Using Conjoint Analysis to Assess Values of Animal Traits in the Manitoba Beef Cattle Industry

by
Hamath Alassane Sy

A Thesis
Presented to the
University of Manitoba
in Partial fulfilment of the
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in
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USING CONJOINT ANALYSIS TO ASSESS VALUES OF ANIMAL TRAITS IN THE MANITOBA BEEF CATTLE INDUSTRY

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HAMATH ALASSANE SY

A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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ABSTRACT

The purpose of this study was to estimate values that producers of beef cattle attach to animal attributes and compare these values across different segments of the industry, purebred breeders —cow-calf operators and feeders.

The study focused on beef producers in Manitoba. A survey instrument was developed and sent to producers in rural Manitoba. Participants were asked to rate a set of hypothetical bulls and steers. Information on respondent profiles also was collected.

Data from the survey were analyzed using conjoint analysis. Results of the analysis indicated that producers across all segments have higher preferences for calving ease, weaning weight, and milking ability than for carcass yield and feed efficiency of bull offspring. In addition, temperament, slaughter weight, weaning weight and feed efficiency of steers were very important attributes to producers. Carcass yield and muscling, on the other hand, were important steer attributes to producers.

Comparing the partworth values of animal attributes across different producer groups, revealed that cow-calf operators attached high values to calving ease and temperament while purebred breeders placed high values on weaning weight and milking ability. Feeders, on the other hand, had high values for slaughter weight and feed efficiency. These results suggested that producers at different levels of the beef production system have different partworth values for the same animal attributes. The implication of these findings is that the beef industry is very heterogenous in terms not only of products but also of preferences.

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To my brothers

Abou Sy

&

Amadou Sy

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CHAPTER I
INTRODUCTION

The beef production system can be conceptualized as a system with three different and interdependent segments: (1) purebred breeders or seedstock producers, (2) commercial producers (cow-calf operators), and (3) feeders. The segments produce end-products (e.g., bulls, calves, and fed cattle) in response to demands at each segment for specific traits contained in the animals. For example, feeders would purchase weaned calves with potential performance, that is, calves that are expected to have rapid and efficient feedlot gains, an acceptable slaughter weight and a high carcass yield.

Improving the performance level[1] of traits that are important to producers can contribute to the productivity, efficiency and profitability of beef production. Harris (1970) argues that the primary goal of most livestock producers, including seedstock producers, is to earn profits. Purebred breeders select animals with the anticipation that animal traits or characteristics meet producers' demand who buy them based on the

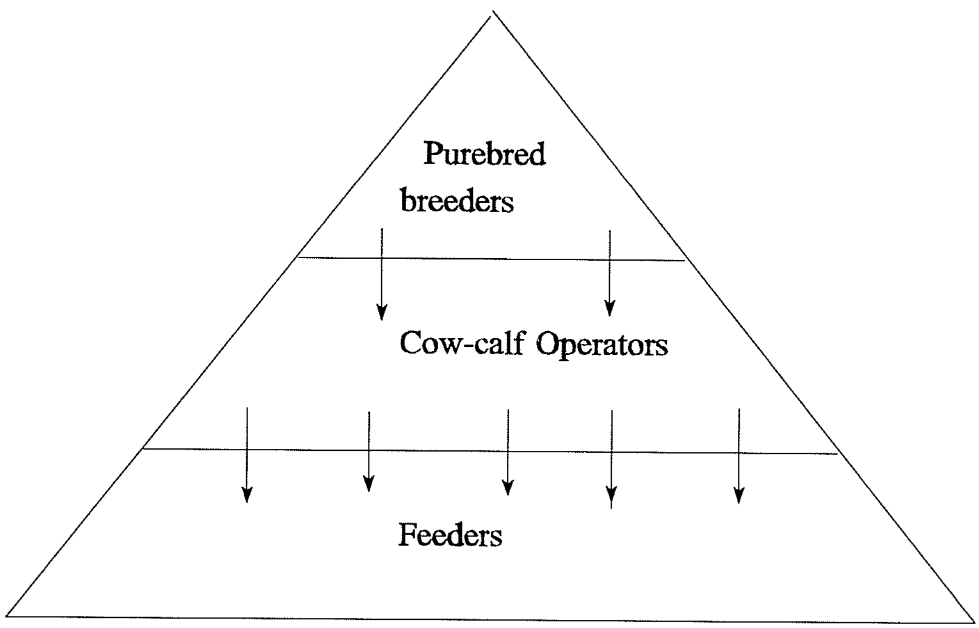
[1] Performance is defined as the observed values of reproduction, production, and carcass trait of an animal. For example, a carcass yield of 59 percent is a measure of performance.

assessment that the animals will contribute in terms of the profit of their operations.

