COORDINATIVE EFFICIENCY OF GRADES AND STANDARDS FOR FEEDER CATTLE

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COORDINATIVE EFFICIENCY OF GRADES AND
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PREFACE

This study was conducted to determine the coordination efficiency of several feeder cattle grading systems and to make recommendations for changes in the USDA feeder cattle grading standards, if necessary. Alternate grading systems were developed from data obtained from a survey of cattle feeders and from published research results. Linear regression analysis was used to determine the most efficient feeder cattle grading system, and an example of the economic gain from implementation of a more efficient grading system was derived.

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CHAPTER I

INTRODUCTION

Beef cattle grading systems have been utilized in the beef industry since the late 1800's. The increased number of beef cattle bought and sold through order buyers and increased dependence on market reporting services have intensified the importance of beef cattle grading systems. Prior to 1964, research was directed toward determining carcass and retail grades. Feeder cattle grades received little attention. However, during the last decade, efforts have increased to refine the feeder cattle grading system.

This increased emphasis to improve feeder cattle grade standards can be attributed to two factors: (1) beef producers striving to increase the coordinative efficiency in the cow-calf to feedlot interface, and (2) a change in the types of feeder animals being produced. Consumer demand for meat with more lean and less fat has increased. Therefore, some beef producers shifted their production to beef animals with relatively heavier mature weights. These changes in production have increased both the variance of mature weights in fed cattle and the variance of carcass compositions of slaughter cattle at a given weight.

Per capita consumption of beef has declined from 95.7 pounds in 1976 to 79.3 pounds in 1979. Meanwhile, per capita pork consumption has increased from 54.6 pounds in 1976 to 65.2 pounds in 1979, and per capita chicken consumption has increased from 44.8 pounds in 1976 to 51.8 pounds in 1979. This declining consumption of beef, while pork and poultry consumption increased, provided an additional incentive for the beef industry to increase efficiency. One method to increase efficiency was to improve the beef grading standards. Improved standards better facilitate the orderly movement of beef through the marketing channels. In addition, improved grading standards enable beef producers to perfect those attributes which determine value.

History of Beef Grades

In colonial times, there were four cattle classifications: Fat, Stock, Cows and Calves. The designations of Wyoming Steers, Native Cattle, and Texas Stock evolved with the westward movement of ranches and railroads. With herd improvements via imported breed stock from England, Scotland, and other countries, common market terminology developed in the western markets for classifying animals. The classifications were Prime, Choice, Fair, Medium and Common; however, the interpretation of these terms was inconsistent between markets.

Market expansion throughout the United States, the increased variety and types of beef cattle, and the market dominance of a few large meat packers stimulated demand for a marketing reporting service. The United States Department of Agriculture (USDA) attempted to report cattle prices; however, without consistent interpretation and use of grades, the attempt was fruitless. In 1916, the USDA introduced carcass grades, based on research conducted by an Illinois experiment station.

Suspicion of monopolistic practices by large meat packers facilitated consumer and producer support for the carcass grading system.

Consumers wanted some type of "guarantee" on the purchased product, and sellers felt they would receive a more equitable price from the packers--given market reports and grading standards.

After accepting input from various interest groups, the USDA published a tentative grading system in 1923, and in 1925 the USDA agreed to tag or mark USDA Prime and USDA Choice carcass grades. Tagging or marking the top two grades was supported by the pure breed associations. Sanders (1925), editor of the Breeder's Gazette and representative for the association, argued that the result of grades would be for "well off" people to purchase quality meat while poor people would purchase meat of lesser quality. He referred to beef other than Prime or Choice as tiger meat and cat meat.

Western producers opposed the USDA marking only the top two grades. They wanted recognition of grass-fed beef cattle which produced USDA Medium and USDA Good grades (Rhodes, 1960, p. 134). Western producers requested that USDA Prime, USDA Choice and USDA Good carcass grades be marketed to distinguish grass-fed beef from "scrub" beef and dairy cattle.

In May 1927, the USDA began marking USDA Prime and USDA Choice grades. Grading and marking was a free service provided upon request. Complying to pressure from western producers, the USDA agreed to mark the USDA Good grade in early 1928. At the same time there was a minimum charge implemented, to be paid by the packer (USDA, 1929).

The major problems with the grading system were: (1) initially, few could properly interpret the grades, (2) total cost of grading was prohibitive (the fee was nominal but the packers were not set up for carcass evaluation; therefore, the costs in terms of disruption of work, loss of time and inconveniences were high), (3) limited funds were available to provide graders and there was a lack of continuous demand for graders (seasonality of supplies), and (4) major packers initiated their own standards; therefore, they did not support the new system.

Because it was the practice that a live animal grading standard be directly related to the standards for dressed beef, live beef standards were developed in conjunction with carcass grades (Clifton and Shepherd, 1953; USDA, 1964). However, only carcass and live slaughter standards were official grades. Feeder cattle standards were only tentatively released in 1928, and only tentative changes were made until the official feeder cattle standards were released in September 1964 (USDA, 1965; Kimbrell and Daugherty, 1970).

The 1928 official standards for carcass and slaughter beef were amended in July 1939 to change the descriptive terms of steer, heifer and cow beef. Medium, Common, and Low Cutter were changed to Commercial, Utility, and Canner, respectively. Similar changes in the grade terminology were extended for bull and stag beef in November 1941. An amendment in October 1949 eliminated all references to color of fat in carcass standards.

In December 1950, the official standards for steer, heifer and cow beef slaughter and carcass standards were amended by including formerly Choice cattle in the Prime grade, renaming Good grade as Choice and dividing the Commercial grade into two grades. Young animals included in the top half of the Commercial grade were designated as Good while the bottom half of the Commercial grade retained the label, Commercial. The official standards were amended again, in June 1956, by dividing the Commercial grade into two grades strictly on the basis of maturity. All young beef was designated as Standard while mature animals remained in the Commercial grade.

In September 1964, after slight revisions of the tentative feeder cattle grades were made, the feeder grades became official. USDA's (1965) application of the standards was described as follows:

> The official standards for live cattle developed by the United States Department of Agriculture provide for segregation first according to use--slaughter and feeder--then as to class, which is determined by sex condition, and then as to grade, which is determined by the apparent relative excellence and desirability of the animal for its particular use. Differentiation between slaughter and feeder cattle is based solely on their intended use rather than on specific identifiable characteristics of the cattle. Slaughter cattle are those which are intended for slaughter immediately or in the very near future. Feeder cattle are those which are intended for slaughter after a period of feeding. However, under some economic conditions, specific kinds of cattle may be considered as feeders, whereas under other economic conditions they might be considered as slaughter cattle (pp. 1-2).

The grade of a feeder animal was determined by its logical slaughter potential and its thriftiness. Logical slaughter potential was defined as the beef animal's slaughter grade at the stage in development when carcass quality grade and carcass conformation grade were equal. Veal and calves were excluded from feeder grades. In the 1964 feeder cattle standards, conformation was determined by appraising the muscle development relative to the skeletal structure. Degree of finish (fatness) was not included as a factor in the feeder grading system. Thriftiness referred to the feeder animal's ability to gain weight and fatten rapidly and efficiently. The grade of a feeder animal was affected by thriftiness only when the animal was relatively less thrifty than normally associated with a particular stage in development. The official 1964 feeder cattle grades were Prime, Choice, Good, Standard, Commercial, Utility and Inferior.

In April 1962, a dual grading for beef carcasses was proposed, involving separate identification for differences in quality and in cutability. Cutability was defined as the proportion of edible lean relative to bone and fat. The dual system was not adopted because of industry response and further research results. The cutability standards were adopted in part when the carcass and slaughter cattle standards were officially amended in June 1965. These changes reflected past research results regarding the effect of maturity on beef palatability. For more mature beef, the minimum marbling requirements for Prime, Choice, Good and Standard grade carcasses were reduced. Evaluation of conformation was clarified by allowing a carcass to meet the conformation requirements for a grade either through a specified development of muscling or a specified development of muscling and fat combined. A requirement that all carcasses be ribbed prior to grading was also implemented. Slaughter cattle standards were amended to reflect the changes in marbling requirements, and five yield grades were established to identify differences in cutability or yield of boneless, closely trimmed retail cuts. Yield grades were numbered 1 through 5 with Yield Grade 1 representing the highest yield of cuts and Yield Grade 5, the lowest.

In July 1973, the official standards for slaughter cattle and carcass beef were revised to establish a separate class for young bulls and old bulls. "Bullock" was designated as the name for bulls under 24 months of age. Quality grade standards were adopted for bullocks, but the quality grade standards were eliminated for the bull class. Yield grades were the only grades applicable to the bull class.

Three major revisions in the carcass and slaughter cattle standards were introduced in April 1975. However, because the legality of the revisions were challenged, the changes did not become official until February 1976. The revisions eliminated conformation as a factor in determining the quality grade because research had shown conformation unrelated to differences in palatability, and conformation's effect on retail cuts was better measured by the yield grades. Maximum maturity for slaughter steers, heifers and cows in the Good and Standard grades and the minimum maturity for slaughter cattle in the Commercial grade was reduced. This was concurrent with the elimination of maturity considerations in carcass quality grades for all bullock beef and for all steer, heifer and cow beef included in the youngest maturity group in Good, Standard, and Commercial grades. Another revision reduced the marbling requirement for the Prime, Choice, and Good grades. The cutability measurements of carcass beef was also changed to five yield grades (USDA, 1975).

In 1973, the USDA appointed a special task force to evaluate the acceptability and use of the 1964 feeder cattle standards. Results of the study implied that the feeder cattle standards should be changed. On August 14, 1978, a proposed feeder grading system was released for discussion purposes only (Tyler, 1978). After further research and input from producers, a new feeder grading system was implemented on September 2, 1979. The new feeder grading system consisted of three frame sizes (large, medium, and small) and three muscle thickness categories (No. 1, No. 2, and No. 3, where Thick = 1). Thus, the present feeder cattle grading system has nine categories designed to better reflect the feeder cattle attributes which determine value.

The history of USDA carcass, slaughter and feeder standards has shown the major emphasis of developing grading standards was directed toward carcass standards. Live slaughter standards have always been subjective estimates of the carcass grades. Feeder cattle grades were almost totally ignored until they became official grades in 1964.

Both USDA carcass and slaughter standards were developed to identify the quality and yield aspects of beef cattle. Quality described the characteristics of beef that were important to retail consumers. Yield grade, on the other hand, estimated the percent of edible lean. Yield grades were important to the slaughter house and fabricators.

USDA feeder cattle standards were originally developed to identify the potential carcass quality of a feeder animal. Thus, "quality" terms were used to describe the grade standards. Since the feeder grades were made official in 1964, it has been observed that normally any beef feeder animal can be fed to any carcass quality grade if managed properly. Thus, the major differences between feeder cattle were the weight a quality grade was reached and the amount of excess fat produced to obtain the required marbling. The 1979 USDA feeder cattle standards removed the "quality" terminology from the standards and replaced them with terms more adaptable to the yield of edible meat. Terms describing the potential yield of a beef animal were more consistent with the objectives of cattle feeders.

Organization of the Beef Cattle Industry

A schematic of the beef industry is depicted in Figure 1 (Purcell and Nelson, 1976). The cow-calf stage involves production of a feeder animal and thus includes both the cow-calf and stocker phases. However, in many cases stocker production is a separate phase. Feeder cattle are grain-fed and marketed in the feeding stage. Slaughter houses purchase and slaughter animals sold by the cattle feeder, separate the edible and inedible portions, and sell or transfer the carcass to fabricating where they are "broken down". Wholesaling is included in the fabricating stage. The final stage (the consumer stage) includes the interaction between retailer and consumer.

Because quality is a subjective measure of consumer acceptance, beef quality groups originate at the retail consumer level. In beef production and marketing, there is a seller and a consumer at each interface. At each interface, supply and demand determine the value of a product via the criteria of time, form, place and possession. The effect of time, place and possession on value is relatively straightforward. However, the form component may involve both physical and quality characteristics. Physical aspects include shape and size of a product. For example, a retail consumer may prefer a two-inch thick T-bone steak to a one-inch T-bone steak; a fabricator may prefer quartered beef to halves; and a feedlot manager may prefer 500-pound feeder steers to 500-pound feeder heifers.

Beef quality refers to consumer acceptance. Retail consumers want palatable, tender cuts with some degree of fat. Fabricators desire

MARKETING SYSTEM STAGE	GRADES USED
CONSUMING STAGE	
↕	TRANSFERRING GRADES USDA CARCASS GRADES HOUSE GRADES
FABRICATING STAGE	
↕	USDA CARCASS GRADES USDA YIELD GRADES HOUSE GRADES
SLAUGHTERING STAGE	
↕	USDA SLAUGHTER CATTLE GRADES UNOFFICIAL MARKET TERMINOLOGY
FEEDING STAGE	
↕	USDA FEEDER CATTLE GRADES UNOFFICIAL MARKET TERMINOLOGY
COW-CALF STAGE	

Figure 1. Stages and Grade Standards in the Beef Marketing System

carcasses which will break down into palatable, tender cuts and which have a high percentage of muscle to bone and fat. Cattle feeders desire feeders which have a potential to produce palatable, tender beef and carcasses with a high percentage of muscle relative to bone and fat as well as a high rate of feed efficiency.

Grade standards are used to facilitate consistent communication between buyers and sellers by identifying quality and yield groups. Thus, the type of beef produced and marketed is in response to signals coming through the system from consumers in the form of prices relative to the cost of production for various forms of beef. Prices and information coordinate the physical production, processing, transportation, storage and exchange functions. Coordinative efficiency is a measure of how well the physical functions are coordinated with consumer desires. Grades should facilitate improved coordinative efficiency.

There are no official USDA beef grading standards at the consumer or fabricating stages. However, quality grades in the form of USDA carcass quality grades and house grades are placed on the carcasses during the slaughter stage. These grades are transferred through fabrication to consumption. USDA carcass quality grades and house grades are designed to identify the palatability and tenderness of beef which is the major concern of the retail consumer.

Carcass classifications used at the slaughter-fabricator interface are identified by USDA carcass and yield grades or house grades (USDA, 1975). USDA carcass grades identify consumer acceptance while the USDA Yield grade is an indication of the cutability, proportion of retail cut to bone and excess fat, of the carcass for the fabricator. House grades are used by fabricators having sufficient market size to take advantage of production differentiation via advertising. House grades are also an efficient method to market beef of less than USDA Choice grades.

Slaughter-packers are concerned with the carcass quality grade and the yield grade; therefore, the official USDA slaughter cattle grades used in the feeder-slaughter inferface are composed of carcass quality and yield grades. The feedlot operator desires a feeder animal with high carcass grade and low yield grade potential and an animal that will put on gain efficiently. USDA feeder grades consist of three frame sizes and three muscle thickness scores (USDA, August 1979). Frame size is designed to indicate the weight a feeder animal will reach a specified USDA carcass grade. Muscle thickness is indicative of the USDA yield grade of the animal at slaughter. To the degree the official USDA feeder cattle grades are inefficient, unofficial market terminology (including "OKIE" grades, color description, body coordination and breed) is substituted for the USDA grades at the stocker-feeder interface.

Problem of Coordination

Communication and coordination between cattle feeders and cow-calf operators have been less than perfect (Rathwell and Purcell, 1972). Rathwell and Purcell found that 71 percent of the cow-calf operators thought they were providing the type of animal demanded by cattle feeders. However, only 24 percent of the cattle feeders felt they were receiving the type of animal they preferred.

Rathwell (1972, p. 117) defined the problem area to be "conflicting interpretation of the worth of a feeder animal." To cattle feeders, the value of a feeder animal was determined by its weight gaining and grade potential, implying frame size and finish. Producers with a limited number of cows placed more emphasis on weight per head sold, which may imply heavy finish. Thus, feeder cattle grades based on objectives at one stage in the system may not adequately classify the animals with respect to the needs of the remaining members of the system. One indication of inadequate feeder cattle grades in the past was the number of market reporting and grading systems being used in the feeder cattle industry, e.g., "Okie" grades. Okie grades were used by beef producers to reflect the growth potential relative to age for groups of beef animals, thus implying a concern for beef production rather than carcass quality grade (Pumphrey, 1979). To correct this deficiency, the USDA (August, 1979) implemented a new feeder grading system on September 2, 1979. However, there were empirical and statistical research results that indicate the new feeder grading system is not properly defined to maximize the efficiency of the feeder grading system (Baquet and Anderson, 1979). Baquet and Anderson's results showed that USDA's frame sizes improved the feeder cattle grades by only six percent and that the muscle scores were not correlated with USDA carcass yield grades.

Objectives

The general objective is to determine the feeder grade standards that will maximize the coordinative efficiency at the cow-calf feeder interface. The specific objectives are:

1. Determine the feeder cattle attributes which determine acceptance, i.e., quality,
2. Determine the efficiency of the 1979 feeder cattle grading system,
3. Compare the efficiency of the 1979 feeder grading system with alternative systems, and
4. Demonstrate the nature of potential economic gains from more efficient feeder cattle grading systems.

Procedure

Bull calves belonging to cooperating producers and research institutions were tagged at birth with USDA Carcass Data Service tags. Records were maintained as the steers progressed through the marketing system from birth to slaughter. Data at birth included the birth weights and dates, ages, weights and breed of the cows and bulls, and maintenance schedules.

The steers were graded twice, once at weaning and again before entering the feedlot. Scores were estimated for age, weight, muscle, thickness, frame, degree of finish, body length, body height, breed, defects, health, and the 1966-1979 USDA feeder grade on each steer. Actual measurements were obtained on height, length, and weight. At slaughter, the live weight, hot carcass weight, and USDA scores on carcass attributes were obtained. Data were also obtained from steers purchased as feeders.

Data for definitions of quality were obtained through a survey of feedlot managers. Past studies also were reviewed to determine important attributes. An indication of the feeder cattle attributes important to cattle feeders was obtained from the survey. The literature review provided attributes which indicate the growth and grade potential of beef animals. Statistical procedures including simple correlations and regression analysis revealed the statistical importance of the attributes.

The measurability, ability of a grader to accurately score an animal's frame size and muscle score, was derived by comparing grader evaluations with actual measurements and by comparing grades of the same animal at two points during its growth cycle. Actual measurements of height and length were used to determine the accuracy of the frame size definition. The measurements of height and length were corrected for age and, when possible, breed was considered also as a correction factor.

Statistical methods were used to measure the accuracy of attributes for which objective measurements were not collected. For example, the muscle thickness score of each animal should have remained constant throughout the steer's growth cycle (USDA, August 1979). By assuming the thickness scores were identically and independently distributed, the frequency of placing a steer in the same thickness category was used to estimate the grader error. This method also was used to determine the accuracy of grader frame size. Further indication of the subjective measurability of live-cattle attributes were obtained from the literature.

Results from studying quality attributes and their measurability were used to determine the attributes which can be used in a feeder grading system. The efficiencies of the different feeder grading systems and the new USDA feeder grading system were compared using ordinary least squares regression.[1] The most efficient grading system

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[1]See Chapter II.

minimized the variance of the carcass quality and yield grades for cattle of the same feeder grade placed on feed at a given age.

The last objective was accomplished by examining a representative feedlot situation. Expected values of two groups of feeder cattle were compared using representative costs and returns from various weights and grades of cattle. The impacts of reducing carcass grade variability of slaughter cattle groups were compared. An improvement in the grading system should reduce production costs and increase net return (Williams, 1962). Short-run gain would be distributed to both consumers and producers in a competitive market situation. In the long run, the distribution would be dependent on supply and demand elasticities (Doll, Rhodes and West, 1968, p. 404). However, the short-run gains can be used as a measure of the total economic gains from improving the grade standards.

Characteristics of Bovine Growth and Predictability of Carcass Traits

Previous studies have been conducted to determine the physiological development of the bovine. Other studies have evaluated the ability of graders to subjectively evaluate live animal traits and the use of subjective measures to predict carcass traits. Such studies were valuable in developing feeder cattle grading standards.

Growth and Composition

Animal growth, whether induced by genetic, nutritional or other factors, is normally evaluated by determining rate of gain, feed conversion, and carcass quality (Berg and Butterfield, 1978). Carcass quality has been defined as an all-inclusive term including differences in composition, conformation and other measures of quality such as tenderness and palatability. Carcass composition refers to the proportion of the major tissues--muscle, fat and bone--in the carcass while conformation includes relative proportions in different parts of the carcass. Carcass composition may be influenced by age, weight, breed, and nutrition while conformation is influenced by tissue distribution. In research, growth patterns of the above measurements were established by dissection of animals slaughtered over a range of ages and weights.

