain per day (GAINDY):

Gives the gain per day of the animal in pounds over the feeding period.

6. USDA Grade (USDAGD)

The USDA Grade is coded as follows:

- 1.1 ---- choice (C)
- 1.2 ---- choice (C+)

- 1.0 ---- choice (C-)
- 2.1 ---- good (G)
- 2.2 ---- good (G+)
- 2.0 ---- good (G-)

7. Yield Grade (YIELDGD)

Represents the actual yield grade given by packers.

8. Yield (YIELD)

The percentage of hot weight to total live slaughter weight.

9. Hot Weight (HOTWT)

Gives the slaughter hot weight in pounds.

10. Dry Matter (DM)

Gives the total amount of dry matter in pounds received by the animal within the feeding period. The figures were calculated using a program provided by Dr. Norris Stenquist that evaluates the total ration fed. The program simply multiplies each ration input by the percent dry matter of each input and totals the result.

11. Ration

The rations are coded as follows:

<u>Ration</u>	<u>Description</u>
1	Alfalfa, corn silage, whole corn, with Moorman's and Trigger 11 feed additives.
2	Alfalfa, corn silage, whole corn, with Moorman's feed additives.
3	Alfalfa, corn silage, ground corn, with Rumensin and Trigger 11 feed additives.
4	Alfalfa, corn silage, ground corn, with Ruymensin feed additive.
5	Alfalfa, corn silage, barley, with Rumensin and Trigger 11 feed additives.
6	Alfalfa, corn silage, barley, with Rumensin feed additives.

Note: Rations 1, 5, and 6, are high energy rations; the alfalfa and corn silage were phased out in later feeding periods.

- 7 Alfalfa, corn silage, barley, with Rumensin and Trigger 11 feed additives.
- 8 Alfalfa, corn silage, barley, with Rumensin feed additives.
- 9 Alfalfa, corn silage, barley, with dry supplement feed additives.
- 10 Alfalfa, corn silage, barley, with dry supplement feed additives.
- 11 Alfalfa, corn silage, barley, with dry supplement and Rumensin feed additives.
- 12 Alfalfa, corn silage, barley, with dry supplement, Rumensin and Trigger 11.
- 13 Alfalfa, corn silage, barley-wheat, with dry supplement, Rumensin, and Trigger 11.
- 14 Alfalfa, corn silage, barley-wheat, with dry supplement, and Rumensin.
- 15 Alfalfa, corn silage, barley-wheat, with dry supplement.
- 16 Alfalfa, corn silage, barley-wheat, with dry supplement and Trigger 11.
- 17 Alfalfa, corn silage, rolled barley, with dry supplement, and Rumensin.
- 18 Alfalfa, corn silage, rolled barley, with dry supplement, and Bovatec.
- 19 Alfalfa, corn silage, ground corn, with dry supplement and Bovatec.
- 20 Alfalfa, corn silage, ground corn, with dry supplement and Rumensin.
- 21 Alfalfa, corn silage, rolled barley, with dry supplement and PMS.
- 22 Alfalfa, corn silage, ground corn, with dry supplement and Feedlot Finisher.
- 23 Alfalfa, corn silage, rolled barley, with dry supplement and Feedlot Finisher.

- 24 Alfalfa, corn silage, ground corn, with dry supplement.
- 25 Alfalfa, corn silage, rolled barley, with dry supplement.
- 26 Alfalfa, corn silage, ground corn, with dry supplement and Feedlot Finisher.
- 27 Alfalfa, corn silage, rolled barley, with dry supplement, and Feedlot Finisher.
- 28 Alfalfa, corn silage, ground corn, with dry supplement, and PMS.

Note: Rations 21 through 28 did not receive dry supplement the first feeding period.

- 29 Alfalfa, corn silage, rolled barley-corn, dry supplement with cattle injected with 1 ml of Depo MGA.
- 30 Alfalfa, corn silage, rolled barley--corn, dry supplement with MGA.
- 31 Alfalfa, corn silage, rolled barley-corn, dry supplement with cattle injected with .5 ml of Depo MGA.
- 32 Alfalfa, corn silage, rolled barley-corn, dry supplement with cattle injected with 1.5 ml of Depo MGA.
- 33 Alfalfa, corn silage, rolled barley-corn, dry supplement without MGA.