Although market prices of animals may be linked to those traits in animals that are of interest to buyers (consumers), there is no definite account of the value of each trait embodied in the animals. In other words, market prices do not specifically provide information (signals) on the marginal value of characteristics that are important to producers. Moreover, the existence of different segments or production levels with different objectives and the indirect communication that exists between some levels increase the potential for misinterpretation of market signals. Hence there is no guarantee that the price signals received at breeders' level are the ones that feeders transmit to cow-calf operators.

The beef production system can be explained using a pyramid with three levels (see Figure 1.1) each symbolizing a segment of the industry: purebred breeders, level 1; cow-calf operators, level 2; and feeders, level 3. Even though there is considerable overlap, and beef producers are often in the process of expanding (or contracting) to enter (or to exit) other levels, most beef cattle producers can be placed in one of the levels.

Figure 1.1 The sectors of beef production and transfer of stock



Breeders, at the apex of the pyramid (level 1), are the backbone of genetic improvement of cattle. They maintain purebred herds and are primarily involved in producing and supplying breeding cows and bulls (or semen and embryos) to commercial producers in level 2. Commercial producers or cow-calf operators, on the other hand, produce and rear calves. The calves remain under their ownership from birth to weaning, thereafter they are sold to feeders in level 3. Feeders, at the end of the production chain (the third level of the industry), are responsible for the growing and fattening of weaned calves. They can also be involved in finishing cull animals from both purebred and cow-calf operations. The end-products of feeders are sold to the slaughtering industry.

Because improvement of beef cattle begins at the breeders' level, or at the top of the pyramid, seedstock producers are key players in the amelioration of the beef cattle industry. Improvement of genetic characteristics in level 1 determine both the quality of feeders and fed cattle produced in the industry (Neumann, 1977). Since breeders' decisions affect the whole industry, they must be aware of the specific preferences of each segment of the industry. The success of their leadership role in the improvement of the genetic make-up of cattle, depends principally upon their ability to accurately identify and evaluate all traits of economic importance to the cattle industry.

The identification and the appreciation of traits that are of economic importance to the industry are complex for several reasons. First, end-products of a segment can have different purposes as they move through the levels of the pyramidal production chain. Each level has a variety of end-products which can either move vertically from the top to the bottom of the pyramid, or laterally among producers on the same level, or back and forth between different levels before engaging in a final move toward the bottom of the pyramid (Williams and Stout, 1971). For example, heifers can be either sold to the subsequent level and be used as an input into a feedlot operation or maintained on the farm for reproduction purposes. In each case, different traits are of interest to cattle producers and this makes the economic evaluation of traits difficult.

Second, producers in each segment are interested in specific animal traits that are different and sometimes opposite to what is demanded by other producers at different levels. Kempster, Cuthbertson, and Harrington (1982) found that cow-calf operators are concerned primarily with calving ease and calf-crop production (reproduction traits); feeders, on the other hand, are interested in production and product traits (e.g., weaning weight, average daily gain in feedlot, carcass yield, and conformation). Performance in reproduction traits are no of direct consequence to feedlot operators.

Finally, the pricing system provides blanket information on the market value of the end-product[2]. Little if any information on the economic importance of each trait or characteristic is transmitted to sellers or producers. Producers at each level can, based on the nature of the activity, identify an array of traits or characteristics of interest. However, the relative economic importance of each characteristic to the producer is not clear. Another limitation of the pricing system is that animals may be sold between two to six times a year (Williams and Stout 1971). Prices for the added value are not broken

[2] End-product is hypothesized to be a collection of characteristics.

down to allow a producer to know specifically the marginal value of each characteristic of the added value.

The problems of identification and assessment of traits of economic importance to the industry are compounded for seedstock producers. At the top of the pyramid, they need not only know the preference of commercial producers who are the immediate users of their improved bulls and/or cows but also the preferences of producers, feeders, who are subsequent to commercial producers. The market signals from prices of slaughter cattle, at the bottom of the pyramid, are sent back to breeders through intermediaries making communication between some of the segments indirect, thus increasing the potential for misinterpretation.

Problem Statement

The basic problem this study investigates is the estimation of values placed on specific traits of cattle at different levels in the production system. This is done by a systematic evaluation of preferences that different producer groups attach to different characteristics of cattle. These estimated values which are derived from producer preferences are comparable to economic weights used in breeding indices. They both are proxies of market values of traits.