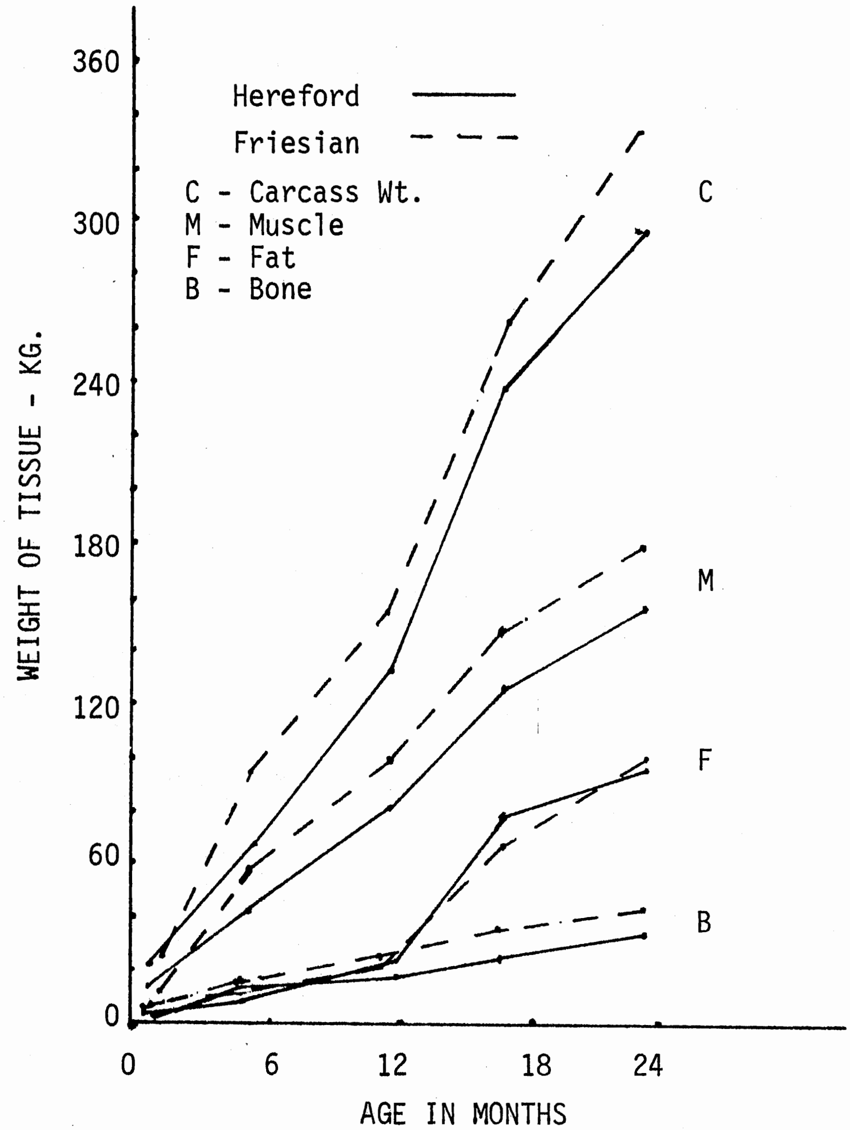
Waldman, Tyler and Bungardt (1969) conducted research to study the nutritional and weight influences for 171 Holstein steers. Steers were slaughtered at birth, 91, 227, 341, 455 and 590 kilograms (birth, 200, 500, 752, 1003, and 1301 pounds) live weight. Increase in the proportions of fat and bone were small compared to muscle between birth and 227 kilograms. After 227 kilograms, increases in carcass fat were similar to increases in muscle weight. Ratios of muscle to bone indicated that muscle growth was greater than bone growth until animals reached approximately 341 kilograms. After the steers reached 341 kilograms, the muscle and bone increased proportionally. Thus in normal growth of a bovine, bone was considered early developing, muscle was intermediate developing, and fat was late developing. These results were consistent with Berg and Butterfield (1978), who described relative growth in terms of allometric relationships. Using this concept, they found that from birth to maturity, muscle had a higher growth impetus than bone and after some point in the growth process, the impetus for fat deposition was greater than that for muscle. Berg and Butterfield used data comparing Herefords and Friesians obtained from the Royal Smithfield Club, London, to derive the plots in Figure 2. They concluded that the difference between Herefords and Friesian steers was the live weights at the inflection points.

Brungardt (1972, R2397) compared the growth characteristics of 300 Angus, Hereford and Charolais feeder animals. Brungardt's conclusions were that larger breeds required longer feeding periods to reach choice grade; grade was reached at a heavier weight and the cattle with more height at the withers gained weight faster and achieved heavier market weight. However, the association was not great enough to merit selection for height rather than weight adjusted for age.

Influence of Nutrition on Growth and Developement

Fox et al. (1972) conducted 2x2x2 trials over a two-year period utilizing a total of 104 Hereford steers. The design factors were: plane of nutrition (five or six months maintenance, then full feed), energy source (high energy corn-based or medium energy soybran flak), and slaughter weight (approximately 364 or 554 kilograms or 800 and 1221 pounds). Their results indicated that during the first part of the full-feeding period, weight gains made by the compensatory steers (steers that just came off a low energy ration) were higher in protein and lower in fat. However, during the last part of full feeding, the compensatory steers had a relative higher increase in fat as compared to protein.

Fox et al. (1972) also found that compensatory steers had higher average daily gain and required less feed per kilogram of gain during the full-feeding period than did the control steers. At 364 kilograms,



Source: Berg and Butterfield, 1974, p. 613.

Figure 2. Carcass and Tissue Weights from Hereford and Friesian Steers Slaughtered at Six-Month Intervals

the compensatory steers had a higher percentage of empty protein and a lower percentage of empty body fat than controls. However, they found no significant difference in energy efficiency, empty protein, or fat between compensatory and control steers at 454 kilograms.

The results, that there is normally no significant difference in the energy consumption of compensatory and control steers if they are fed to the same carcass quality grade, were consistent with the results found by Callow (1961), Henrickson et al. (1965) and Meyer et al. (1965).

Callow's results were based on data obtained from 24 steers (of Hereford, Dairy Shorthorn, and Friesian breeds) fed four planes of nutrition over two time periods. Analysis of variances was used to calculate the effect of breed and level of nutrition. Meyer's et al. (1965) results were obtained from 108 weanling beef steers on a combination of four energy rations over three periods. Meyer et al. concluded:

1. Overall comparison indicates that steers given a high energy intake immediately after weaning and continued to a low choice finish have the smallest body weight, empty body weight and carcass weight, but make equal energy gain because of a higher fat percent. . . . All other treatments produced carcass with similar characteristics with the exception of rib eye areas. A low energy intake during period one and two tended to produce a smaller rib eye.

2. Compensatory growth was demonstrated in each period following a low energy intake period, even though the animals were realimented at different planes of nutrition. Not only did compensatory growth response occur in terms of empty body weight gain or caloric gain, but the carcass characteristics, fat content, back-fat thickness, marbling score and rib eye area were enhanced. When a liberal to low energy intake of 124 days on pasture intervened before realimentation, there was no significant compensatory growth response. Improvement in partial efficiency of feed utilization and feed capacity were shown to be responsible for compensatory growth (p. 37).

Henrickson et al. (1965) conducted research to evaluate the relationship of rate of gain via compensatory growth to carcass composition in growing and fattening steer calves. Eighty-eight, eight-month old Hereford steers were fed a high-high, a high-moderate, a moderate-high, or a moderate-moderate energy ration. When fed to a constant weight, the moderate-high steers had the highest energy conversion level and the carcass grade, composition of lean, tenderness and desirability of the "cuts" were equivalent to the high-high steer carcasses. High-high steers were second in energy conversion efficiency, followed by moderate-moderate and high-moderate steers. However, if the steers were fed to a constant carcass quality rather than a constant weight, there was no significant difference in feed efficiency.

To determine the effect plane of nutrition had on carcass composition, Guenther et al. (1965) fed a weaned group of half-sib Hereford steers on a high plane or a moderate plane of nutrition. They concluded that the increase in weight of the animals on the high plane relative to steers on the moderate plane was due to increased muscle and fat development and that bone was affected very little. Berg and Butterfield (1978) re-examined the data used by Guenther et al. and found that the muscle-bone ratio was higher with the high nutrition steers versus the moderate nutrition steers. Callow (1961) and Henrickson et al. (1965) found no difference in muscle-bone ratios with different planes of nutrition. Berg and Butterfield (1978) summarized the findings:

> . . . based on conflicting results, it is not possible to conclude whether plane of nutrition has an effect on the relative growth of muscle and bone or if it is merely involved with slowing down or speeding up the whole process in a normal allometric manner (p. 612).

Arthaud et al. (1977) found that ration energy levels significantly affect most growth, carcass composition, conformation, and marbling characteristics but not most maturity or taste panel evaluations.

Previous studies have shown that following low energy diets, feeder cattle exhibited less external finish and had a higher energy conversion than feeder cattle which had been fed relative higher energy diets. Therefore, it was implied that finish is an important characteristic to the cattle feeder and should be considered in the development of feeder cattle standards.

Influence of Breed on Relative Growth and Carcass Traits

Jeremiah et al. (1970) collected data on 415 Angus, 852 Hereford, 160 Shorthorn and 203 crossbreed steers. Results indicated that Angus carcasses had the largest rib eye areas per 45.4 kilograms (100 pounds) of carcass, the highest conformation, marbling scores and USDA quality grades. Shorthorn carcasses possessed the smallest rib eye areas, percent kidney, pelvic and heart fat, conformation scores and cutability index. Hereford carcasses exhibited the lowest percentage of internal fat, marbling score and USDA carcass grades. The crossbred steers were ranked intermediately between the Angus and Hereford steers.

In a research project conducted by the Royal Smithfield Club, London, Herefords and Friesians were raised from birth to approximately two years to compare body development (Comparison of the Growth of Different . . ., 1966). Four steers of each breed were slaughtered at birth and at six-month intervals thereafter. For both breeds, the relationship between carcass weight and age exhibited the traditional sigmoid curve with the point of inflection approximately at the stage of increased fat deposition (Figure 2). They found, that at a given age, the Friesians had greater size, more muscle, and more bone but essentially the same amount of fat. They concluded that the Herefords' fattening phase began at a lower weight but at approximately the same age as Friesians and that the stage of development at slaughter can potentially have a great influence on carcass composition.

Callow (1961) using Hereford, Dairy Shorthorn, and Friesians also concluded that Herefords fatten at a lower weight than Shorthorn and that Shorthorns fatten at a lower weight than Friesians.

Brungardt examined the variation of growth within Angus, Hereford and Charolais breeds (Brungardt, 1972, R2397). One-hundred steers in each breed category were segregated into five groups based on size and weight. Brungardt found significant differences within a breed for the weight at which the fat deposition increases relative to muscle and bone.

Previous research results indicated that the weight, at which an animal's fat deposition increases relatively faster than muscle and bone, was dependent on the breed. Moreover, there was a large variation of weights for increased fat deposition within a breed. If no other information was available, breed could be an important characteristic; however, if information pertaining to weight, age and other attributes was available, breed would not sufficiently improve the efficiency of the grading system.

Summary of Bovine Growth and Composition

Maintenance energy requirements for growing animals increase in proportion to metabolic weight, and requirements for gain increase as more fat and less protein and water are included in body development. The allocation priority for nutrients and energy in the maintenance and growth process is to the nervous system, bone, muscle, and finally, to fat. Normal bovine tissue development, from birth to maturity, is that muscle has a higher growth impetus than bone but after some point in the developmental process, the impetus for fat deposition is greater than muscle. Thus, animals slaughtered at an earlier percentage of their mature size will yield a lower fat percentage, a lower dressing percentage, a lower yield grade, and less marbling than an animal slaughtered at a higher percentage of its mature size.

The normal growth pattern of an animal can be altered by changing the nutritional plane. Energy deficiencies will first restrict development of fatty tissue. There is disagreement as to what tissue development is affected next. One school of thought is that muscle development is hindered while bone development continues--if sufficient nutrient is available. The second school of thought is that muscle and bone development is hindered concurrently. For this study, the important fact is that a low nutritional plane will affect normal muscle development.

When animals have been on a low-energy ration during their growth cycle and then are placed on a higher-energy ration, the increased rate of gain and efficiency of energy utilization is identified as compensatory gain. Studies show that animals in early stages of compensatory gain gain faster, convert feed more efficiently, and deposit more protein and less fat than similar animals on full feed. The animals on full energy rations reach a quality grade at a lighter weight and an earlier age than the compensatory animals. However, toward the end of the compensatory growth, the impetus for fat development increases and leaves the final carcass composition the same as for steers on full energy rations. Moreover, if compensatory animals and full energy animals are fed to the same carcass quality grade, the total energy requirement from birth to slaughter will be approximately the same for both animals.

Even though the same amount of energy is required to produce compensatory and full energy animals of the same carcass quality grade, compensatory gain can be an important factor for cattle feeders. The compensatory steer reaches the desired carcass quality grade at an older age; thus, is on feed longer than the full energy steer. However, if the cattle feeder purchases the two animals when the compensatory animal starts compensatory growth, the compensatory steer will have a higher average daily gain, utilize energy more efficiently and produce more pounds of edible meat than the full-energy steer. The only negative of the compensatory steer is that it is in the feedlot longer; thus, yardage and interest costs will be higher.

Studies have shown that breed alters the rate of tissue development and the weight at which the growth impetus of muscle and fat deposition change. At the same weight, small breeds such as Angus tended to have a higher proportion of fat, grade higher, contain a lower proportion of saleable meat, have higher dressing percentage, and have lower feed efficiencies than larger breeds such as Herefords, Charolais, or Friesians. Herefords fall between Angus and Charolais, and Charolais fall between Herefords and Friesians. However, if beef animals are fed to the same quality grade, feed and energy efficiency per pound of edible meat is approximately the same.

Estimation of Carcass and Performance Traits

Numerous research projects have been conducted to determine the ability of graders to evaluate live cattle attributes and the efficiency of the subjective evaluations for predicting final carcass merit. Previous research results include evaluation of feeder and slaughter cattle and their consequent carcass measurements. Both have implications for feeder cattle standards.

Crouse et al. (1974) used visual appraisal of 14 feeder calf traits on 449 feeder calves to determine prediction equations of average daily gain and subsequent carcass qualitative and quantitative characteristics. Stepwise regression analysis was used to evaluate the 14 feeder calf traits for predicting USDA carcass quality grade and yield grade. The feeder calf traits included disposition, hair coat, overall muscling, round muscle, body depth, skeletal depth, condition, bone size, growth potential, height, length of rump, length of body, trimness and 1964 USDA feeder calf grade. The results of the analysis showed that no combination of these feeder calf traits produced a meaningful estimate of USDA carcass quality grades. USDA feeder cattle grades were not significantly ($P < .05$) correlated with USDA carcass quality grades. Neither hair coat nor disposition score were significantly ($P < .05$) associated with daily feedlot gains, carcass quality or yield grades. Condition, depth, trimness, and overall length were highly correlated with yield grade while percentage of retail product and muscle round was correlated with conformation. Crouse et al. also concluded that the pen average characteristics of steers can be predicted more reliably than those of individual steers.

In another study, five graders made subjective estimates of carcass traits for 452 slaughter steers and then used these estimates to predict USDA carcass quality and yield grade (Crouse, Dikeman, and Allen, 1974). Using stepwise regression procedures, they concluded that fat was the single most important variable in predicting yield grade and that overall muscle increased the reliability or accuracy of the yield grade equation very little. The standard deviation of yield grade was 0.77; the standard deviation of the yield grade equation was 0.54 without muscle and 0.53 with muscle.

To test the accuracy of a grader's ability to evaluate live slaughter cattle characteristics, Gregory et al. (1964) obtained subjective scores by three graders for dressing percentage, fat thickness, rib eye area, percent kidney fat, percent cutability and USDA carcass quality grade in thirds for two groups of 104 and 100 steers. Nine breed combinations including Angus, Hereford, Shorthorn, and their reciprocal crosses made up the two groups. Results indicated that graders were more accurate when predicting fat than muscle and that the graders had used their knowledge of breed characteristics in scoring the traits. Subjective grader scores were able to explain only 25 to 30 percent of the variance in actual carcass cutability.

Subjective scores of fat thickness, rib eye area, percent kidney fat, dressing percentage, and quality for 135 Hereford slaughter steers were used to determine the accuracy of six graders (Wilson et al., 1964). Their conclusions were consistent with Gregory et al. (1964). The accuracy of the graders ranged from 20 to 40 percent, and fat thickness was a more reliable estimate than muscle. They summarized the importance of fat as follows: "A single estimate for fat thickness is of as much predictive value in relation to carcass cutability as any of the equations studied" (p. 1106).

McPherson and Dixon (1966) evaluated the grading performances of seven graders on 497 slaughter animals in five groups over a four-year period. Five of the graders were employed as livestock market-news reporters. Each lot of steers had approximately the same number of Angus, Brahman, Hereford and crossbreeds; the pens contained 119, 102, 128, 76, and 72 steers. The graders evaluated the slaughter in one-third USDA carcass grades. They summarized the results as follows:

> 1. Competent graders can estimate the grades of large numbers of cattle with a high degree of accuracy but in doing so many, on lots of 100 or less, make errors that have considerable economic significance. . . Thus, a trader may gain (or lose) 7.5 percent of the total value of the lot . . . if the same buyers and sellers trade a large number of animals, their errors of over- and under-estimation will average out.
>
> 2. Competent graders can keep their estimates within a range of 1.3 thirds above or below the current third of a federal grade for only two of every three animals graded.
>
> 3. Individuals are able to improve their ability to classify animals into homogeneous groups more readily than improve their ability to estimate the correct federal grade of individual animals, i.e., the grade-standards for beef cattle are highly subjective (pp. 71-73).

Summary of Grader Performance and Predictability of Carcass Traits

Results from previous research indicated that no combination of feeder calf traits was meaningful in predicting USDA carcass grades of the animal at slaughter. Condition, depth, trimness and overall length were the most efficient predictors of USDA yield grade; the percentage of retail product and round muscle was correlated with conformation. Overall muscle scores were not as significant in predicting conformation as round muscle. The most significant subjective slaughter animal trait in predicting USDA carcass yield grade was estimated fat cover at the twelfth rib. Overall muscle scores and estimated fat cover at the twelfth rib contributed very little to the accuracy or reliability of the yield grade equation.

Graders' estimates of slaughter cattle traits were only able to explain 20 to 40 percent of the variance in the carcass traits. Predictions of carcass fat cover and content were more accurate than predictions of muscle. When estimating USDA carcass quality grades, in one-third grade units, grader estimates were only within 1.3 thirds of the actual carcass grade for two out of three animals.

Results from previous research implied that subjective estimates of live animal attributes have a low rate of accuracy; thus, the efficiency of a feeder grading system may appear relatively low. Also, if a choice between muscle or finish is to be included in a grading system, finish should be used because it was more accurately estimated.

Summary

Research results and industry response in the late 1960's and early 1970's indicated that the USDA feeder cattle grades were inefficient. As a result, in 1979 the USDA implemented a new feeder cattle grading system comprised of three frame sizes and three muscle sizes. The frame sizes were defined as an animal's height and length relative to age and were designed to predict the weight a beef animal would reach a specific carcass grade. Muscle score was developed to indicate yield grade.

Research results presented in the literature indicated that feeder weight adjusted for age was a more efficient indicator of the weight a beef animal would reach a USDA carcass grade than the feeder's height at the withers relative to age. Researchers discovered fat was a more efficient indicator of yield grade than muscle for slaughter cattle. Moreover, experienced graders predicted fat more accurately than muscle.

CHAPTER II

CONCEPTUAL ISSUES

The importance of efficient feeder cattle standards could have been determined using any number of methods. However, before reviewing the method used to determine grading efficiency, the physical and economic factors affecting a cattle feeder's production and marketing decision will be presented, followed by a presentation of the purpose and types of grade standards and their theoretical basis. Based on the structure of the beef industry and the theoretical basis for grade standards, a method to determine the relative efficiency of grade standards was developed.

Cattle Feeders' Decision Process

Each cattle feeder has a comparative advantage in producing homogeneous groups of slaughter animals of a given weight, carcass quality, and yield grade. Empirical support for the comparative advantage can be deducted from observing sales at auctions and commission houses. Before a group of stockers or feeders are sold, they are normally sorted into homogeneous groups. The price received for a pen of slaughter cattle depends on the percentage of animals in a specific grade (Jebe and Clifton, 1956). Additional support can be obtained by observing the cost and return structure (USDA, December 1979) and the growth curves of feeder cattle (Hedrick, 1972; McMeekan, 1959). The carcass quality for which the comparative advantage exists depends on the feeder cattle characteristics, managerial ability, facilities, etc. for each pen of cattle.

After initial assembly of feeder cattle, it is usually economically unfeasible to sort a pen of slaughter cattle. Sorting may result in shrinkage and inefficient use of feedlot space. Cattle feeders typically produce and sell feeder cattle in groups. The price received for a pen of cattle can be defined as a composite price:

$$P_R = \frac{N_P P_P + N_C P_C + N_G P_G + N_S P_S}{N}$$

where:

N_P = Number of Prime cattle,

N_C = Number of Choice cattle,

N_G = Number of Good cattle,

N_S = Number of Standard cattle,

P_R = Price received per unit,

P_P = Price received per unit for Prime cattle,

P_C = Price received per unit for Choice cattle,

P_G = Price received per unit for Good cattle,

P_S = Price received per unit for Standard cattle, and

$N = N_P + N_C + N_G + N_S$.