12. Net Energy for Maintenance (NEM)

From the program supplied by Dr. Norris Stenquist, by inputting the total amount of feed received by an animal in a feeding period, the program gives the total Net Energy for Maintenance supplied by the feed. The amount is reported in MCAL.

13. Net Energy for Gain (NEG)

Gives the amount of Net Energy for Gain supplied by the feed during the specific feeding period. Once again, figures were derived from the program supplied by Dr. Norris Stenquist.

14. Rumensin (Rumn)

Gives the amount of Rumensin in the feed during the specific feeding period. The cattle received the feeding period gave the amount in grams.

15. Bovatec (Bova)

Gives the amount of Bovatec in the feed during a specific period. Reported in grams and fed at the same rate as Rumensin in (14) above.

16. Dry Supplement (Drysup)

Gives the amount of dry supplement, 32% protein, in the feeding period. Reported in pounds and fed at a rate of 1 pound/head/day.

17. Trigger 11 (Trq2)

Trigger 11 is a top-dressed feed additive that was fed at a rate of 1 ml per 100 lbs. of body weight per day. Therefore, the weight-in and weight-out figures for each animal in each feeding period were averaged and divided by 100. This figure was then multiplied by the number of days in the feeding period to get the total amount of Trigger 11 fed in ml.

18. Feedlot Finisher (FDFIN)

Feedlot Finisher comes in a feed supplement form and was fed at a rate of 3 lbs. per head per day. The total amount received by the animal in each feeding period is reported in pounds.

19. PMP

PMP is another supplement-type feed additive and was fed at a rate of 1 lb. per head per day. The total amount received by the animal in each feeding period is reported in pounds.

20. Moorman's (Moor)

Moorman's is another supplement type feed additive that was fed at a rate of .75 lbs. per head per day. The total amount received by the animal in each feeding period is reported in pounds.

21. Hormone (Hormo)

Shows the presence of a growth stimulating hormone. The column is coded as:

0 ---- none, 1 ---- Ralgro, 2 ---- Compudose.

22. Sex

Records the sex of the animal. The column is coded as:

0 ---- heifer, 1 ---- steer.

23. Breed

Records the breed of the animal. The column is coded as:

0 ---- Herford, 1 ---- Angus, 2 ---- Tarantaise
 3 ---- Simmental Cross, 4 ---- Red Bally
 5 ---- Red Angus, 6 ---- Black Bally, 7 ---- Red Angus Cross
 8 ---- Herford Cross, 9 ---- Shorthorn

24. Prices

Show the respective prices of the animals in the feeding period's weight and time.

25. Medical Care (MEXIST)

Shows the existence of animal problem associated with the animal in the respective feeding period. Coded as follows:

0 ---- Autopsy (Dead Animal), 1 ---- Diagnosis
 2 ---- Ivermec (Warble Control), 3 ---- Spotton (Warble)
 4 ---- Foot rot, 5 ---- Jaw Abscess

26. Medical Cost (Cost)

Reports the cost associated with the problem in the respective feeding period.

27. Weight in Date (Wtindt)

Shows the month that the feeding period began. The number before the decimal reports the month and the number after the decimal reports the year.

28. Weight out Date (Wtoutdt)

Shows the month that the feeding period ends. Coded the same as weight in date.

29. Feed MGA (FMGA)

Shows the use of MGA in the feed. It was fed at a rate of .5 mg per head per day.

30. Depo MGA (DMGA)

Shows the use of MGA. See specific rations 29, 31, 32 for feeding rate.

Appendix B. Example Slaughter Cattle Prices

(Monthly Omaha Slaughter Cattle Prices, \$/cwt. for 1986)

<u>Month</u>	<u>\$/cwt</u>
1	57.02
2	54.90
3	53.21
4	51.41
5	52.29
6	50.86
7	54.41
8	55.66
9	56.55
10	57.35
11	58.89
12	56.60

Note: The average price for beef (live) for the whole year of 1986 was \$54.9/cwt.

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