Two questions form the basis for the evaluation:

> What are the values placed on specific characteristics of cattle at the different levels of the production system?
>
> What are the perceptions by cattle producers of characteristics which are actually being introduced or bred at the different levels of the production system?

Both questions can be answered by measuring the values placed on specific genetic characteristics by different cattle producers. A method called conjoint analysis has been identified as appropriate for this study. Unlike the profit function method which is a production based approach, conjoint analysis, is a user-side approach. A survey to collect data on users' preferences for animals (bulls, and steers) is conducted. The users or producers are asked to reveal their preferences for a set of animals that are described to them using a limited array of characteristics. The characteristics used in the description of the animals are chosen based upon their relative importance to the survey population. The analysis of the data is done using an ordered probit model which decomposes the revealed preferences, ratings, into values for each trait included in the animal's description.

This study is confined to a specific component of the entire production system that includes breeders, commercial producers and feeders or feedlot operators. An obvious extension of this research plan would be to evaluate the values for traits and performance in downstream levels, i.e., packers, retailers and consumers.

The fundamental assumption of the model is that preferences are less sensitive to changes in economic conditions than prices and profits. The introduction or the annulation of price support programmes, the variations in marketing and purchasing, and changes in management practices are more likely to affect profits than preferences. Since breeding is a long process, Cartwright (1970 p.706) states that "traits which will be important at least several cattle generations in the future are the traits of interest for current selection within breeds." Given that profit is a highly volatile economic variable, value of traits computed from the profits can also be expected to be volatile.

Hypotheses

Two hypotheses form the basis of this study.

1) Utility of an animal to a producer can be decomposed into a meaningful and measurable marginal value or partworths for the different characteristics that constitute the animal.

2) Producers at different levels of the beef production system have different partworths for the same characteristics.

Economic Value of Traits

The contribution of genetic improvement to the overall economic efficiency of the beef cattle industry depends primarily on the accurate identification and evaluation of the economic value of animal traits. Melton, Heady and Willhiam (1979) argue that although literature contains many estimates of genetic and phenotypic parameters, economic weight estimations are relatively limited. Without loss of generality, the authors argue that these difficulties can be related to the fact that it is the animals and not the attributes that are sold.

Hazel (1943) introduced a selection index as a way of formulating an economically sound selection program. The index is constructed using three types of information or variables: economic value of traits, phenotypic information, and measures of breeding values. In the following paragraphs, each of the selection index variables is defined.

The economic value of a trait is defined as the amount by which profit may be expected to increase as a result of a unit of improvement in the trait or characteristic

(Hazel, 1943). In other words, the economic value of a characteristic is the first partial derivative of the profit function with respect to the characteristic.

The use of a profit function to determine the economic weights of traits is very limiting. First, numerous variables including management, government programs, cattle cycles, and prices can impact the profit of a beef cattle operation. Second, each segment of the industry can have its own profit function with specific variables. Since breeders need to know how each segment of the industry values certain traits, it is not clear which profit function is relevant for the estimation of the economic weight of traits. Should breeders use their own profit functions, commercial producers' and/or feeders' profit functions? Because profit functions are different for each segment, the economic values of traits derived from the profit functions are expected to vary.

The determination of the breeding value and phenotype, on the other hand, is a straight forward case. Breeding value is defined as the actual genetic merit of an animal for a given trait[3]. It is estimated using performance records. The estimated breeding values (EBV) are reported as differences from breed average (de Rose, 1987). For example, a slaughter animal with an EBV of +2 percent of carcass yield has the genetic potential to yield 2 percent of carcass yield above average. Phenotype, on the other hand, is the observed or measured value of a trait. For example, weaning weight of 500 lbs., easy calving, and slaughter weight of 1,200 lbs. are all phenotypes of an animal.

[3] Alberta Agriculture "Beef Herd Management". Reference Binder and Study Guide. Published by Alberta Agriculture Beef Cattle and Sheep Branch. Home Study Program 1987.

Outline of the Thesis

Chapter II of this study reviews different methods used to estimate the marginal value of animal attributes. Special focus was put on the most common technique, production-driven approaches. Chapter III focuses on the theoretical aspects of the study. Extensive discussion on consumer theory is provided in an attempt to link the conjoint analysis technique to consumer theory. Chapter IV discusses the method to be used. An empirical example is provided to give readers a good understanding of the conjoint analysis technique. Chapter V contains discussion on research design and the approach used for data collection. Finally, chapter VI and chapter VII concentrate on the results and conclusion of the study, respectively.