The cost structure for a pen of cattle can also be defined as a composite cost:

$$P_C = \frac{N_P P_{CP} + N_C P_{CC} + N_G P_{CG} + N_S P_{CS}}{N}$$

where:

P_C = Composite costs per unit,

P_{CP} = Cost per unit to produce Prime cattle,

P_{CC} = Cost per unit to produce Choice cattle,

P_{CG} = Cost per unit to produce Good cattle, and

P_{CS} = Cost per unit to produce Standard cattle.

Assuming maximization of net return as the decision criterion, a cattle feeder's production decision for a pen of cattle can be reviewed by using Figure 3 (Purcell and Dunn, 1972). Dollars per unit of final product are exhibited on the vertical axis and the variance of carcass grade per unit appears on the horizontal axis. For simplicity, linear marginal cost (MC) and marginal return (MR) curves were assumed. Empirically, both the marginal revenue and the cost per unit to increase the grade of the final production (USDA, October 1979) increase as the grade progresses from standard to choice (USDA, December 1979). Therefore, both the MC and MR curves slope upward. At some point in growth, as more fat is deposited relative to muscle, yield grade and cost of gain increase at a faster rate than the value of the animal. Thus, the slope of MR is less than the slope of MC which satisfies a necessary condition for stability in the model (Henderson and Quandt, 1971, pp. 70-75).

The upward slope of the MR curve was not a necessary condition in this analysis. Of concern was the effect an efficient live cattle grading system has on net return rather than the equilibrium price and quantity. For example, without carcass grades, the MR curve would be horizontal at the average price. Equilibrium price and grade may not be at point E, but the relative loss in net revenue for not producing at point E could still be shown.

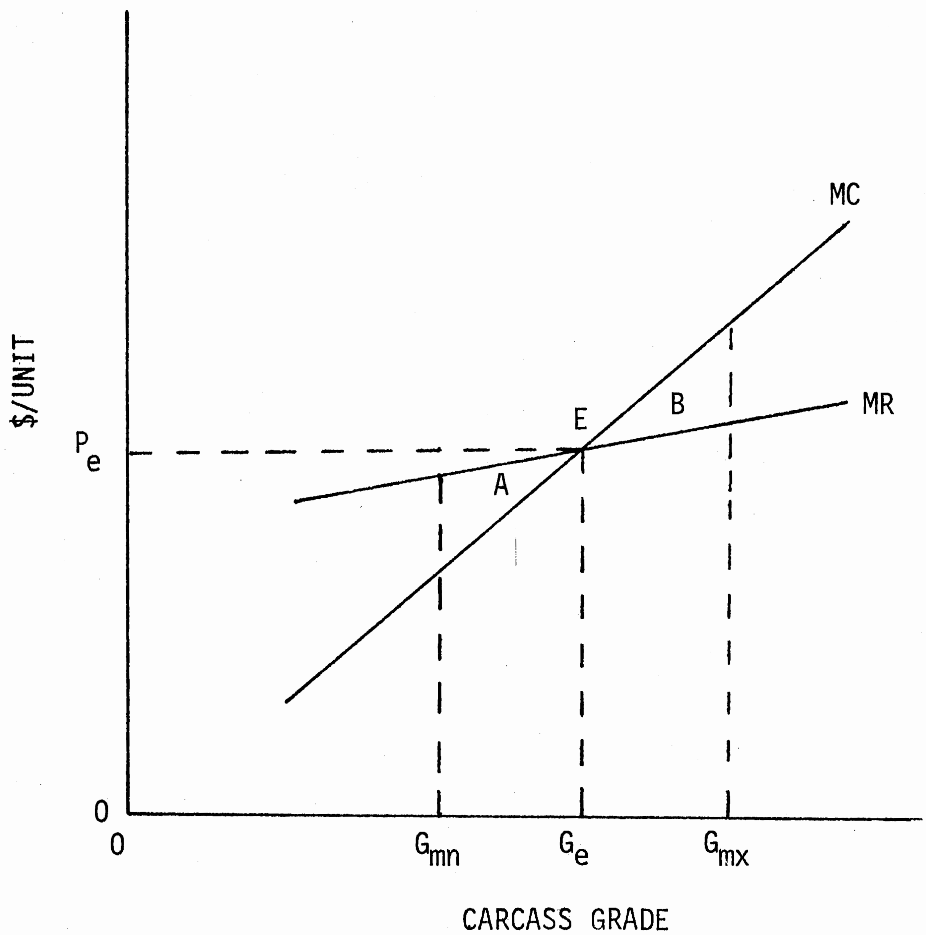


Figure 3. Loss in Net Return Due to an Inefficient Grading System

In production, each animal would be fed to grade G_e and sold at price P_e. However, because feeder cattle are produced and sold in groups rather than individually, it is economically unfeasible to feed each animal to G_e. The decision criterion must be to maximize the net return per pen of cattle; therefore, the cattle in each pen are sold concurrently. The cattle would be sold when the average grade is G_e and the range of carcass grades for each pen would be from G_{mn} to G_{mx}.

Area A, where MR is greater than MC, represents net return foregone from underfed cattle. Net return could be increased by feeding these cattle to grade G_e. The area to the right of point E, area B, represents loss in net return due to overfeeding. Net return could be increased by selling these cattle earlier when they reach grade G_e.

A hypothetical net return function for cattle feeders is shown in Figure 4. Net return per unit is presented on the vertical axis and the variance of the carcass grades for a pen of cattle is shown on the horizontal axis. Net return was maximized when the variance of the carcass grade was zero. As the variance increased in magnitude, net return decreased.

If a live cattle grading system is introducted to facilitate assembly of a homogeneous group of feeder cattle, the variance of the carcass grades from point G_e will be reduced (Purcell, 1979, p. 91). Reducing variance will increase the producer's net return.

The analyses presented above were applicable to each pen of feeder cattle. Because each pen would not have identical MR and MC curves, the "target" grade will differ between pens depending on the type of cattle and market to which the cattle will be sold (Breimyer, 1976, p. 141). Regardless of the market and target grade, reduction of the

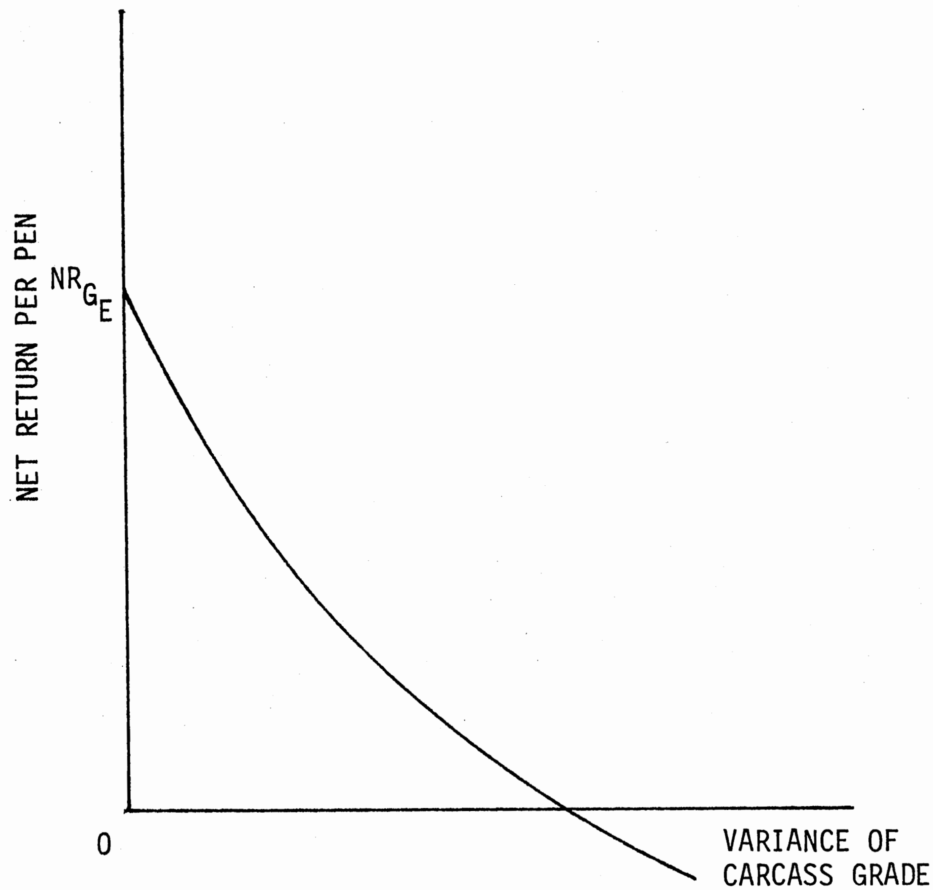


Figure 4. The Relationship of the Magnitude of the Standard Deviation of Carcass Grades and Net Revenue from a Pen of Feeder Cattle

carcass grade variance will increase net return to each pen. Thus, producers would be better off with a more efficient feeder cattle grading system.

Feeder Grade Issues

Consumer tastes and preferences are normally transmitted to the producer via the price mechanism; however, if a commodity has large variations in quality and attributes, it becomes impractical not to price each commodity quality group separately (Doll, Rhodes and West, 1968, p. 403). Meaningful lines of distinction between the quality and attribute differences must be determined for the price mechanism to function efficiently. Grades serve to classify products into groups according to consumer acceptance (McPherson, 1966). For grades to function efficiently, they must represent distinguishable and measurable attributes important to the buyer. Moreover, based upon attribute and quality (grade) differences, the buyer must be willing to discriminate price-wise. Because of the large variety of beef cattle, grades are essential to the beef industry (Mason, 1969, p. 268).

Purposes of Grades

The two major purposes of grades are (1) to add to total value (reduce costs), and (2) to increase efficiency in production and consumption (Williams, 1962). Value is added or costs are reduced through improvements in coordinative efficiency. Coordinative efficiency is defined as the ability of a market, through an accurate matching of supply and demand, to identify and evaluate the quality characteristics of a product necessary to achieve maximum output relative to input.

Quality is the sum of the attributes determining consumer acceptance; therefore, the price differential of a product.

By facilitating stratification of the product, grades can assist the development and use of electronic markets, futures contracts, private contracts, and market reporting services (Breimyer, 1960; Purcell, 1979, pp. 25-26).

Buying and selling by description reduces the time and expenses associated with travel (Doll, Rhodes, and West, 1968, p. 403). These cost reductions are directly related to reducing the costs of activities necessary to coordinate the market system. The cost reduction presumably implies an increase in net revenue received by the producer (Williams, 1962). Increasing net revenue is accomplished directly by increasing prices received or indirectly by lowering prices to consumers which then increases the product volume producers can sell at specified prices.

Efficiency implies that premium prices are received by producers of higher "quality" goods purchased by consumers. Two efficiency aspects in market functions are pricing accuracy and pricing efficiency. The degree of pricing efficiency is determined by grading accuracy, acceptability of the grading system, and the length of the marketing channels.

Grading also provides a universal language to identify differences and variations in attributes of concern to the consumers (Purcell, 1979, pp. 115-116). An efficient information system improves the knowledge level of both the buyer and seller which, in turn, facilitates bargaining. A faster, more precise and efficient grading system decreases marketing costs and facilitates a balanced marketing process.

An efficient grading system also has spillover effects beyond adding value and increasing efficiency. Through pricing accuracy, resources are more efficiently allocated by both the producer and consumer. Competition also is facilitated because small businesses can merchandise Federal Grades and thus compete with large firms who have developed a market for a private label or grade (Shaw, 1961).

Types of Grades

Attribute differences or grades are classified as homogeneous or heterogeneous (Doll, Rhodes, and West, 1968, p. 400). Homogeneous grades imply an ordinal distinction between classifications. All buyers agree as to what is good, better, and best, although they may disagree on the relative prices they are willing to pay for the different qualities. The relative prices should be highly correlated with the classifications because some buyers will be satisfied only with the "best" while others may settle for "good" if it is less costly. One example of homogeneous demand in the beef industry is the demand for feeder steers and heifers. At the same price, steers are normally preferred over heifers. However, at a certain price differential, when the price of steers is greater than the price of heifers, heifers are normally preferred over steers.

With heterogeneous demand, buyers disagree on what is good, better and best. Moreover, differences in tastes and preferences cause conflicts in quality determination. For example, an inferior product to one buyer may be a superior product to another. Relative prices may be uncorrelated with the classifications, revealing no meaningful relationships between prices since price differentials are determined by supply and demand. Because there is no clear definition of quality, production and demand may change between classes over time. For example, when the demand for lean beef increases, prices may signal the feeder to produce larger-framed animals which produce more meat and less fat at a younger age and lower percentage of mature weight. If consumer demand increases for choice cuts, prices may signal the feeder to produce medium-frame cattle that grade at lower weights. Therefore, depending on consumer demand and the product supply, the price differential may change between frame sizes.

Note that price or value is always related to scarcity, supply and demand. Moreover, the "good" can be higher prices than "better" if "good" becomes "scarce".

Theoretical Basis for Grade Standards

Because of the wide variation in attributes and the quality of the products produced by the beef industry, the price mechanism alone does not efficiently transmit consumer tastes and preferences to producers (Breimyer, 1976, pp. 139-140). Assume beef has two quality levels, X and Y, and the production possibility curve, XY, shown in Figure 5 (Clifton and Shepherd, 1953). Also, assume a competitive relationship exists between grades X and Y and more resources are required to produce X than Y. If buyers and sellers were unable to differentiate between grades X and Y at the feeder level, an average price would be paid for the two grades. Thus, the cow-calf operator's iso-revenue curve would be line P_FP_F, which is the negative ratio of the price of Y to the price of X and the ratio equals negative one. Equilibrium in production

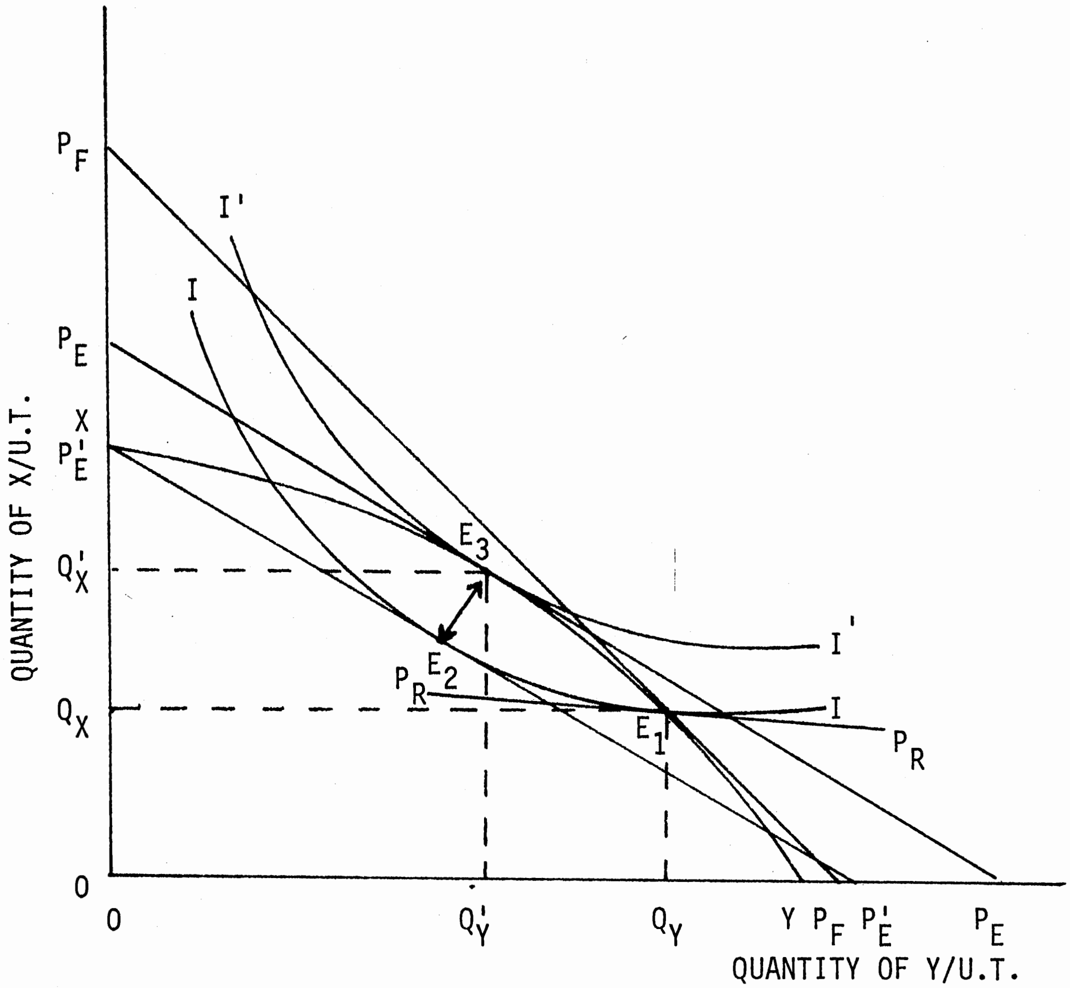


Figure 5. Economic Gain from an Efficient Grading System

is at point E_1, where the marginal rate of transformation equals the slope of the iso-revenue curve ($MRT_{YX} = \frac{-P_Y}{P_X} = -1$).

Assume consumers discriminate between X and Y, and they have identical indifference maps. A representative consumers' indifference curve for beef consumption is represented by Curve II (Figure 5). Both the indifference curve and the relative prices of X and Y are projected from the consumer to the cattle feeder via the relative prices paid by the consumer and the carcass grading standards. Because an average price was paid for X and Y in production, quantities Q_X of X and Q_Y of Y were produced. Allocation of Q_X of X and Q_Y of Y at consumption is controlled by the price mechanism. At equilibrium in consumption, the price ratio of Y to X is represented by the line P_RP_R and the marginal rate of substitution of Y for X is equal to the slope of the retail price ratio ($MRS_{YX} = \frac{-P_Y}{P_X} < -1$).

Equilibrium was obtained at production and at consumption, point E_1. However, the "market" is not in equilibrium because $MRT_{YX} > MRS_{YX}$. Without price differentiation via feeder cattle grades to differentiate between qualities X and Y, cow-calf producers will not adjust production to better meet consumer demand.

Now assume an efficient feeder grading system is implemented. Given the $MRT_{YX} > MRS_{YX}$, at production the price of X received will increase relative to the price of Y. Producers will increase the production of X and decrease the production of Y. Therefore, the price of X at retail will decrease relative to the price of Y. The quantities and prices of X and Y will serpentine as the market system approaches equilibrium at point E_3. At E_3, $MRT_{YX} = MRS_{YX}$ and an optimum point of production and consumption is obtained.

Implementation of the grading system has increased the production of X to Q_X' and has decreased the production of Y to Q_Y'. Consumers have moved to a higher indifference curve, I'I', which implies an increase in consumer satisfaction. The gain obtained from the efficient grading system is equivalent to the distance from E_2 to E_3 in Figure 5. Market allocation of the gain among producers and consumers is determined by the elasticities of supply and demand.

The theoretical application given above is also applicable to improvements in existing grading systems. Disequilibrium in the market exist when $MRT_{YX} \neq MRS_{YX}$. If the existing grading system is inefficient, the disequilibrium will exist and producers and consumers would gain by implementing a more efficient grading system.

Determining the Efficiency of Grade Standards

A procedure to measure the efficiency of a grading system can be derived from the results in the previous section, "Theoretical Basis for Grade Standards". To determine the procedure, assume: (1) consumers can efficiently classify the final product into two grades, (2) each producer attempts to produce only the quality of product for which he has a comparative advantage, and (3) the input must be classified into homogeneous groups to produce a single quality of product.

In the previous section the optimal point of production and consumption was point E_3 (Figure 5). However, point E_3 can only be obtained if the input is efficiently classified (graded) into homogeneous groups. Without an efficient grading system, input cannot be accurately classified into homogeneous groups; therefore, production will vary around point E_3 (Figure 6). Assume production of X will vary from X_L to X_U and the production of Y will vary from Y_L to Y_U. Optimal production levels of X and Y are X_0 and Y_0, respectively.

Assume the expected range of production is from R to R' and the probability of R and R' is one-half, respectively. Because of imperfect knowledge (inefficient grading), producers will discount the grading information and will attempt to produce at an expected level of production, E_e, rather than optimal point E_3. Cord RR' is one of a finite number of expectation cords that could be used to derive the expectation production transformation curve X'Y'. For simplicity, only cord RR' is used. With an inefficient grading system, both production and consumer satisfaction is at a lower level. The expected production of X and Y is X_E and Y_E, and consumers are on the indifference curve I" which is lower than indifference curve I'.

The expected range of production around point E_3 could be reduced by implementing a more efficient grading system (Figure 7). A more efficient grading system would improve the producers' information, thus shifting the expectation curve RR' and the product transformation curve X'Y' toward point E_3. With higher expectations, production of X and Y increases to X_E' and Y_E' and consumers move to a higher indifference curve I"I". Production and consumption are in equilibrium at point E_4 where both producers and consumers are better off.

The above theoretical application has shown that if a grading system for inputs is efficient, the variance around the desired level of production will be minimized. Minimizing the variance maximizes consumer satisfaction and producer net return. Therefore, a measure of the relative efficiency of a grading system is the system's ability to predict the final product or explain its variation.

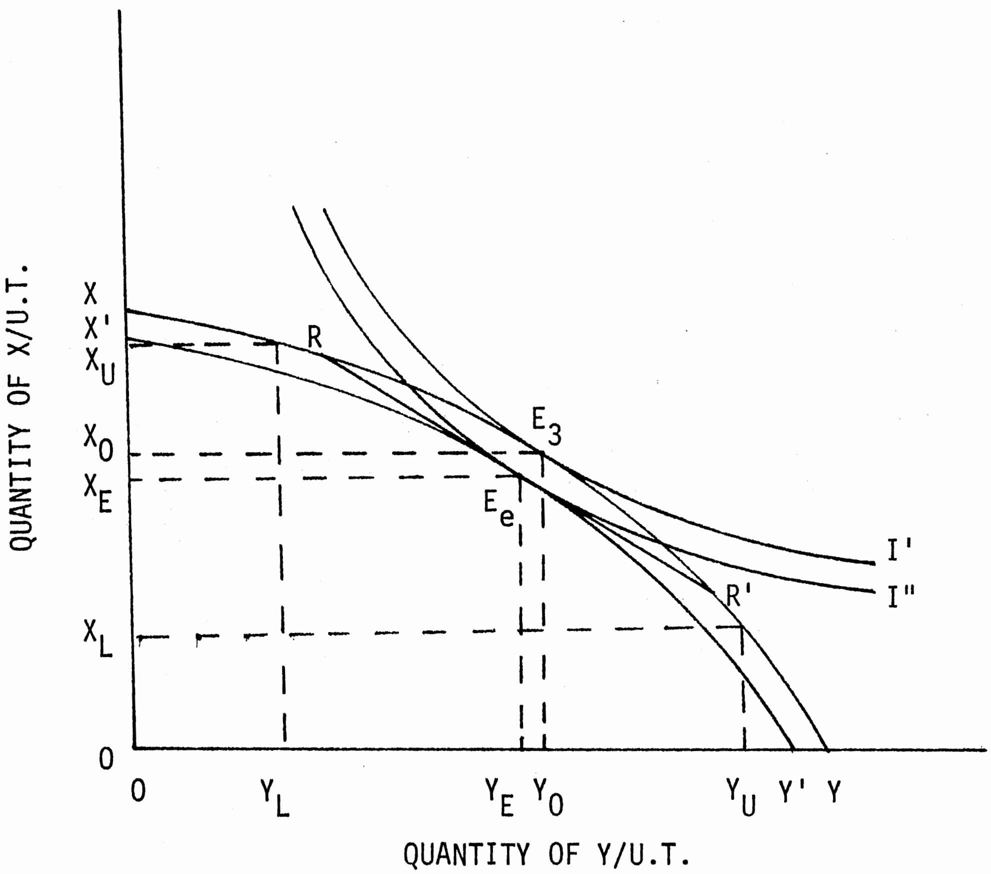


Figure 6. Economic Gain from Increasing the Efficiency of the Feeder Cattle Grading System

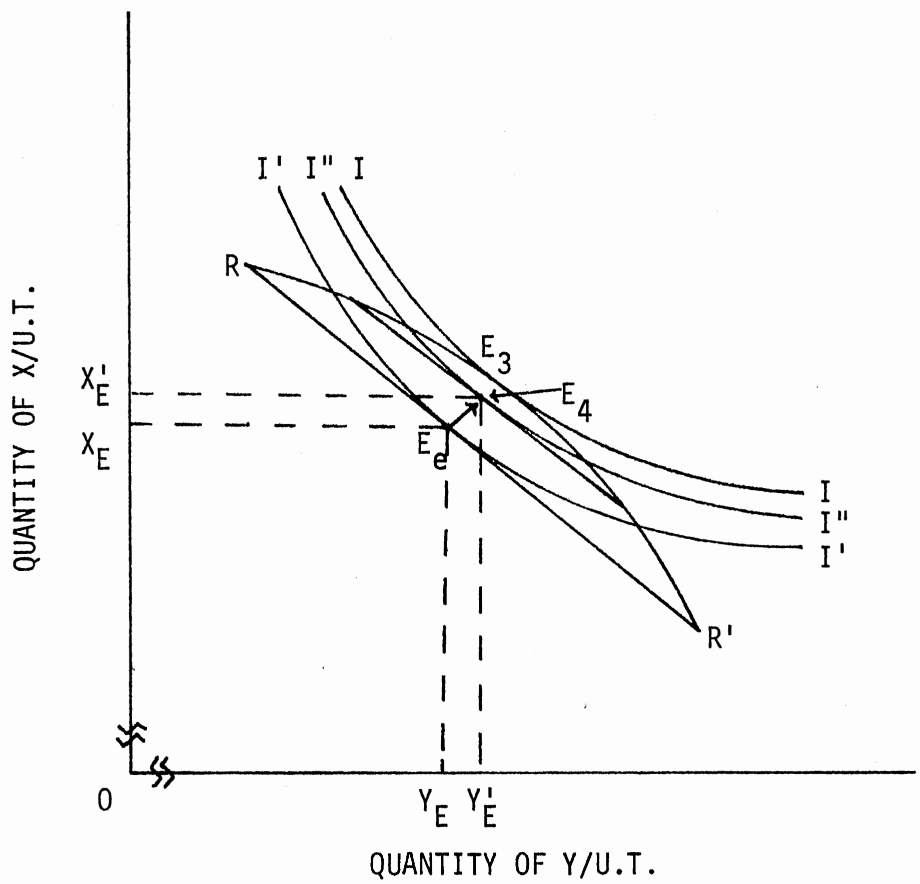


Figure 7. A Measure of Economic Gain from Increased Efficiency of Feeder Cattle Grading Standards

CHAPTER III

DATA, ANALYSES AND RESULTS

> Grading requires expertise. The experts sometimes come to believe in an expert standard. They argue that a decent standard cannot be based on the average of uninformed opinions of consumers. 'Standards should be set up 'right' whether most people recognize what's 'right' or not,' these experts say. The economist replies that there must be expert interpretation of market demands rather than personal standards of experts. If market grades are to aid communication, they must deal with market realities rather than with value judgments of experts (Doll, Rhodes, and West, 1968, p. 407).

The general objective of this chapter is to measure the efficiency of the present and alternate feeder cattle grading standards. Efficiency is partially determined by acceptance; therefore, cattle feeders were surveyed to obtain their choice of feeder cattle attributes for determining feeder cattle value. A summary of data collected by researchers in four states is presented; then, the statistical analysis of the present and alternate feeder cattle grading systems is discussed. Finally, an economic evaluation is presented to show possible economic gains from implementing a more efficient feeder cattle grading system.

Survey of Feedlot Managers

To obtain an indication of "market realities" with respect to feeder cattle, 100 feedlot managers in Oklahoma, Texas, Kansas and Nebraska were surveyed. Names and addresses of the cattle feeders were obtained from the OSU Cattle Feeders Seminar mailing list. The questionnaire, which consisted of a short explanatory letter and a self-addressed postcard with the feeder steer attributes listed on the back, asked the cattle feeders to specify which live cattle attributes were essential to known, nice to know, or not necessary to know when purchasing feeder cattle. The list of attributes on the postcard included: (1) sex, (2) weight, (3) age, (4) frame size, (5) degree of muscling, (6) degree of finish or fatness, (7) conformation, (8) breed, and (9) origin. Sixty-one percent of the managers surveyed responded (Table I).

Sex and weight were specified as essential in 95 and 92 percent of the responses, respectively. Both sex and weight are reported in the present USDA Feeder Cattle Standards. Age was considered essential by 48 percent of the respondents, and 80 percent of the respondents indicated that frame size was essential to know. Frame size was defined as skeletal size relative to age; therefore, the lower percentage of respondents listing age may be explained: if frame size and weight are known, it is unnecessary to know age. Frame size and age were specified as nice to know by 20 and 47 percent of the respondents respectively. The remaining five percent specified age was unnecessary to know.

Degree of muscling was rated the least necessary attribute in the essential group with only 32 percent regarding it as an essential characteristic. Sixty-one percent of the respondents specified muscling was convenient to know while seven percent indicated knowledge of muscling was unnecessary.

Fatness or degree of finish was ranked as essential to know by 80 percent of the respondents while the remaining 20 percent categorized fatness as nice to know. The high response to fatness may be attributed to the relationship of finish or fatness to compensatory gain and feed efficiency (Fox et al., 1972).

TABLE I

SURVEY RESPONSE FROM FEEDLOT MANAGERS[a]

Variable	Essential (Percent)	Convenient (Percent)	Not Necessary (Percent)
Sex	95	5	--
Weight	92	8	--
Age	48	47	5
Frame Size	80	20	--
Degree of Muscling	32	61	7
Degree of Finish or Fatness	80	20	--
Conformation	53	44	3
Breed	46	39	15
Origin	44	41	15

[a]61 responses were received out of 100.

Breed was considered essential by 46 percent, convenient by 39 percent, and not necessary by 15 percent of the respondents. Forty-four percent felt that origin was essential; 41 percent replied origin was convenient; and 15 percent indicated that knowledge of origin was unnecessary.

According to the survey, buyers purchase feeder cattle by sex, weight, frame size, and degree of finish or fatness. Both breed and origin of feeders were classified as more essential than degree of muscle thickness.

Data

Primary data were a composite of four independent but coordinated studies related to Southern Regional Research Project, S-116. A total of 801 observations were collected on steers purchased as feeders by Mississippi State University, New Mexico State University and the University of Illinois.

Select attributes were scored and the steers were individually weighed before they were placed on finishing rations. Attribute scores were based on the values described on the S-116 feeder calf evaluation form (Appendix). The feeder steer attributes scored were: (1) muscle scored Very Thick + = 1 to Thin - = 15, (2) body type scored Framey + = 1 to Compact - = 9, (3) age in months, (4) degree of finish scored Extremely Thin = 1 to Extremely Fat = 10, (5) body length scored Extremely Long = 1 to Extremely Short = 10, (6) height at hips and withers both scored Extremely Tall = 1 to Extremely Short = 10, (7) breed, (8) defects, health scored Fresh + = 1 to Sick - = 9; and 1964 USDA feeder cattle grade scored USDA Prime + = 1 to USDA Low Utility - = 15.

When possible, individual live weights were obtained at slaughter. Each carcass was measured and graded by a USDA grader. Measurements and grades were based on the Carcass Evaluation Form LS-106-1 (Appendix). The carcass attributes measured were : (1) maturity, (2) marbling scored abundant + to partially devoid -, (3) USDA quality grade in one-third units scored Prime + to Canner -, (4) adjusted fat thickness in inches, (5) rib eye area in square inches, (6) percent kidney, pelvic and heart fat, (7) calculated yield grade to nearest tenth, and (8) packer's warm carcass weight in pounds.

The final data set was collected by Oklahoma State University. Calves were weighed and tagged with USDA Carcass Data Service tags on the day of birth; records were maintained on each steer until slaughter. The S-116 feeder calf evaluation form was used to score the steers at weaning and again before entering the feedlot, and measurements were recorded for weight, height, and length. Both live and hot weights were obtained at slaughter, and a USDA grader evaluated the carcasses according to the Carcass Evaluation Form.

Illinois Data

The Illinois data set consisted of 272 Hereford, Angus, and Hereford-Angus cross feeder steers purchased by an order buyer at the Oklahoma City stockyards. The steers were trucked to South Farms, University of Illinois, where Animal Science Department personnel inspected, treated, and tagged the steers with USDA Carcass Data Service tags. The average weight of these steers was 685 pounds; the feeder weight varied from 495 to 810 pounds (Table II). The estimated average age of the feeders was 15 months with individual age varying from 12 to 16 months.

A finishing ration, 90 percent total digestible nutrient, was fed to the steers for 148 days. Thirty-three steers were lost due to death, lost tags, or the steers were transferred to another research project. The average slaughter weight was 1,003 pounds with a range from 770 to 1,240 pounds. High good was the average carcass grade; the low and high grades were USDA Low Standard and USDA Prime, respectively.

TABLE II

UNIVERSITY OF ILLINOIS FEEDER STEER DATA SUMMARY[a]

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Feeder Age (Mo.)	15	0.75	12	16
Feeder Weight (Lbs.)	685	66	495	810
Frame Score[b]	5	1.3	1	8
Thickness Score[c]	7	1.2	3	10
Fatness Score[d]	5	0.9	3	8
Days Fed	148	0.0	148	148
Slaughter Weight (Lbs.)	1,003	85	770	1,240
Hot Weight (Lbs.)	599	52	448	742
USDA Carcass Grade	High Good	1.6[e]	Low Standard	Low Prime
USDA Yield Grade	2.82	0.67	.5	4.4

[a]Data were collected on 239 steers by Dr. Kenneth E. Nelson, USDA, University of Illinois, Urbana-Champaign, Illinois.

[b]The frame scores were from 1 to 9 with: Large = 1-3, Medium = 4-6, and Small = 7-9.

[c]Thickness was proportional to the muscle thickness. Thickness Number 1 was scores 1-6, thickness Number 2 was scores 7-9, and thickness Number 3 was scores 9-15.

[d]Fatness was scored 1 through 10.

[e]The USDA Carcass Grades were placed into one-third grades.

Mississippi State Data

Data were obtained from two separate projects in cooperation with the Department of Animal Science at Mississippi State University and the S-116 project. Three-hundred and ten observations were from a study conducted on the King Ranch, Kingsville, Texas, and 67 steers were from project MIS-3001 of the Mississippi Agricultural and Forestry Experiment Station. All steers were Santa Gertrudis or Santa Gertrudis crossed with British breeds. A summary of the 377 steers is presented in Table III.

Three-hundred and two complete observations were collected from the 310 King Ranch steers. The average age of the feeder steers was 11 months with an age range of 9 to 13 months. A finishing ration was fed the steers for 161 days. Average daily gain for the feeder steers was 3.2 pounds. The average slaughter weight was 1,121 pounds with a range from 699 to 1,536 pounds. Carcass quality varied from USDA Low Standard to USDA Choice and averaged USDA Good.

Sixty-eight steers from the same group were shipped to Mississippi State Experiment Station to be fed out. These feeder steers averaged 590 pounds with a range of 370 to 732 pounds. The average age of the feeder steers was 10 months and the age varied from 8 to 14 months. At slaughter, the average steer weighed 997 pounds with a range of 736 to 1,283 pounds. The average carcass grade was USDA High Good while the grade varied between USDA Low Standard and USDA Low Prime.

New Mexico Data

Individual data were collected from a random sample of 208 steers out of a total population of 588 steers from 10 individual herds

TABLE III

MISSISSIPPI STATE UNIVERSITY FEEDER STEER DATA SUMMARY[a]

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Feeder Age (Mo.)	11	1.4	8	14
Feeder Weight (Lbs.)	636	74	370	868
Frame Score[b]	4	1.1	1	9
Thickness Score[c]	7	1.9	1	12
Fatness Score[d]	4	1.2	2	7
Days Fed	165	13	134	216
Slaughter Weight (Lbs.)	1,098	125	699	1,536
Hot Weight (Lbs.)	641	72	450	860
USDA Carcass Grade	Good	1.7[e]	Low Standard	Low Prime
USDA Yield Grade	2.70	0.61	1.0	4.7

[a]Data was collected on 369 steers by Dr. Warren Couvillion, Mississippi State University. The steers were Santa Gertrudis and Santa Gertrudis crosses.

[b]The frame scores were from 1 to 9 with: Large = 1-3, Medium = 4-6, and Small = 7-9.

[c]Thickness was proportional to the muscle thickness. Thickness Number 1 was scores 1-6, Thickness Number 2 was scores 7-9, and Thickness Number 3 was scores 9-15, where No. 1 was classified as Thick, No. 2 was Medium, etc.

[d]Fatness was scored 1 through 10 with Number 1 equal to thin, etc.

[e]The USDA Carcass Grades were placed into "one-third grades".

(Table IV). The breeds included Hereford, Angus, Hereford-Angus cross, Beef Masters, Charolais, Limousine, Santa Gertrudis, and Brahama crosses. Beginning feeder weight averaged 502 pounds with a range of 300 to 725 pounds. Nine months was the average age of the feeder steers; the range was 6 to 11 months.

Because of lost tags and death, carcass data were collected on 193 of the 208 steers. The steers were fed an average of 172 days with the minimum and maximum days being 139 and 202, respectively. Slaughter weight averaged 987 pounds and ranged from 682 to 1,363 pounds. USDA High Good was the average carcass grade and the range was between USDA Low Standard and USDA Prime.

Oklahoma State Data

To examine the value of data that was not included in the other three data sets, Oklahoma State collected data for each steer beginning at birth and ending with the USDA carcass data obtained at slaughter. In this project 458 steers were owned by private individuals and 189 head were research cattle owned by OSU (60 head), Noble Foundation (60 head), and the Eli Lili Company (69 head). Therefore, the project started with 647 steers. The birth weights ranged from 38 to 99 pounds with an average of 61 pounds.

Because the steers were to be scored according to the new (proposed at that time) feeder grading standards, the steers could not be scored until after October 2, 1978. This was the earliest date that Dr. Fred Williams, USDA Livestock Standardization Branch, could train Dr. Steve Armbruster, OSU Department of Animal Science, to grade the steers using the new standards.

TABLE IV

NEW MEXICO STATE UNIVERSITY FEEDER STEER DATA SUMMARY[a]

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Feeder Age (Mo.)	9	1.1	6	11
Feeder Weight (Lbs.)	502	91	300	725
Frame Score[b]	5	1.4	2	8
Thickness Score[c]	6	1.4	2	10
Fatness Score[d]	5	.56	3	8
Days Fed	173	22	139	202
Slaughter Weight (Lbs.)	987	127	682	1,363
Hot Weight (Lbs.)	628	88	428	858
USDA Carcass Grade	High Good	2.0[e]	Low Standard	Prime
USDA Yield Grade	2.8	0.70	1.0	5.0

[a]Data were collected on 193 steers by Scott Smith in conjunction with research project W-145. The steer breeds were Hereford, Charolais-Angus cross, Angus-Hereford cross, Santa Gertrudis, and Beef Master.

[b]The frame scores were from 1 to 9 with: Large = 1-3, Medium = 4-6, and Small = 7-9.

[c]Thickness was proportional to the muscle thickness. Thickness Number 1 was scores 1-6, Thickness Number 2 was scores 7-9, and Thickness Number 3 was scores 9-15.

[d]Fatness was scored 1 through 10.

[e]The USDA Carcass Grades were placed into "one-third grades".

A dry summer and fall prevented one producer from raising fall and winter pasture; consequently, 65 head were sold before October 2, 1979. An additional 308 head were sold because the stocker steer price dropped one dollar per hundred pounds one week before the steers were scheduled to be graded. The producer, coming off the lean years of 1973-1977, decided he could not risk a further decline in the stocker price.

A total of 274 steers were weighed, measured and scored twice: once at weaning and again before entering the feedlot. OSU's Department of Animal Science had tagged 60 head with OSU tags. To facilitate collecting carcass data, the steers were to be tagged with USDA Carcass Data Service tags. However, because of lack of communication the steers were sold without USDA tags. Another 61 head were disqualified because their ear tags were lost in the feedlot or on the kill floor of the slaughtering plant. For example, in one group of 61 head, 45 tags were inadvertently removed when the steers were processed in the feedlot.

Records from birth to slaughter were completed on 153 steers which included 23 breed combinations (Table V). Forty-one steers were angus crosses; the remaining 112 were exotic crosses (some had a small proportion of dairy breeding). The average weaning weight was 444 pounds; weights varied between 254 and 645 pounds. Weaning age varied between 5 and 11 months with an average of 8 months.

Beginning feeder weight averaged 703 pounds with a range from 415 to 945 pounds. Steer age upon entering the feedlot varied from 11 to 16 months and averaged 13.6 months. The steers were fed an average of 144 days with a minimum of 133 and a maximum of 156 days. Slaughter weight averaged 1,139 pounds with the range from 736 to 1,543 pounds. The average carcass grade was USDA Low Choice. Carcass grades varied between USDA High Standard and USDA Prime.

TABLE V

OKLAHOMA STATE UNIVERSITY STEER DATA SUMMARY[a]

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Birth Weight (Lbs.)	61	11.4	38	99
Wean Weight (Lbs.)	444	81.8	254	645
Wean Age (Mo.)	8	1.5	5	11
Feeder Weight (Lbs.)	703	99	415	945
Feeder Age (Mo.)	14	.69	11	16
Frame Score[b]	4	1.4	1	8
Thickness Score[c]	7	2.2	3	12
Fatness Score[d]	6	1.2	3	9
Days Fed	144	9.9	133	156
Slaughter Weight (Lbs.)	1,139	173	736	1,543
Hot Weight (Lbs.)	716	112	447	990
USDA Carcass Grade	Low Choice	1.3[e]	High Standard	Prime
USDA Yield Grade	3.26	0.71	1.32	5.0

[a]The 153 steers were Angus crosses and exotic breeds.

[b]The frame scores were from 1 to 9 with: Large = 1-3, Medium = 4-6, and Small = 7-9.

[c]Thickness was proportional to the muscle thickness. Thickness Number 1 was scores 1-6, Thickness Number 2 was scores 7-9, and Thickness Number 3 was scores 9-15, with thick equal to No. 1, etc.

[d]Fatness was scored 1 through 10 with thin equal to No. 1, etc.

[e]The USDA Carcass Grades were placed into "one-third grades".

Comparison of the Data Sets

Mississippi and Oklahoma had the largest frame size steers. Average frame scores for both states were four while the average frame score for Illinois and New Mexico was five. The frame scores are consistent with the breed of steers in each group. The Mississippi steers were Santa Gertrudis and Santa Gertrudis crosses. The majority of the Oklahoma steers were Charolais cross, Brangus, and Brangus crossed. Both the Illinois and New Mexico steers were British and British crosses.

The average muscle thickness on the steers was seven except for the New Mexico steers which scored six (Table VI). This implies that the New Mexico steers should have a lower yield grade than the other three groups. The New Mexico steers had a yield grade of 2.8 compared to 2.82, 2.70, and 3.26 for Illinois, Mississippi and Oklahoma, respectively.

The major difference between the data sets was the age and weight at which the steers entered the feedlot. New Mexico had the lightest and youngest steers, 502 pounds and 9 months, respectively. These steers were fed more days than the other three groups. However, the New Mexico steers' average USDA carcass grade was higher than that for the Mississippi steers; USDA High Good versus USDA Good. The Oklahoma steers were the only group to average USDA Low Choice. However, these steers entered the feedlot at the heaviest weight, 703 pounds, and with the largest amount of finish. The Oklahoma steers also were on feed for the least amount of time.

Few conclusions can be drawn from the raw data. For example, the Illinois steers were older and smaller framed but had the same muscle thickness and were on feed approximately the same number of days as the Oklahoma steers. However, the Oklahoma steers dressed out at a higher

TABLE VI

A COMPARISON OF THE DATA SETS

Attribute	Illinois	Mississippi	New Mexico	Oklahoma
Frame Size (Large = 1)	5	4	5	4
Thickness (Thick = 1)	7	7	6	7
Finish (Thin = 1)	5	4	5	6
Feeder Age (Mo.)	15	11	9	14
Days Fed	148	164	173	144
Feeder Weight	685	636	502	703
Slaughter Weight (Lbs.)	1,003	1,098	987	1,139
Carcass Grade (1/3)	High Good	Good	High Good	Low Choice
Dressing Percent	59.7	58.4	63.6	62.8
Yield Grade	2.82	2.70	2.80	3.26

USDA carcass grade than the Illinois steers. Based on the definition of frame size, the Illinois steers should have dressed out at a higher USDA carcass grade than the Oklahoma steers. The data sets provide a large amount of variance to statistically analyze feeder cattle standards.

Evaluation of Feeder Cattle Grade Standards

Beef producers have increasingly selected beef cattle with less external fat and a higher percentage of lean to accommodate a change in consumer demand (DeRouen et al., 1974). Therefore, the U.S. beef industry developed new breeds and introduced exotic breeds with relatively larger skeletal structure and less external fat than the traditional beef animal of the 1950's and early 1960's (Zinn, Durham and Hedrick, 1970). Having recognized this change in beef production, USDA appointed a special task force in 1973 to review the adequacy of the 1964 USDA feeder cattle standards. The task force concluded:

(1) the 1964 standards were not widely accepted as a tool for use in trading of feeder cattle,

(2) feeder cattle type had dramatically changed since 1964, and

(3) new standards which better reflect the needs of the feeder cattle industry should be developed (USDA, August 1979, p. 45320).

Present USDA Feeder Cattle Standards

The 1973 task force recommended that frame size and muscle thickness be used in the new feeder cattle standards to identify feeder cattle merit. "Frame size--the most important consideration--effectively identifies feeders for the weight at which they are expected to produce carcasses of a given grade--U.S. Choice, for example" (USDA, August 1979, p. 45320). The second recommended attribute, muscle thickness, identifies the effect muscle thickness has on ultimate yield grade.

The USDA implemented a new feeder cattle grading system on September 2, 1979. Three frame sizes and three thickness groups were used to classify the merit of feeder cattle into one of nine categories. Frame size is roughly defined as an animal's skeletal size--its height and length in relation to its age. The three frame categories and their official USDA definitions are:

(1) Large Frame. Feeder cattle which possess typical minimum qualifications for this grade are thrifty, have large frames, and are tall and long bodied for their age. Steers and heifers would not be expected to produce U.S. Choice carcasses (about 0.50 inch fat at twelfth rib) until their live weights exceed 1,200 pounds and 1,000 pounds, respectively.

(2) Medium Frame. Feeder cattle which possess typical minimum qualifications for this grade are thrifty, have slightly large farmes, and are slightly tall and slightly long bodied for their age. Steers and heifers would be expected to produce U.S. Choice carcasses (about 0.50 inch fat at twelfth rib) at live weights of 1,000 to 1,200 pounds and 850 to 1,200 pounds, respectively.

(3) Small Frame. Feeder cattle included in this grade are thrifty, have small frames, and are shorter bodied and not as tall as specified as the minimum for the Medium Frame grade. Steers and heifers would be expected to produce U.S. Choice carcasses (about 0.50 inch fat at the twelfth rib) at live weights of less than 1,000 pounds and 850 pounds, respectively (USDA, August 1979, p. 45322).

Thickness Number 1 relates to feeder cattle that formerly would have been placed in the USDA Prime or USDA Choice grades, Thickness Number 2 includes feeders that were formerly in USDA Good or USDA Standard grades, and Thickness Number 3 includes feeders of less than USDA Standard grade. The formal definitions are:

(1) No. 1. Feeder cattle which possess minimum qualifications for this grade usually show a high proportion of beef breeding. They must be thrifty and slightly thick throughout. They are slightly thick and full in the forearm and gaskin, showing a rounded appearance through the back and loin with moderate width between the legs, both front and rear. Cattle show this thickness with a slightly thin covering of fat; however, cattle eligible for this grade may carry varying degrees of fat.

(2) No. 2. Feeder cattle which possess minimum qualifications for this grade are narrow through the forequarter and the middle part of the rounds. The forearm and gaskin are thin and the back and loin have a sunken appearance. The legs are set close together, both front and rear. Cattle show this narrowness with a slightly thin covering of fat; however, cattle eligible for this grade may carry varying degrees of fat.

(3) No. 3. Feeder cattle included in this grade are thrifty animals which have less thickness than the minimum requirements specified for the No. 2 grade (USDA, August 1979, p. 45322).

The USDA also considered degree of fatness or finish, concluding it was a significant factor affecting value. However, because fatness can be influenced by managerial practice, the USDA elected not to include fatness in the new standards unless price relationships warranted its inclusion. The statistical analysis for this study used fatness as an alternate attribute to be included in a feeder cattle grading system.

Data Use and Methodology

Since slaughter weight was not available on all the steers, hot carcass weight was used in the analysis. To compare the results with USDA's frame size definition, hot carcass weight was converted to slaughter weight by dividing hot carcass weight by a dressing percent of 61.[1] A second justification for using hot weight rather than slaughter weight was that hot weight offers a more accurate measurement (Meyer et al., 1960). A proportion of the steers slaughtered were weighed on scales designed to weigh large groups of animals; therefore, the degree of error would be greater than if the steers had been weighed on scales designed to weigh individual animals. Using the Oklahoma data set, the relationship of slaughter weight and hot carcass weight was:

$$\text{SLAUGHTER WEIGHT} = -217 + \underset{(0.0001)}{1.49}\ \text{HOT WEIGHT} + \underset{(0.02)}{0.51}\ \text{KILLAGE} \qquad (1)$$

$$R^2 = 0.96$$

with the significance levels in parentheses and

HOT WEIGHT = Hot carcass weight in pounds, and

KILLAGE = Age at slaughter in days.

As defined in Chapter II, the efficiency of grade standards was determined by regressing hot carcass weight on the selected feeder cattle attributes that were expected to indicate within what range of slaughter weights a feeder steer should reach a given carcass grade. The feeder cattle attributes which explained the largest amount of hot weight variance for any carcass grade comprised the most efficient grading system.

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[1] The dressing percentage of 61 was the average dressing percentage of the steers where both hot carcass weight and slaughter weight were available.

Efficiency of USDA's Frame Size

To estimate the efficiency of USDA's frame sizes in determining the hot carcass weight at which a steer will reach a specific USDA carcass grade, hot carcass weight of 957 steers was regressed on the grader frame scores. The frame scores were placed on the steers before they entered the feedlot. The derived equation was:

$$\begin{aligned} \text{HOTWEIGHT} = {} & 586 + \underset{(0.001)}{40\ \text{LGOOD}} + \underset{(0.0002)}{39\ \text{GOOD}} + \underset{(0.0001)}{44\ \text{HGOOD}} + \underset{(0.0001)}{73\ \text{LCHOICE}} + \\ & \underset{(0.0001)}{58\ \text{CHOICE}} - \underset{(0.0001)}{56\ \text{SFRAME}} + \underset{(0.0001)}{59\ \text{LFRAME}} \end{aligned} \qquad (2)$$

$R^2 = 0.18$

STD DEV = 79.6

where the significance levels in parentheses and

HOTWEIGHT = Hot carcass weight in pounds,

LGOOD = zero-one dummy variable for USDA Low Good carcass grade,

GOOD = zero-one dummy variable for USDA Good carcass grade,

HGOOD = zero-one dummy variable for USDA High Good carcass grade,

LCHOICE = zero-one dummy variable for USDA Low Choice carcass grade,

CHOICE = zero-one dummy variable for USDA Choice carcass grade,

SFRAME = zero-one dummy variable for grader specified Small Frame, and

LFRAME = zero-one dummy variable for grader specified Large Frame.

The working hypothesis tested by the above equation was that grader frame should explain the variance of hot carcass weight given a USDA carcass quality grade. All the coefficients associated with frame size were highly significant ($P < 0.0001$) which indicated that the grader frame score was a significant variable in predicting hot weight for a given USDA carcass grade. The standard deviation of hot weight after it was regressed on USDA carcass grade and grader frame was 79.6 pounds. Actual standard deviation of hot weight was 87.5 pounds. Therefore, only nine percent of hot weight standard deviation was explained.

By USDA's definition, large-framed steers should reach USDA Low Choice carcass grade at a slaughter weight in excess of 1,200 pounds, medium-frame steers reach USDA Low Choice at slaughter weights between 1,000 and 1,200 pounds and small-frame steers reach USDA Low Choice at less than 1,000 pounds.

The coefficients on Equation 1 were of the appropriate sign. However, when compared to the USDA's definition, they did not have the desired magnitude. Using Equation 1 and the average dressing percentage of 61, the predicted mean slaughter weights for small-, medium-, and large-frame steers at USDA Low Choice was 988, 1,080, and 1,177 pounds, respectively.

In Equation 2, the magnitude of the coefficients on the USDA carcass grade dummies were not as hypothesized. The hypothesis was that as the USDA carcass grade increased (USDA Good = 10, USDA High Good = 11, USDA Low Choice = 12, etc.), the coefficients would increase in magnitude. All coefficients on the USDA carcass grade dummies were significantly different from zero ($P < 0.0001$); however, as determined by a F-Test, there was no significant difference between the coefficients of USDA Low Good, USDA Good, and USDA High Good or between USDA Low Choice and USDA Choice. There was a significant difference between the coefficients on the USDA Good and USDA Choice grades. No statistical difference between USDA one-third carcass grades but statistical difference between USDA "whole" grades was consistent with USDA Carcass grade standards. The USDA does not officially break carcass grades into one-third grade classifications.

The magnitude of the USDA carcass grade coefficients was also characteristic of the data. Larger-framed steers were not fed to a sufficient weight to reach USDA Choice. Therefore, the mean weight of the USDA Low Choice steers was greater than the mean weight of USDA Choice steers and the frame variable did not fully explain the difference. The purpose of the equation was to test the efficiency of frame-size classifications at a constant carcass grade; inclusion of the quality grades allows this test to be conducted.

Based on Equation 2, a significant relationship between USDA frame size and the hot carcass weight, given the USDA carcass grade, did exist. If the original hypothesis was correct (that frame size can be used to predict the weight at which a steer reached some USDA carcass grade), there were at least two reasons why grader frame size failed to explain a larger portion of hot carcass weight standard deviation. First, the grader may have been inconsistent when grading the steers. Second, the USDA's definition of frame size may not be accurate.

Grader Consistency--Frame. A total of 221 steers were measured for height and length, and subjectively scored for frame size at weaning and again six months later before entering the feedlot. By definition, frame size should be constant throughout the growth cycle of the steer (Callow, 1961; Henrickson et al., 1965; and Meyer et al., 1965). Therefore, one method to determine grader consistency is to determine the probability of a steer being placed in the same frame-size classification when graded at two intervals on the growth curve.

The probability of the grader placing the steer in the same frame classification was calculated by determining the frequency of the steer being scored the same both times (Table VII). Large-frame animals were scored as ones, medium-frame steers were scored as twos, and small-frame steers were scored as threes. Twenty-eight of 31 steers were scored as large frame at both evaluations. Only three steers scored as large at weaning were scored as medium as feeders. Of 166 steers, 125 scored as medium frame at weaning were also medium frame as feeders; 36 scored medium frame at weaning were scored large frame as feeders, and five medium steers at weaning were placed in the small-frame category as feeders. Three of 24 small-framed steers at weaning were classified large-framed as feeders, 16 small-framed steers were placed in the medium-frame category, and only six steers remained in the small-frame group.

Of 221 steers, 159 or 72 percent were placed in the same frame classification both times. If the hypothesis was correct that the frame size remains constant throughout a steer's growth cycle, the grader inconsistency on the Oklahoma data for frame size was 28 percent. Therefore, the predictive ability of Equation 2 could be improved by removing grader inconsistency.

Alternate Frame Definitions

USDA (August 1979) defined frame size as: "An animal's skeletal size--its height and body length--in relation to its age." Frame size, defined as a subjective score based on height, explained only nine percent of the variance. To test if the definition of frame was defined accurately, the amount of hot weight standard deviation explained by actual height can be compared with the ability of alternate attributes to explain the standard deviation of hot weight. Alternate definitions of frame size are: (1) actual feeder weight relative to age, (2) estimated feeder weight relative to age, or (3) some combination of height and weight relative to age.

TABLE VII

FREQUENCY OF FRAME SCORES

Weaning Frame Score[a]	Feeder Frame Score[a]	Frequency
1	1	28
1	2	3
2	1	36
2	2	125
2	3	5
3	1	2
3	2	16
3	3	6

[a]Large Frame = 1, Medium Frame = 2, and Small Frame = 3.

Bench Mark Grading System

In attempting to explain the standard deviation of a continuous variable, e.g., hot weight, with a discontinuous variable, e.g., frame, all the standard deviation cannot be explained. A grading system that had only three categories and that met the USDA's definition of frame size was constructed to establish a bench mark grading system which could explain the maximum amount of hot weight standard deviation. If a steer graded low choice and weighed more than 1,200 pounds, it was classified as large frame; if the slaughter weight at low choice was between 1,000 and 1,200 pounds, the steer was classified as medium; and if the slaughter weight was less than 1,000 pounds, the frame size was classified as small.

Hot carcass weight was regressed on the bench mark frame scores with large frame equal to one, medium frame equal to two, and small frame equal to three. The resulting equation was:

$$\text{HOTWEIGHT} = 936 - \underset{(0.0001)}{116}\ \text{BMFRAME} \qquad (3)$$

$R^2 = 0.80$

STD DEV = 47

with the significance level in parentheses and there:

HOTWEIGHT = actual carcass hot weight in pounds, and

BMFRAME = bench mark frame size.

The actual standard deviation of hot weight was 104 pounds. Therefore, the largest proportion of hot weight standard deviation that can be explained by a discontinuous three-group variable was 65 percent [(47 ÷ 104) x 100 = 65%].

Efficiency of Alternate Frame Size Definitions

To determine the feeder cattle attributes which best described frame size as defined by the USDA, seven alternate attributes and attribute combinations were tested. The seven methods were: (1) grader frame score, (2) actual feeder steer height, (3) actual feeder steer weight, (4) a combination of weight and height, (5) an index derived by dividing the actual feeder height by the logarithm of estimated age, (6) an index derived by dividing actual feeder weight by the log of estimated age, and (7) an index determined by dividing estimated feeder weight by the log of estimated age.

There were at least two justifications for using the log of age variable rather than the age variable. First, the relationship between age and weight or age and height was curvilinear and second, if beef animals were placed on a finishing ration at an earlier age (lighter weight), they reached low choice at an earlier age and weight (Fox and Black, 1977; and Gill, 1968). The nonlinear relationship between age and weight or age and height was important because the relationship of frame size to slaughter weight was defined as a linear relationship.

By definition, frame size was constant throughout the growth cycle of the animal. In Figure 8, an increasing at a decreasing rate curve which is asymptotic to mature weight represents a growth curve for a steer over some portion of its growth cycle. If a linear relationship was assumed between weight and age, line BB, the frame size would be overestimated or underestimated depending on the steer's age.

As mentioned previously, the second factor affecting the frame size derivation was the weight and age the steer was placed on a finishing ration. Trapp (1980) modified research by Fox and Black, and Gill to derive Figure 9. Trapp's results show that the weight at which a steer enters the feedlot affects both the age and weight the steer reaches USDA Low Choice. The results also show that the weight differential was greater when entering the feedlot as compared to the weight differential at slaughter.

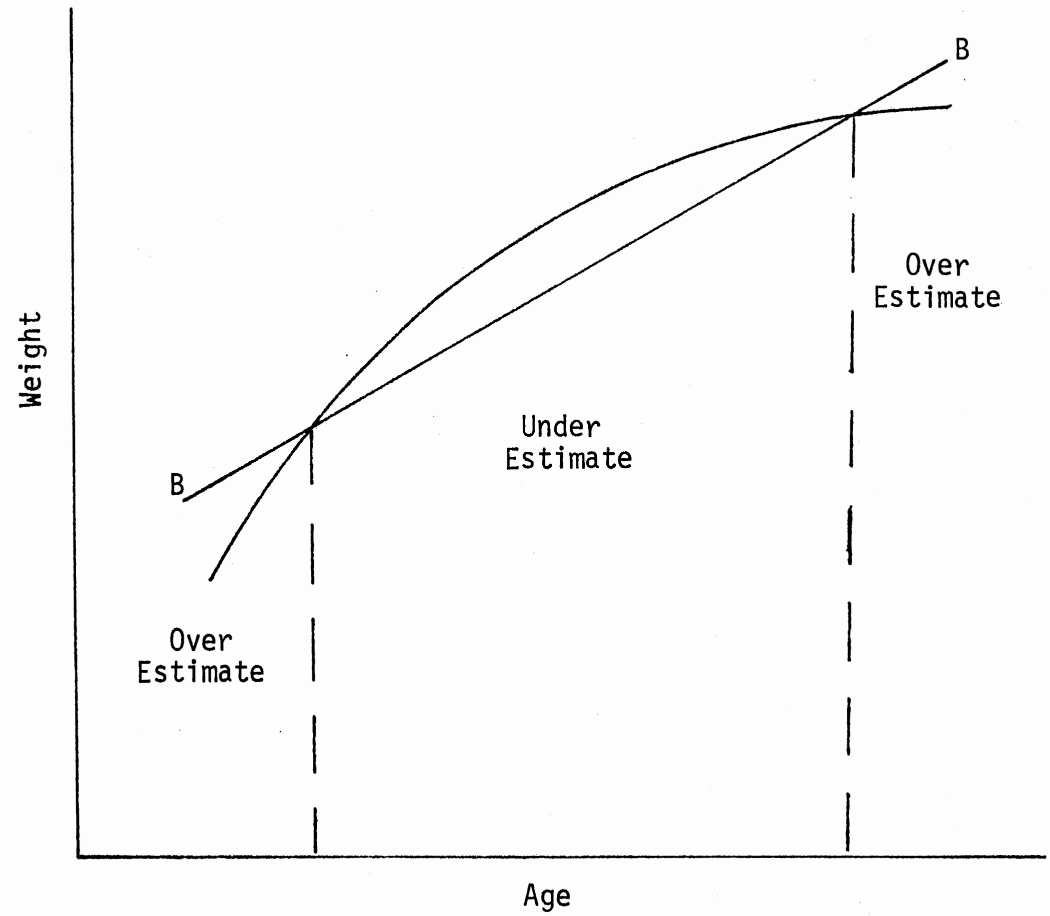

Figure 8. Relationship of Steer Age and Weight Relative to Frame Size Estimation

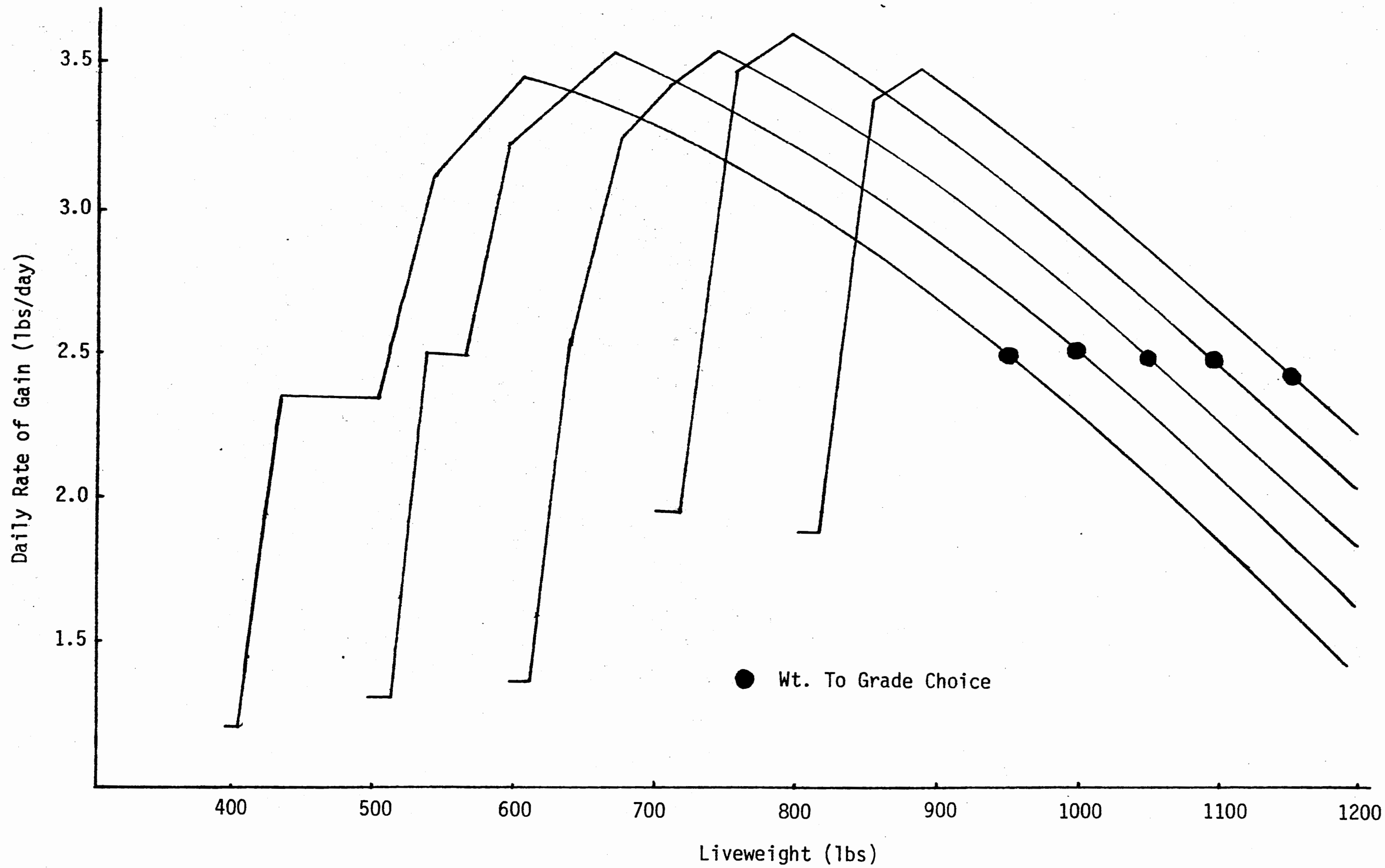

Figure 9. Typical Daily Rates of Gain for Steers by Placement Weight and Current Weight

Adjusting the feeder weight by the log of age, rather than age, reduced the error caused by the above curvilinear relationships. In equations derived by regressing hot carcass weight on the index, weight divided by age, and an age variable, the age variable was statistically significant ($P < 0.01$). However, when the index, weight divided by the log of age, was used, the age variable was not considered statistically significant at $P < 0.1$ ($P < 0.26$).

A comparison of the seven alternate methods used to describe frame size was conducted using the Oklahoma data set because of the availability of a larger number of variables. To meet the USDA restriction, that the carcass grade be held constant, hot carcass weight was regressed on the explanatory variables using only data from a single carcass quality grade. Hot weight was regressed on each attribute or combination of attributes five times, once using all the data with no carcass quality grade variable and once on each of the four one-third carcass grade classifications (Table VIII). Only the results for the low choice steers were discussed when determining the most efficient attributes for defining frame size.

The actual standard deviation of hot carcass weight for the 70 steers that graded USDA Low Choice was 104 pounds. The bench mark frame size reduced this standard deviation to 47 pounds or 56 percent of the hot weight variance. Regressing hot weight on the grader frame score reduced the standard deviation to 98 pounds or only six percent of the total standard deviation and only 11 percent of the explainable standard deviation [$(6 \div 56) \times 100 = 11$ percent].

The remaining methods used to define frame were in their continuous forms. After the most efficient variables were selected,

TABLE VIII

STANDARD DEVIATIONS OF HOT CARCASS WEIGHT AND OF THE RESIDUALS OF HOT CARCASS WEIGHT REGRESSED ON EXPLANATORY VARIABLES

Variables	Standard Deviation				
	All Data (157)	Good (25)	High Good (25)	Low Choice (70)	Choice (19)
Actual[a]	113	111	119	104	94
Bench Mark[b]				47	
Frame Scores[c]	107	112	111	98	92
Height[d]	82	95	95	70	61
Weight[e]	54	58	59	47	49
Weight and Height	54	60	60	45	47
Height ÷ Log (Age)[f]	94	100	110	83	65
Weight ÷ Log (Age)	55	53	66	46	49
Estimated Weight ÷ Log (Age)	56	62	70	47	47

[a]Actual standard deviation of the hot carcass weight.

[b]If slaughter weight $\geq$ 1,200 Frame = 1; if 1,000 $\leq$ slaughter weight $\leq$ 1,200 then Frame = 2; if slaughter $\leq$ 1,000 then Frame = 3.

[c]Frame scores determined subjectively before the steers entered the feedlot where Large = 1, Medium = 2, Small = 3.

[d]Actual feeder steer shoulder height in inches.

[e]Actual feeder steer weight.

[f]Estimated age in months.

frame scores were developed by using three groups. Feeder steer height reduced the standard deviation of hot carcass weight 33 percent (to 70 pounds) or 41 percent of the possible reduction.

Feeder steer weight reduced the standard deviation of hot carcass weight to 47 pounds, which was identical to the bench mark frame scores. Adding feeder steer height to the equation explained only an additional two pounds or another two percent to 45 pounds.

The index derived by dividing feeder steer height by the logarithm of estimated age in months reduced the standard deviation to 83 pounds or by 20 percent. This was 13 percent less than explained by height alone; however, this index reduced the standard deviation of hot weight 16 more pounds than height divided by age (standard deviation = 100).

Actual weight divided by the log of estimated age reduced the standard deviation of hot carcass weight to 46 pounds as compared to 47 pounds for weight alone. An index derived by dividing estimated feeder steer weight by the log of estimated age reduced the standard deviation of hot carcass weight to 47 pounds. This implied that estimated feeder weight and estimated age could have been used to develop a frame-size grade as efficient as actual weight and estimated age.

There was no significant increase in the explanatory power of the continuous variables when they were divided by the log of estimated age. A review of the steer ages in the Oklahoma data set indicated the age differential of the steers was minimal (mean age = 13.6 months, standard deviation = 0.68 months). However, when using the complete data set, where the age of the feeder steers ranged from 6 to 16 months, age was a highly significant variable (mean age = 11.9 months, standard deviation = 2.4 months).

Estimated feeder steer weights were not available for the steers in the Mississippi State, Illinois, and Texas data sets. Therefore, in lieu of estimated steer weight, the index of actual feeder steer weight divided by the log of estimated feeder steer age in months was used to define feeder steer frame size.

Based on the preceding analysis, the index of actual weight divided by the log of estimated age and actual weight were the two variables used to identify frame size categories. The data set containing 888 observations was used to determine and test the frame size definitions.

To develop a bench mark feeder grading system, the steers were divided into three categories based on their slaughter weight: large frame if the slaughter weight was greater than 1,200 pounds, medium frame if the slaughter weight was between 1,000 and 1,200 pounds, and small frame if the slaugher weight was less than 1,000 pounds. Carcass grade was not considered when defining frame classifications. Therefore, this bench mark system did not directly correspond to the USDA's definition of frame size.

The continuous versions of frame specification were reduced to three categories by deriving the means and standard deviations of the variables. The break points used to create the three categories were determined first by placing an equal number of steers in small, medium, and large categories using plus or minus .44 standard deviations from the means. The break points were then adjusted so the mean slaughter weight in each category would match the USDA's specifications.

Both the USDA one-third carcass quality grades and the three frame categories were converted to zero-one dummy variables. The medium frame and USDA High Standard dummies were dropped to avoid creating a singular matrix. In addition, 69 observations out of 957 were deleted because there was an insufficient number of steers in grades below USDA High Standard or above USDA Choice to include these dummy variables in the equations.

The mean of the index, actual weight divided by the log of estimated age, was 258.51; the standard deviation was 32.81 and the range of values was between 145.5 and 366.8. Steers with index values less than 244.1 were classified as small-framed animals, index values between 244.1 and 299.1 were classified as medium frame, and steers with indices greater than 299.1 were classified as large frame. This classification system yielded 282, 526, and 80 small-, medium-, and large-framed steers, respectively. The number of steers in each frame category was consistent with a visual check of the data set.

The three frame categories derived from actual feeder steer weights were: small frame, feeder steers weighing less than 587 pounds; medium frame, feeder steers weighing between 587 and 799 pounds; and large frame, steers weighing more than 799 pounds. The mean weight was 642 pounds with a standard deviation of 104 pounds.

Table IX shows the three derived equations of hot carcass weight regressed on carcass quality grade and either the bench mark frame categories, the frame categories derived using the index of actual weight divided by the log of age, or the frame categories derived from feeder weight. Hot weight standard deviation was reduced from 87.5 pounds to 46.1 pounds by the bench mark frame system and the R^2 was 0.72. All coefficients were highly significant, $P < 0.005$ or better. The magnitude of the coefficients on the frame variables was -89 for small frame and 127 for large frame comprising a differential of 216. Using

TABLE IX

REGRESSION EQUATIONS OF HOT CARCASS WEIGHT REGRESSED ON VARIOUS COMBINATIONS OF WEIGHT AND AGE

HOTWT[a]= (87.5)	Inter-cept	Low[b] Good	Good[b]	High[b] Good	Low[b] Choice	Choice[b]	Small[c] Frame	Large[c] Frame	Small[d] Weight / Log (Est. Age)	Large[d] Weight / Log (Est. Age)	Small[e] Weight	Large[e] Weight
R^2=0.72	623	20	30	29	38	37	-89	127				
STD=46.1	(0.0001)	(0.005)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)				
R^2=0.39	617	33	37	35	53	49			-74	113		
STD=68.5	(0.0001)	(0.002)	(0.0001)	(0.0002)	(0.0001)	(0.0001)			(0.0001)	(0.0001)		
R^2=.28	614	31	32	25	47	37					-48	122
STD=74.4	(0.0001)	(0.002)	(0.0002)	(0.0026)	(0.0001)	(0.0007)					(0.0001)	(0.0001)

[a]HOTWT is the actual hot carcass weight in pounds. The standard deviation of hot carcass weight was 87.5 pounds.

[b]Zero-one dummy variable for USDA Carcass quality grade in one-third grades.

[c]Zero-one dummy variable for frame size determined from the slaughter weight: small frame is slaughter weight < 1000 pounds and large frame is slaughter weight > 1200 pounds.

[d]Zero-one dummy variable for frame size determined by dividing actual feeder weight by the log of estimated age. Small frame is Index < 244.2 and Large frame is Index > 299.2.

[e]Zero-one dummy variable for frame size determined from actual feeder weight. Small frame is actual feeder weight < 587 and large frame is actual feeder weight > 799.

[f]Significance levels are presented in the parenthesis.

a dressing percentage of 61 percent, there is a 354-pound differential between the mean small and the mean large frame slaughter weights. Derived from the equation, the mean slaughter weights for small, medium, and large USDA Low Choice steers were 934, 1,084, and 1,292 pounds, respectively.

The standard deviation of hot weight was reduced to 68.5 when hot weight was regressed on the feeder weight ÷ log (age) index. All variables were significant at $P < .002$ or better. Twenty-two percent of the hot weight standard deviation was explained; this was 46 percent of the amount explained by the bench mark variable. The R^2 was 0.38. Mean frame slaughter weights predicted by the model for USDA Low Choice steers were 977, 1,093, and 1,284 pounds for small-, medium-, and large-framed steers, respectively.

The equation using feeder weight explained 15 percent of the hot weight standard deviation or 32 percent less than the index frame system. The R^2 on weight alone was 0.28. Therefore, it was concluded that the best method to define frame size was the index weight divided by the log of estimated age.

To test this conclusion and the break points for determining large, medium, and small frame sizes, the method was tried on the Oklahoma data set. The resulting equation was:

$$\begin{aligned} \text{HOTWEIGHT} = {} & 671 + 35\ \text{GOOD} + 68\ \text{HGOOD} + 56\ \text{LCHOICE} + \\ & (0.0001)\ \ (0.0001)\ \ \ (0.14)\ \ \ \ \ (0.009) \\ & 57\ \text{CHOICE} - 150\ \text{SMYFRAME} + 128\ \text{LMYFRAME} \\ & (0.025)\ \ \ \ \ (0.0001)\ \ \ \ \ \ \ \ (0.0001) \end{aligned}$$

$R^2 = 0.64$

STD = 67

with significance levels in parentheses and

HOTWEIGHT = actual hot carcass weight in pounds,

GOOD = zero-one dummy variable for USDA Good carcass grade,

HGOOD = zero-one dummy variable for USDA High Good carcass grade,

LCHOICE = zero-one dummy variable for USDA Low Choice carcass grade,

CHOICE = zero-one dummy variable for USDA Choice carcass grade,

SMYFRAME = zero-one dummy variable for Small Frame, and

LMYFRAME = zero-one dummy variable for Large Frame.

The standard deviation of hot carcass weight was reduced 41 percent by regressing hot carcass weight on the carcass quality grade dummy variables and the index derived by dividing estimated weight by the log of estimated age.

Summary of Frame Definitions. In the section above, the results indicated that the USDA's definition of frame size was statistically significant and explained approximately six percent of the hot carcass weight standard deviation. Alternate methods to define frame size showed that the most efficient method was to use the estimated weight divided by the log of estimated age. This variable explained 46 percent of the explainable standard deviation when compared to the bench mark system.

Interpretations of the index frame sizes were: If the index of the steer was greater than 299, the frame classification was large. On the average, a large-framed steer graded low choice when it reached a slaughter weight of approximately 1,284 pounds. Eighty percent of the large-framed steers reached low choice between 1,139 and 1,429 pounds.

If the index frame score was between 244 and 299, the steer was classified as medium frame. An average medium-frame steer reached low choice at 1,098 pounds and 80 percent of the steers weighed between 953 and 1,243 pounds. Index values less than 244 were classified as small frame. Small-framed steers averaged 977 pounds at slaughter. The slaughter weights ranged from 832 to 1,122 pounds for 80 percent of the steers.

The relationship of feeder steer weight as a function of age and frame size is presented in Figure 10. The equation used to derive the break points for small-, medium-, and large-framed steers was:

Feeder Weight = Frame Index * Log (Age).

Frame index was set at 244.1 or 299.1 for the small-medium or medium-large frame breaks, respectively. Feeder steers in areas A, B, or C were classified small-, medium-, or large-framed, respectively. For example, at eight months of age, if the feeder steer weighed less than 508 pounds, the feeder steer was small-framed; if the weight was between 508 and 622 pounds, the feeder steer was medium-framed; and if the steer weighed greater than 622 pounds, the feeder steer was large-framed.

The frequency of the index, feeder weight divided by the log of age, correctly categorizing feeder steers was presented in Table X. All of the steers were USDA Low Choice carcass grade. Of the 37 feeder steers classified as large, 28 steers weighed greater than 1,200 pounds; eight weighed between 1,000 and 1,200 pounds; and one weighed less than 1,000 pounds at slaughter. In the medium-frame feeder category, 37 of the 192 medium-frame steers weighed greater than 1,200 pounds, 130 weighed between 1,000 and 1,200 pounds, and 25 weighed less than 1,000

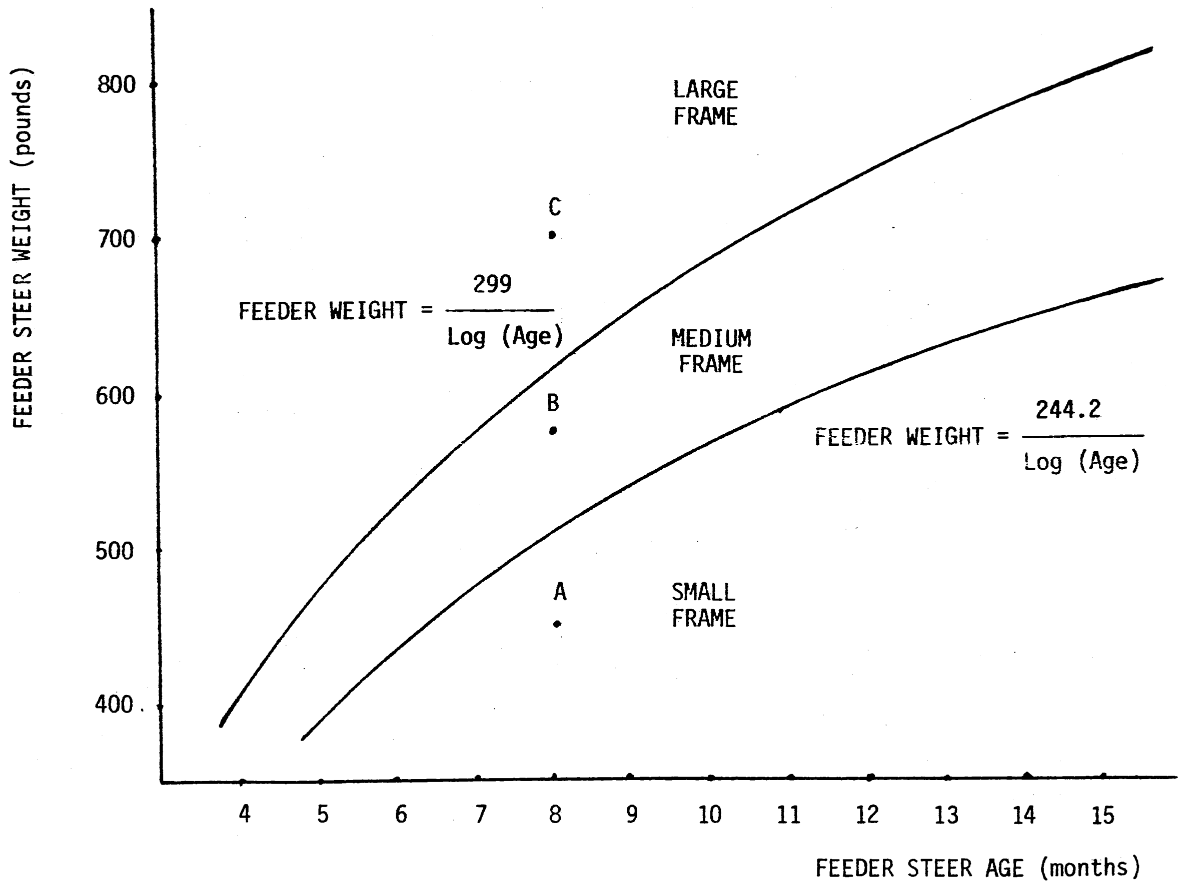

Figure 10. Frame Size Determination Based on Feeder Steer Weight and the Logarithm of Feeder Steer Age

pounds at slaughter. Sixty-one of the small-frame feeder steers weighed less than 1,000 pounds, 25 weighed between 1,000 and 1,200 pounds, and one weighed greater than 1,200 pounds at slaughter.

TABLE X

FREQUENCY OF INDEX FRAME SIZE CORRECTLY CATEGORIZING FEEDER STEERS[a]

Slaughter Frame[c]	Feeder Frame[b] Large	Medium	Small
Large (head)	28	37	1
Medium (head)	8	130	25
Small (head)	1	25	61

[a]All steers graded low choice.

[b]If feeder steer weight ÷ log (age) > 299.1, feeder frame = large; if 244.2 $\leq$ feeder steer weight ÷ log (age) $\leq$ 299.1, feeder frame = medium; and if feeder steer weight ÷ log (age) $\leq$ 244.2, feeder frame = small.

[c]If slaughter weight > 1,200 pounds, slaughter frame = large; if 1,000 $\leq$ slaughter weight $\leq$ 1,200 pounds, slaughter frame = medium; and if slaughter weight < 1,000 pounds, slaughter frame = small.

Logic dictates that there is more to explaining or predicting the slaughter weight at which a steer reaches low choice than weight and age. Two animals with the same weight and age may appear to have the same frame size but may not because of environmental factors, breed, or some unmeasured attribute. However, the results indicate that the index of weight divided by the log of age may be the most efficient method available to estimate frame.

In practical application of the index frame, weight divided by the log of age indicates that to compare animals, their weight and age must be considered. Moreover, there was a nonlinear relationship between weight and age. The older the steers, the more apparent was their relative size. If a linear weight to age relationship was assumed, the frame size of the younger steers would be overestimated while the frame size for the older steers would be underestimated.

Efficiency of USDA Thickness Scores

In data collection, muscle thickness was scored from 1 to 15 (very thick + to thin -). Based on the USDA description of the relationship between muscle thickness and the 1964 USDA feeder grades, scores 1 through 6 were designated as thickness No. 1, scores 7 through 12 were identified as thickness No. 2, and scores 13 through 15 were labeled thickness No. 3. In the 957 observations collected by the four states, there were no steers with muscle thickness scores between 13 and 15. Therefore, the following analyses include only thickness No. 1 and thickness No. 2 steers. According to the USDA's feeder grading standards, thickness scores should explain differences in USDA carcass yield grades.

Simple correlations were used to indicate what attributes should be used to predict carcass yield grade. Carcass yield grade was most highly correlated with carcass quality grade, 0.43 (Table XI). Hot weight had a 37 percent correlation with yield grade. However, thickness had only a 3 percent correlation with yield grade. The simple correlations indicated that carcass quality grade and hot weight should be used to predict carcass yield grade. If yield grade was regressed only on the thickness scores, the R^2 of the equation would be 0.001 $[(0.03)^2]$.

TABLE XI

SIMPLE CORRELATIONS OF YIELD GRADE AND RELEVANT VARIABLES

Variable	Grade	Quality Grade	Hot Weight	Finish	Thickness
Yield Grade	1.0	0.43	0.37	0.28	0.03
Quality Grade	0.43	1.0	0.18	0.29	-0.01
Hot Weight	0.37	0.18	1.0	0.10	-0.09
Finish	0.28	0.29	0.10	1.0	-0.05
Thickness	0.03	-0.01	-0.09	-0.05	1.0

To determine the ability of carcass quality, carcass hot weight, and thickness scores to predict carcass yield grade, yield grade was regressed on the three independent variables. The resulting equation was:

YIELD GRADE = 0.91 + 0.22 LGOOD + 0.29 GOOD + 0.51 HGOOD +
(0.0001) (0.017) (0.0003) (0.0001)
0.58 LCHOICE + 0.76 CHOICE + 0.002 HOTWT -
(0.0001) (0.0001) (0.0001)
0.10 MUSC1
(0.016)

R^2 = 0.23

STD DEV = 0.587

with the observed significance levels in parentheses and

YIELD GRADE = USDA carcass yield grade,

LGOOD = zero-one dummy variable for USDA Low Good carcass grade,

GOOD = zero-one dummy variable for USDA Good carcass grade,

HGOOD = zero-one dummy variable for USDA High Good carcass grade,

LCHOICE = zero-one dummy variable for USDA Low Choice carcass grade,

CHOICE = zero-one dummy variable for USDA Choice carcass grade,

HOTWT = hot carcass weight in pounds, and

MUSC1 = zero-one dummy variable for muscle thickness scores from 1 through 6.

The coefficient on the thickness dummy variable was significant ($P < 0.016$). However, the magnitude of the coefficient implies that the difference between the yield grade of thickness No. 1 and thickness No. 2 steers was one-tenth of a yield grade. Except on borderline cases, thickness would not affect the USDA yield grade--reported as integers--of a steer.

For each 100 pound change in hot carcass weight or 164 pound change in slaughter weight, yield grade will change by two-tenths of a yield grade. The coefficient was highly significant ($P < 0.0001$).

The coefficients on the carcass grade dummies were all significant ($P < 0.0003$). There was three-fourths of a yield grade difference between USDA Choice and USDA Standard carcass grades and approximately one-half of a yield grade difference between USDA Choice and USDA Good carcass grades.

The above equation reduced the standard deviation of yield grade from 0.695 to 0.587 or by 15.5 percent. If muscle thickness was not included in the equation, the standard deviation would be reduced to 15.4 percent or only 0.1 percent less than when muscle was in the equation.

Grader Consistency--Muscle. The possibility of errors in the thickness scores offers a probable explanation for the inability of muscle thicknesses to explain the yield grade variance. Using the 157 Oklahoma observations, an estimate of the degree of grader consistency was calculated by determining the probability that muscle thickness was scored in the same category in two successive periods. The USDA (August 1979) claimed that muscle thickness was an "inherent characteristic" which remained constant throughout the growth cycle of a feeder. However, as presented in the literature, the nutrient level may affect muscle development (Berg and Butterfield, 1978).

The frequency of the steer being classified as thickness No. 1 and thickness No. 2 at weaning, and again as feeders, was presented in Table XII. There were 43 steers classified as thickness No. 1 at weaning. As feeders, 23 were classified as thickness No. 1 and 20 were classified as thickness No. 2. Of 114 steers classified as thickness No. 2 at weaning, 38 were classified as No. 2 and 76 were classified as No. 1. Thus, 61 of the 157 steers were placed in the same thickness classification, indicating a grader inconsistency of 61 percent.

It is interesting to note that as feeders when the steers were coming off wheat pasture (thus, carrying a heavier finish), the grader placed 102 steers in the No. 1 category versus 44 when the steers were weaned. The steers did not carry a heavy finish at weaning because they had come off a dry summer and poor pasture. These results substantiate the concern of some animal scientists that "it is difficult to differentiate between muscle and finish on live animals" (McPherson and Dixon, 1966, p. 63) and that the nutritional level, if low enough, does retard muscle development (Berg and Butterfield, 1978).

TABLE XII

FREQUENCY OF THICKNESS SCORES

Weaning Thickness Score[a]	Feeder Thickness Score[a]	Frequency
1	1	23
1	2	21
2	1	79
2	2	39

[a]Thick = 1, Medium = 2, Thin = 3.

Finish as an Indicator of Yield Grade

The USDA (August 1979) considered including finish as a factor for feeder cattle standards. However, finish was not included because: (1) it would greatly increase the number of grade combinations, (2) using fatness in lieu of muscle thickness would result in feeders being so dissimilar in appearance that their marketability would be impaired, (3) using finish could necessitate placing a different feeder grade on the same animal in different stages of its development, and (4) cattle from the same herd may be graded differently from year to year depending on their plane of nutrition and management. The USDA did conclude, however, that variations in finish may have an effect on feeder cattle value.

Finish and compensatory growth have been the subject of research studies since Osborne and Mendell (1915, 1916) found that growth continued at an accelerated rate after a long period of restriction. Later, controversy arose over the physiological reasons for compensatory growth. Osborne and Mendell (1916) suggested that increased feed intake during recovery was partially responsible for the compensatory gains. These results were substantiated in independent studies by Quinby (1948) and Taylor (1959). However, a study by Meyer et al. (1965) suggested an increase in energy utilization independent of feed intake during compensatory growth. Fox et al. (1972) conducted research to determine which of the above conclusions was correct. They concluded that increased efficiency utilization of energy and protein during the full feeding period was responsible for compensatory growth and that there was only a slight increase in the total intake of metabolizable energy. Thus, feed efficiency was not independent of the cattle's previous nutritional treatment or their level of finish.

Crouse et al. (1974) conducted research to determine which feeder calf traits most efficiently predicted subsequent carcass characteristics. Using the step-wise regression procedure, their carcass yield grade prediction equation included both muscle and finish variables. The coefficients were significant ($P < 0.01$) and of approximately the same magnitude, 0.18 for finish and 0.16 for muscle. The finish variable was feeder calf backfat scored Thin = 1 and extremely Fat = 10. The muscle variable was muscle thickness at the round scored Thick = 1 and Thin = 10. The R^2 was 0.30 for the equation.

Based on the data collected for the S-116 project, the simple correlation between carcass yield grade and finish scores (Thin = 1, . . ., Fat = 10) was 0.28 (Table XI). Thus, the R^2 of yield grade regressed on finish would be 0.08. However, to include finish in the grade standards, the steers were divided into two groups: thin and fat. Scores from 1 to 6 were thin, and scores 7 to 10 were fat steers. The resulting equation was:

$$\begin{aligned} \text{YIELD GRADE} = {} & \underset{(0.0001)}{1.19} + \underset{(0.015)}{0.22}\ \text{LGOOD} + \underset{(0.0015)}{0.26}\ \text{GOOD} + \underset{(0.0001)}{0.47}\ \text{HGOOD} + \\ & \underset{(0.0001)}{0.51}\ \text{LCHOICE} + \underset{(0.0001)}{0.65}\ \text{CHOICE} + \underset{(0.0001)}{0.002}\ \text{HOTWT} - \underset{(0.0001)}{0.26}\ \text{THIN} \end{aligned}$$

$R^2 = 0.25$

STD DEV = 0.577

with the observed significance levels in parentheses and

YIELD GRADE = USDA carcass yield grade, 1-5,

LGOOD = zero-one dummy variable for USDA Low Good carcass grade,

GOOD = zero-one dummy variable for USDA Good carcass grade,

HGOOD = zero-one dummy variable for USDA High Good carcass grade,

LCHOICE = zero-one dummy variable for USDA Low Choice carcass grade,

CHOICE = zero-one dummy variable for USDA Choice carcass grade,

HOTWT = hot carcass weight in pounds, and

THIN = zero-one dummy variable for thin finish scores 1-5 where Thin = 1, ..., Fat = 10.

The coefficient on the thin finish zero-one dummy variable was highly significant ($P < 0.0001$) and the magnitude implied that there was 0.26 difference in the carcass yield grade of thin versus fat steers. There was little change in the coefficient on the hot weight and USDA quality grade variables compared to the equation that included the thickness variable. The magnitude of the USDA Choice variable decreased from 0.76 to 0.65. However, the magnitude of the coefficients on USDA Low Good and hot weight remained the same.

The actual standard deviation of carcass yield grade was 0.695. Carcass quality grade, hot weight and finish reduced the standard deviation to 0.577 or by 17 percent. Thus, adding finish explained an additional 1.6 percent or increased the explained yield grade variance 10.4 percent compared to carcass quality grade and hot weight alone.

Finish had only limited correlation with yield grade; consequently, the yield grade variance was only slightly reduced when finish was included in the regression equations. Based on these analytical results, only limited support can be derived for including finish. On the other hand, the literature supports inclusion of finish in the feeder grade standards. As indicated in the literature, finish is an indicator of potential compensatory gains and compensatory gains are important to cattle feeders.

Other researchers have found that finish partially indicates the relative weight a steer will reach a carcass quality grade (Brungardt, 1972, R2398). Feeder cattle with relatively heavier finish will reach grade at a lighter weight than feeder cattle with relative less finish.

Economic Evaluation

Prices are determined by relationships between the supply of and the demand for products in a competitive economic environment. The characteristics of the supply and demand functions are different for different qualities of products. Moreover, the relative prices of different grades of commodities vary over time. Impacts that alter the supply or demand function of a given product change its relationship to the supply of and demand for competing products and their relative prices. Continuous changes in the range and magnitude of beef prices make it almost impossible to determine the economic value of an improved grading system. However, an example using specific costs and returns was developed to further illustrate the economic value of a more efficient feeder grading system.

Maximization of Net Return

A mathematical model developed by Nelson (1979) was used to simulate the relationship between beef slaughter weight and net return per head per day for various weights of cattle development. Nelson incorporated the "California Net Energy System" of feeder animal net energy maintenance and gain requirements (Lofgreen and Garrett, 1968), costs of gain and ration formulations from Gill (1979), and a price function developed by Ikerd (1979) into the simulation model. The growth equation projected the daily feedlot gain based on the available ration and the feeder's weight and growth potential. Costs of gain were a function of the ration cost, interest, and other feedlot fixed and variable costs.

Ikerd's price equation combines the actual feeder animal price with the expected feeder price and a grade discount to develop a price equation that reflects the slaughter animal price as the carcass grade and yield grade change during growth. In the initial feedlot phase, the price declines until the animal reaches its minimum slaughter weight, normally high standard carcass grade. As the carcass grade increases, the price per pound increases, until the deposition of fat decreases the carcass value relative to the increase in value from increasing the carcass grade, e.g., going from yield grade 3 to yield grade 4. At this stage in growth, the price declines as fat increases.

In the example, it was assumed that 806 pound (774 pound shrunk) feeder steers were purchased for $76 per hundred weight (cwt.). For a simulated 2.8 pounds average daily gain, the gain costs were $54.13 and the slaughter sale price at the target grade (low choice) was $73.89 per cwt. The simulated net return per head per day was $0.36 for 1,156 pound steers fed 126 days. Steers simulated for 215 days weighed 1,358 pounds, sold for $69.84 per cwt., and yielded a profit per head per day of -$0.01.

The net returns relative to weight simulated from minimum slaughter weight to the slaughter weight of approximately yield grade 5 were used to derive a net return equation. The derived example equation was:

$$\Pi = -8.79102843 + 0.01579908\ WGT - 0.00000688\ WGT^2$$

$$(0.0001) \qquad (0.0001) \qquad (0.0001)$$

$$R^2 = 0.93$$

with significance levels in parentheses and

Π = Net return per head per day,

WGT = slaughter animal weight in pounds, and

WGT^2 = slaughter animal weight in pounds squared.

The net return equation was consistent with the hypothesis developed in Chapter II. Initially, marginal revenue was greater than marginal costs; therefore, net return was increasing. At some point, marginal cost became greater than marginal revenue; thus, net return was declining. Based on the net return equation, net return was maximized at 1,148 pounds. Maximum net return per head per day was $0.279.

The analysis and results in this study were based on the hypothesis that a cattle feeder's net returns increased as the carcass quality grade variance for pens of slaughter cattle was reduced. This assumption was examined using a general net return equation and deriving, in general terms, the expected net return of a pen of cattle relative to the slaughter weight variance around the point of maximum net return. Slaughter weight was assumed to have a normal distribution with mean μ and standard deviation σ.

Expected net return as a function of weight was depicted as:

$$E[\Pi(w)] = \int_{-\infty}^{\infty} \Pi(w)\ f(w/\mu_0, \sigma_0) \tag{1}$$

where

$E[\Pi(w)]$ = expected net return,

$\Pi(w)$ = net return as a function of slaughter weight,

$f(w/\mu,\sigma)$ = probability distribution function of slaughter weight,

w = slaughter weight,

μ_0 = mean slaughter weight, and

σ_0 = standard deviation of slaughter weight.

Inserting the general form of the net return function:

$$E(\Pi) = \int_{-\infty}^{\infty} (c + bw + aw^2)\ f(w)\ dw \tag{2}$$

$$c < 0,\ b > 0,\ a < 0$$

Integrating for $w \sim N(\mu_0, \sigma_0)$

$$E(\Pi) = c + b\mu_0 + a\mu_0 + a\sigma_0^2 \qquad (3)$$

Note in the second degree polynomial equation of net return as a function of slaughter weight, "a" was less than zero. Therefore, partial differentiation of Equation 3 with respect to σ_0, shows that net return was maximized when σ_0 equaled zero. (Given $a < 0$, the second order conditions for a maximum were met.)

$$\frac{\partial E(\Pi)}{\partial \sigma_0^2} = 2a\sigma_0$$

$$a < 0, \ \sigma_0 \geq 0$$

This implied that as σ_0 increased, $E(\Pi)$ decreased and the maximum net return equation was:

$$\hat{\Pi} = c + b\mu_0 + a\mu_0^2$$

The analysis above showed that net return was maximized if the animals were slaughtered at μ_0 and the slaughter weight variance was zero. In the following illustration, it was assumed that the animals were not slaughtered at weight μ_0. Let

$$E[\Pi\mu(w)] = c + b\mu + a\mu^2 + a\sigma^2 \qquad (4)$$

$$c < 0, \ b > 0, \ a < 0, \ \mu > 0, \ \sigma \geq 0$$

be the expected net return for average weight μ ($\mu \neq \mu_0$). The reduction in net return, when the average slaughter weight was not μ_0, was

$$\Delta = \hat{\Pi}_{\mu_0} - E[\Pi\mu(w)] = c + b\mu_0 + a\mu_0^2 - c - b\mu - a\mu^2 - a\sigma^2.$$

To maximize net return, the change in net return (Δ) should be minimized. The effect of σ on Δ was derived by deriving the partial derivative of Δ relative to σ:

$$\frac{\partial \Delta}{\partial \sigma} = -2a\sigma \; .$$

Since $a < 0$, Δ was minimized when σ equaled zero. Thus, in all cases net return would be increased by reducing the variance.

This was further illustrated by letting:

$$d = b\mu_0 + a\mu_0^2$$

then:

$$b\mu + a\mu^2 + a\sigma^2 = d - \Delta$$

completing the square:

$$a(\mu + \frac{b}{2a})^2 + a\sigma^2 = d - \Delta + \frac{b^2}{4a}$$

and then putting in the general form of

$$\frac{(\mu + \frac{b}{2a})^2}{\sqrt{\frac{d - \Delta + \frac{b^2}{4a}}{a}}^{\,2}} + \frac{\sigma^2}{\sqrt{\frac{d - \Delta + \frac{b^2}{4a}}{a}}^{\,2}} = 1 \qquad (5)$$

which is the general form of a circle with radius $\sqrt{\frac{d - \Delta + \frac{b^2}{4a}}{a}}$
Equation 4 was used to produce contours around the slaughter weight where net return was maximized (Figure 11). Any point on a contour represents the combinations of standard deviation and mean slaughter weight that maintained a constant net return. It was deducted from Figure 11 that net revenue was reduced equally for deviations of mean slaughter weights, above and below μ_0, and that any increase in the variance would decrease net revenue.

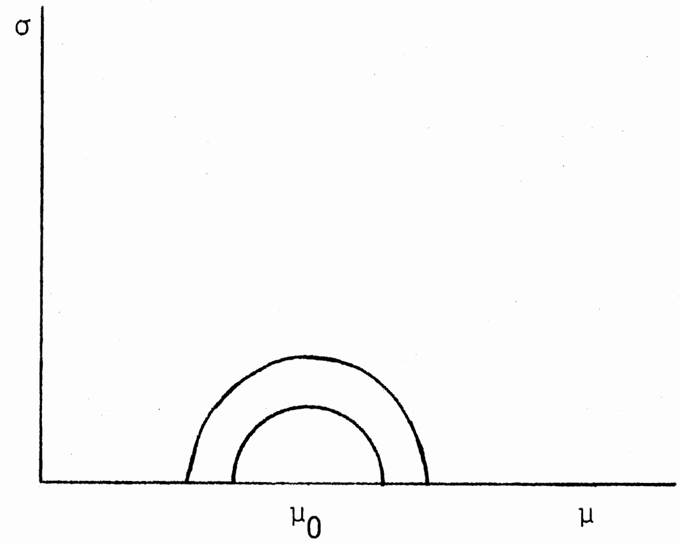

Figure 11. Relationship of the Standard Deviation of Slaughter Weight and the Mean Slaughter Weight for a Pen of Cattle

Using the derived net return equation and different levels of slaughter weight variance, a numerical example of the economic gains from decreasing the slaughter weight variance was developed (Table XIII). Standard deviation of slaughter weight was calculated in 22 percent increments from 128 to 23 pounds which represented the improved efficiency from implementing the feeder cattle grading system developed in this study. Note that the values presented in this example were only estimates of one set of an infinite number of possible economic conditions.

If the standard deviation of slaughter cattle was reduced 22 percent, from 100 pounds to 78 pounds, the net return per head per day increased \$0.027, from \$0.21 to \$0.237, or for a 155 day feeding period,

TABLE XIII

NET RETURN PER HEAD PER DAY OF FEEDLOT CATTLE[a]

Standard Deviation of Slaughter Weight (Pounds)	Net Return Per Head Per Day (Dollars)	Change in Net Return (Dollars)
128	0.166	
100	0.210	0.044
78	0.237	0.027
61	0.253	0.011
47	0.264	0.006
37	0.270	0.003
29	0.273	0.003
23	0.275	
.		
.		
.		
0	0.279	

[a]An example of loss in net revenue due to the slaughter weight variance for a homogeneous group of feeder cattle.

$4.19 per head. In 1979, approximately 27.74 million cattle were fed out (USDA, 1980). The average number of days the feeders were on feed was approximately 155 days (P.C.C., 1980). Given the economic conditions assumed in this illustration, the potential economic gain to the beef industry would be $116,091,900 per year.

The potential economic gain to the beef industry from a reduction in the standard deviation was less under the assumption of a lower original standard deviation. If the standard deviation was reduced 22 percent, from 78 to 61 pounds, the potential economic gain to the industry was $68,795,200 per year ($0.016 x 27,740,000 x 155 = $68,795,200).

Implementation of a more efficient feeder cattle grading system would have positive economic gains. Data are not available to determine the cost of implementing a more efficient system or to derive the cost of using the present versus an efficient grading system. However, it is hypothesized that a more efficient feeder cattle grading system would be no more costly to use than the current system. The additional costs would involve the expense of introducing the feeder grades to the beef industry. Previous actions of both the beef industry and consumers have indicated that efficient grading standards are in their best interests, and there is no indication that their opinions will change.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Beef cattle grading systems have been utilized in the beef industry since the late 1800's. The increased number of beef cattle bought and sold through order buyers and the increased dependence on market reporting services intensified the importance of beef cattle grading systems. Prior to 1964, research was directed toward determining carcass and retail grades. Feeder cattle grades received little attention. However, during the last decade, efforts have increased to refine the feeder cattle grading system.

This increased emphasis to improve feeder cattle grade standards can be attributed to two factors: (1) beef producers striving to increase the coordinative efficiency in the cow-calf to feedlot interface, and (2) a change in the types of feeder animals being produced. Consumer demand for meat with more lean and less fat has increased. Therefore, some beef producers shifted their production to beef animals with relatively heavier mature weights. These changes in production have increased both the variance of mature weights in fed cattle and the variance of carcass compositions of slaughter cattle at a given weight.

Grading systems provide a basis for separating a heterogeneous product into several relatively homogeneous products on the basis of characteristics that are important to buyers and sellers. Thus, grade standards can be expected to increase the net returns to sellers, reduce the costs of buying and selling, and establish a more efficient basis for determining the economic value of products. To develop an accurate and efficient feeder grading system, the live-cattle traits which indicate the desired attributes of the final product must be identified. In addition, their determination process must be available and acceptable to the buyers and sellers in the industry.

The purpose of this study was to measure the coordinative efficiency of the 1979 feeder cattle grading system and to determine the efficiency of alternate grading systems. The specific objectives were:

1. Determine the feeder cattle attributes which determine acceptance,
2. Determine the efficiency of the 1979 feeder cattle grading system,
3. Compare the efficiency of the 1979 feeder cattle grading system with alternate systems, and
4. Estimate the economic gains from the feeder cattle grading systems.

Feedlot managers were surveyed to determine the feeder cattle attributes that were considered important when purchasing feeder cattle. According to the 61 percent who responded, cattle feeders based their purchasing decisions on a feeder animal's sex, weight, frame size, and degree of finish. Approximately 80 percent felt these attributes were essential to know when purchasing feeder animals. Only 32 percent of the respondents indicated degree of muscling was essential information. Age, breed, and origin were considered more essential than muscle.

The literature was reviewed to determine the bovine's growth characteristics. The normal growth curves for weight, bone, muscle, and fat relative to age were all sigmoid shaped. Normal tissue development from birth to maturity in the bovine was such that muscle had a higher growth impetus than bone, and after some point in the developmental process, the impetus for fat deposition was greater than muscle. Thus, animals slaughtered at an earlier percentage of their mature size had a lower percentage of fat, a lower dressing percent, a lower yield grade, and less marbling than an animal slaughtered at a higher percentage of its mature size.

The normal growth pattern of an animal was altered by changing the nutritional plane. Energy deficiencies first restricted development of fatty tissue; further energy deficiencies restricted muscle and bone development.

When animals had been on a low-energy ration during their growth cycle and then were placed on a higher-energy ration, the increased rate of gain and efficiency of energy utilization was identified as compensatory gain. Studies show that animals in early stages of compensatory gain gain faster, convert feed more efficiently, and deposit more protein and less fat than similar animals that have been on full feed. The animals on full energy rations reach a quality grade at a lighter weight and an earlier age than the compensatory animals. However, toward the end of the compensatory growth, the impetus for fat development increases, leaving the final carcass composition the same as for steers on full energy rations. Moreover, if compensatory animals and full energy animals were fed to the same carcass quality grade, the total energy requirement from birth to slaughter was approximately the same for both animals.

Even though the same amount of energy was required to produce animals of the same carcass quality grade when comparing compensatory and full energy animals, compensatory gain was an important factor for cattle feeders. The compensatory steer reached the desired carcass quality grade at an older age; thus, the compensatory steer was on feed longer than the full energy steer. However, if the cattle feeder purchased the two animals at the time the compensatory animal started compensatory growth, the compensatory steer yielded a higher average daily gain, utilized energy more efficiently, and produced more pounds of edible meat than the full-energy steer. The relationship between finish and compensatory gain strongly supported the inclusion of finish in the feeder cattle grading system.

Studies have shown that breed altered the rate of tissue development and the weight at which the growth impetus of muscle and fat deposition change. At the same weight, small breeds such as Angus tended to have a higher proportion of fat, grade higher, contain a lower proportion of saleable meat, have a higher dressing percentage, and have lower feed efficiencies than larger breeds such as Herefords, Charolais, or Friesians. Herefords fall between Angus and Charolais, and Charolais fall between Herefords and Friesians. However, if beef animals were fed to the same quality grade, feed and energy efficiency per pound of edible meat was approximately the same.

Results from previous research indicate that no combination of feeder calf traits were meaningful in predicting USDA carcass grades of the animal at slaughter. Condition, depth, trimness and overall length were the most efficient predictors of USDA yield grade, and percent of retail product and round muscle was correlated with conformation. Overall muscle scores were not as significant in predicting conformation as round muscle. The most significant, subjective slaughter animal trait in predicting USDA carcass yield grade was estimated fat cover at the twelfth rib. Overall muscle scores and estimated rib eye area at the twelfth rib contributed little to the accuracy or reliability of the yield grade equation.

Graders' estimates of slaughter cattle traits were able only to explain 20 to 40 percent of the variance in the carcass traits. Prediction of carcass fat cover and content was more accurate than predicting muscle. When estimating USDA carcass quality grades, in one-third grade units, grader estimates were only within 1.3 thirds of the actual grade for two out of three animals.

The literature reviewed indicated that frame size was more efficiently identified by feeder weight corrected for age as compared to height, and that fat was a more efficient predictor of carcass yield grade than muscle thickness. The degree of finish was more accurately evaluated than muscle thickness by graders. Thus, finish may be a more efficient addition to the feeder cattle grade standards than muscle thickness.

Summary of Results

Data of feeder steers were collected independently by the University of Illinois, New Mexico State University, Mississippi State University, and Oklahoma State University. The data sets were combined to form one data set which contained 957 observations of more than 30 beef breeds or crossbreed combinations of feeder steers. All steers were scored by the Southern Region Research Project Feeder Calf Evaluation Form. Graders weighed the feeders, and then obtained the hot carcass weight, USDA carcass grade, USDA yield grade, and other carcass measurements.

Records were maintained on the Oklahoma steers from the day of birth. In addition, the steers were scored and weighed at weaning.

These data were used to test the efficiency of the 1979 USDA feeder cattle grading system. USDA's frame size scores were defined by the USDA as skeletal size--height and body length--relative to age, and were designed to predict the slaughter weight at which a steer would reach a USDA carcass quality grade. Because carcass hot weight was a more accurate measurement of final steer weight than the live weight, it was used in lieu of live slaughter weight in the analysis to determine the most efficient feeder grading system.

An efficient feeder grading system improves the coordinative efficiency between cow-calf producers and cattle feeders. The price relationship between the types of feeders coordinated supply to meet the cattle feeder's demand. Moreover, an efficient feeder grading system facilitated assembly of homogeneous pens of feeders which minimized the animals' carcass grade variance at slaughter. Therefore, the most efficient feeder grading system was the one that explained the largest amount of carcass hot weight variance.

The efficiency of the 1979 USDA feeder cattle grades was compared to the efficiency of seven alternate methods to define feeder cattle frame sizes. The alternate methods were: (1) actual feeder steer height, (2) actual feeder steer weight, (3) a combination of weight and height, (4) an index derived by dividing the actual feeder height by the logarithm of estimated age, (5) an index derived by dividing actual feeder weight by the log of estimated age, (6) an index determined by dividing estimated feeder weight by the log of estimated age, and (7) a bench mark grading system.

To develop the bench mark system, actual carcass quality and slaughter weight were used to group the steers into three frame-size categories that met the USDA's frame-size definition. The bench mark frame size explained approximately 65 percent of the carcass hot weight variance. This implied that the maximum amount of the carcass hot weight variance, a continuous variable, that could be explained by a variable with only three categories was 65 percent.

Using the Oklahoma data set, the indexes, actual weight divided by the log of estimated age and estimated weight divided by the log of estimated age, were determined to be the most efficient indicators of frame size. In their continuous form, they reduced the hot carcass weight standard deviation from 104 to 46 and 47 pounds, respectively. This was compared to the 98 pounds that the USDA's frame size reduced the carcass weight variance.

The complete data set of 888 observations was used to determine the breaking points to derive three groups from the index, actual feeder weight divided by the log of estimated age. This index was used rather than the estimated weight; estimated weight was only available for the Oklahoma steers.

The USDA's 1979 feeder cattle frame size reduced hot carcass weight standard deviation nine percent. The index of actual weight divided by the log of estimated age reduced the standard deviation 22 percent. Thus, the index explained 34 percent of the explainable variance and was the most efficient definition of frame size. Moreover, from the Oklahoma data, it was determined that the index, estimated weight divided by the log of estimated age, was approximately as efficient as actual weight divided by the log of estimated age.

The index frame sizes were interpreted as follows: If the index of the steer was greater than 299, the frame classification was large. On the average, a large-framed steer graded low choice when it reached a slaughter weight of approximately 1284 pounds. Eighty percent of the large-framed steers will reach low choice between 1139 and 1429 pounds.

If the index frame score is between 244 and 299, the steer was classified as medium frame. An average medium-frame steer reached low choice at 1098 pounds, and 80 percent of the steers will weigh between 953 and 1243 pounds. Index values less than 244 were classified as small frame. Small-framed steers averaged 977 pounds at slaughter. The slaughter weights ranged from 832 to 1123 pounds for 80 percent of the steers.

Based on the USDA's definition of muscle thickness No. 1, No. 2, and No. 3, there were no No. 3 steers in the 957 observations collected. There was no reason to indicate whether the observations were or were not a random sample of the beef cattle population. Moreover, there was only a small difference, 0.1 yield grade, in the yield grade of No. 1 and No. 2 muscle thickness cattle. The R^2 of the equation of carcass yield grade regressed on muscle thickness was 0.01.

Carcass quality grade and hot carcass weight were the two most powerful predictors of yield grade. They explained 15.4 percent of the yield grade variance. Introducing degree of finish into the equation in two categories explained an additional 1.6 percent of the variance or increased the variance explained by approximately 10 percent. Therefore, we concluded that degree of finish was a more efficient indicator of yield grade than muscle thickness.

Conclusions

The USDA feeder cattle grading system was not the most efficient system. Using frame size to identify the slaughter weight category in which a beef animal will reach a given USDA carcass quality grade was, however, an improvement over the 1964 feeder cattle grading system. A review of the literature and the results from this study indicate that the USDA did not properly define frame size. Frame size would have been better identified as feeder weight adjusted for age rather than height and length adjusted for age.

Carcass quality grade and carcass hot weight were the most efficient predictors of carcass yield grade. Muscle thickness did not explain a sufficient amount of the carcass yield grade variance to warrant its inclusion in the feeder cattle grading standards. The survey of feedlot managers also revealed that muscle thickness was the attribute of least concern to the managers.

Both the literature and the analysis conducted in this study determined that degree of finish was significant in predicting final carcass merit. However, the benefit of including finish as a predictor of yield grade was unclear. The mean difference between thin and fat steers was approximately one-fourth of a yield grade. The value of knowing the degree of finish may be in the relationship between finish and feed efficiency. Various literature cited showed definite measured compensatory gains. The degree of finish may be related to compensatory gains and feed efficiency.

The conclusions based on the literature review, survey of feedlot managers, and the results from this analysis were:

1. Frame size should be defined as feeder weight divided by the logarithm of estimated age in months,
2. Degree of finish should be the second factor included in the feeder grading standards, and
3. The only need for muscle thickness is to differentiate beef and dairy type cattle.

Limitations

Errors and inconsistencies in the data could originate from many sources. Each group of steers were weighed and scored under differing environmental and managerial conditions. While the graders were experienced feeder cattle graders, they did not evaluate feeder cattle on a daily or weekly basis. Because they were using a new grading system, it is possible that the graders were inconsistent between groups of steers and in scoring each steer. Also, each group of steers were scored by one grader. There was no method to determine the accuracy of a grader's scores.

The analyses involving actual measurements of weight, height, and length were subject to measurement errors. Both feeder and slaughter weights were obtained from steers that were not consistently shrunk; consequently, a two to three percent error could exist in the weights from different shrink alone. Differences in the calibration of the scales could also contribute to this error. However, hot carcass weight was determined in a relatively consistent manner.

This study also was limited by the lack of certain data. Data from birth, including actual age, height, length and weaning weight measurements, were available for a small number of steers. There was a deficient number of large-framed steers that were fed to USDA Low Choice or better. Feed efficiency data would have been useful for determining the relative importance of degree of finish. The study also lacked steers with muscle thickness No. 3. Consequently, the complete value of the muscle thickness categories could not be determined.

Unfortunately, there is no method to determine whether the 957 observations could be considered representative of the beef cattle population. Steers purchased by research institutions were selected for performance ability. Likewise, cooperating producers and feedlot managers culled the low performing steers from their steer groups. This sorting and culling of low performing feeder animals appears to be consistent with normal practices within the beef industry.

The results may be biased by the selection of the feeder steer attribute and carcass characteristics scores. The scores may not represent the magnitude of attribute differences between steers belonging in two classifications. Irrespective of the limitations, however, the results conclusively show that the determinants of frame size should have been weight adjusted for age and that finish was more efficient in predicting yield grade than muscle thickness.

Implications for Further Research

Results from this study indicate that changing the frame size definition and using degree of finish rather than muscle thickness would increase the efficiency of the 1979 USDA feeder cattle grading system. Related questions and problems arising during the analysis imply a need for further research.

The cattle feeders surveyed indicated a strong preference for knowing degree of finish over breed, age, muscle, and origin. Previous research has shown that calves exhibiting a relatively high degree of finish at weaning also have a relatively high degree of finish as a feeder. Research should be conducted to determine if an animal with a relatively higher degree of finish will reach a USDA carcass quality grade at a relatively lower weight and earlier age than an animal produced in the same environment but with relatively less finish. If there is a significant difference, the economic implications need to be determined.

Relative to improvements in the feeder grading system, research should be conducted to determine the relationship between degree of finish and feed efficiency. The effect that feed efficiency has on carcass quality and yield grade should be investigated. Moreover, researchers need to determine which feeder attributes can be used to predict feed efficiency.

Data utilized in the study were collected with the validation of the proposed feeder cattle grading system as the objective. Therefore, the data set was not adequate to validate the results or to answer additional questions. Because the entire data set was used to determine the most efficient method to sort feeder steers into homogeneous groups, additional research is needed to determine the validity of the suggested system. Also, only one grader, using an unfamiliar grading system, scored the feeder steers. Several graders, familiar with the grading systems, should be used to assemble a new data set; this would allow an estimation of grader error.

Further economic analyses should be conducted. Profit functions by frame size, various costs of gain, and varying feeder and slaughter prices would help determine the economic gain for assembling homogeneous groups of feeder steers. To determine the profit functions, feeder growth curves need to be developed by frame size and the weight differences estimated between carcass quality grades. Data on the discount paid for slaughter steers because of over finish or not reaching grade would be required. The discount could be determined by analyzing historical price data and surveying order slaughter cattle buyers.

Additional research is needed to improve the feeder cattle grading system. The results and technique presented in this manuscript should aid in improving the feeder cattle grading standards.

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APPENDIX

Date ____________________
Location ________________
I.D. ____________________

S-116 FEEDER CALF EVALUATION SCORING FORM
(Score according to footnote directions on reverse side)

Grader ________________
Recorder ______________
Page ____ of ____

Special Comments	Tag Number	Weight	1 Muscling Code 1-15	2 Body Type 1-9	3 Age 6-24	4 Degree of Finish 1-10	5 Body Length 1-10	6 Height at		7 Breed Comment	8 Defects Comment	9 Health 1-9 Comment	10 Present Feeder Grade
								Hips 1-10	Withers 1-10				

(Reverse Side)

1 Muscling

Designation:	Code
Very thick +	1
Very thick 0	2
Very thick -	3
Thick +	4
Thick 0	5
Thick -	6
Sl. thick +	7
Sl. thick 0	8
Sl. thick -	9
Sl. thin +	10
Sl. thin 0	11
Sl. thin -	12
Thin +	13
Thin 0	14
Thin -	15

2 Body Type

Designation:	Code
Framey +	1
Framey 0	2
Framey -	3
Med. Frame +	4
Med. Frame 0	5
Med. Frame -	6
Compact +	7
Compact 0	8
Compact -	9

Framey--Means not expected to produce Choice at less than 1200#. Med. frame--expected to produce Choice between 1000# and 1200#. Compact--expected to provide Choice at less than 1000#.

3 Age

Designation:	Code
6 Mos & less	6
:	
7 to 23 Mos	# of Mos
:	
24 & more	24

4 Degree of Finish

Designation:	Code
Extremely thin	1
Very thin	2
Thin	3
Med. thin	4
Sl. thin	5
Sl. fat	6
Mod. fat	7
Fat	8
Very fat	9
Extremely fat	10

Extremely fat--means .4 inch or more ribeye at 12th rib.

5 Body Length

Designation:	Code
Extremely long	1
Very long	2
Long	3
Med. long	4
Sl. long	5
Sl. short	6
Mod. short	7
Short	8
Very short	9
Extremely short	10

Reflects length (first rib to aitch bone) at maturity.

6 Height: Hips-Withers

Designation	Code
Ext. tall	1
Very tall	2
Tall	3
Mod. tall	4
Sl. tall	5
Sl. short	6
Mod. short	7
Short	8
Very short	9
Ext. short	10

7 Breed

Comment

Write apparent breed or cross e.g. Heifer Charolais X Angus etc.

8 Defects

Comment

Comment on any factor reducing desirability of calf, including
horns
grubs
lice
limping
piggy
bullock
etc.

9 Health

Designation	Code
Fresh +	1
Fresh 0	2
Fresh -	3
Stale +	4
Stale 0	5
Stale -	6
Sick +	7
Sick 0	8
Sick -	9

Comment on the nature of disorder e.g. pinkeye-one eye, respiratory, scours, etc.

10 Present Feeder Grade

Designation	Code
Prime +	1
Prime 0	2
Prime -	3
Choice +	4
Choice 0	5
Choice -	6
Good +	7
Good 0	8
Good -	9
Standard +	10
Standard 0	11
Standard -	12
Utility +	13
Utility 0	14
Utility -	15

FORM LS-106-1
(9-4-73)

USDA - AMS
Livestock Division

CARCASS DATA SERVICE *(BEEF)*

CONFOR-MATION *(Thirds of a grade)*	MATURITY *(Thirds of a group)*	MARBLING *(Thirds of a degree)*	QUALITY GRADE *(Thirds of a grade)*	PACKER'S WARM CARCASS WEIGHT *(Lbs.)*	ADJUSTED FAT THICKNESS *(Inches)*	RIBEYE AREA *(Sq. Inches)*	KIDNEY, PELVIC, & HEART FAT *(Percent)*	YIELD GRADE *(Tenths)*	EVALUATION DATE
	A	SM+	C-	716	.30	11.9	2.5	2.6	10/25/79

NAME OF ASSOCIATION OR PRODUCER	Grader Code	EARTAG NUMBER†
SOUTH REG LIVESTOCK MARKETING	07	161699

REMARKS:

† Duplicate eartags for different carcasses denoted by an asterisk (*)

PRODUCER'S COPY

(See reverse side for code abbreviations)

FORM LS-106-1 (REVERSE)

GRADE	ABBREVIATION
Prime	P
Choice	C
Good	G
Standard	S
Commercial	CM
Utility	U
Cutter	CU
Canner	CA

DEGREES OF MARBLING	ABBREVIATION
Abundant	AB
Moderately Abundant	MDA
Slightly Abundant	SLA
Moderate	MD
Modest	MT
Small	SM
Slight	SL
Traces	T
Practically Devoid	PD

+ indicates upper 1/3 of grade, degree, or maturity group.

– indicates lower 1/3 of grade, degree, or maturity group.

P, C, G, MT, SM, etc., indicates the middle 1/3 of a grade, degree, or maturity group.

VITA

Kim B. Anderson

Candidate for the Degree of

Doctor of Philosophy

Thesis: COORDINATIVE EFFICIENCY OF GRADES AND STANDARDS FOR FEEDER CATTLE

Major Field: Agricultural Economics

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