CHAPTER II

LITERATURE REVIEW ON THE VALUE OF ANIMAL TRAITS

Seedstock producers have used different methods to assess the economic importance of animals traits. Madalena (1986) stated that breeding objectives[4] and economic performance of a production system can be measured using three different methods: (1) profit functions, (2) efficiency of animal production $\boldsymbol{C/R}$, and (3) return to investment $\boldsymbol{R/C}$ where $\boldsymbol{C}$ represents total cost and $\boldsymbol{R}$ is total revenue for both methods. In this chapter, these three methods will be reviewed and their limitations discussed.

Profit Function Approach

The use of profit functions to estimate the economic weight of animal attributes has been the most common method. Moav and Moav (1966); Melton, Heady, and Willhiam (1979); Goddard (1983); and Magnussen (1990) all used one form of profit function or another to derive the economic weights of traits of a production system. To illustrate how the economic weights are derived from a profit function, the development by Moav and Moav (1966)[5] is re-examined.

Moav and Moav (1966) used a profit function to assess the economic weight of traits in a broiler enterprise. They asserted that profit $\boldsymbol{P}$ in a broiler enterprise is a

---

[4] Ponzoni (1985, p.465) defines a breeding objective as "those traits which one attempts to improve genetically because they influence returns and costs to the producer."

[5] Moav and Moav's paper on *Profit in a Broiler Enterprise as a Function of Egg Production of Parent Stocks and Growth Rate of their Progeny*, is often referred to in the literature of economic weight of animal characteristics.

function of the arguments X, representing the egg production of parent stocks (reproductive rate) and Y (or market age[6]) of the progenies (growth productivity). Their profit function was written as:

$$P = \alpha_0 - \alpha_1 Y - \alpha_2 \frac{1}{X} \tag{2.1}$$

where α_0 is the market value of a bird, α_1 is the daily feed costs and α_2 is the costs of maintaining breeder parents. Taking the first partials of the profit P with respect to Y and X gives $-\alpha_1$ and $+\alpha_2/X^2$ respectively, representing the economic values of productive and reproductive traits.

Note that the profit equation (2.1) is not explicitly a function of prices as the theory of duality dictates[7]. Moav and Moav (1966) used reproductive rate and growth productivity to capture variations in costs and revenues. They assumed that reproductive rate, the number of production units (pounds of broiler meat) produced by a hen in one year, influences production costs per chick. While growth productivity (which is related to efficiency of weight gained by broilers), affects output and costs of production through carcass quality, food conversion, and growth rate.

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[6] Market age is defined as the number of days from hatching to marketing.

[7] In duality theory profit is a function of argument input and output prices or $\pi = (w, p)$ where W, and p input and output prices, respectively.

The use of a profit function to estimate the economic value of traits in a production system has some serious shortfalls. The relative economic weights of a characteristic depends on the perspective taken, whether in the national interest, in the producer's interest or per unit investment made (Moav, 1973). For example, in their study Moav and Moav (1966) used a profit function for an integrated enterprise that produces and rears its own chicks. Had they used a profit function for a single operation (e.g., chicks production), the breeding objectives would have been different. In the context of the present study, if a breeder's objective is to maximize the profit function of cattle operators in general (e.g. the study done by Melton, Heady, and William, 1979), or of single operations such as cow-calf operators' profit function, or his own profit function, the economic weights would be different even if the traits are the same. Hence which profit function to use as a basis is crucial for evaluating the relative economic weights, $\boldsymbol{\alpha}_1$ and $\boldsymbol{\alpha}_2$ in Moav and Moav's (1966) study.

This apparent confusion about appropriate economic weights to use in an improvement scheme led Brascamp, Smith and Guy (1985) to suggest the use of economic profit[8] instead of accounting profit.[9] They argue that if profit is zero or set to zero the relative economic weights of traits are the same for all individuals involved in a production system and for any unit of evaluation. Their model can basically be summarized as follows:

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[8] Economic profit is defined as total revenues minus total opportunity costs.

[9] Accounting profit is defined as total revenues minus total explicit money expenditures.

$$P = N(nwV - nC_1d - C_2) \quad (2.2)$$

where N represents breeding females with each producing n offspring per year; w refers to weight of the product (e.g lean) per offspring; V is the product value per unit; d is the number of days grown (d can also be referred to as a growth variable); C_1 represents costs per day of growth per individual, and C_2 is costs per female per year.

Brascamp, Smith and Guy (1985) showed first that using different bases of evaluation leads to different economic weights. For example, if the basis for evaluation is per female then the profit function can be written as $P_1 = nwV - nC_1d - C_2$. The partial derivative of the profit function P_1 with respect to the growth trait d is equal to $-nC_1$. Referring to the same growth trait but using offspring as a basis of evaluation, the profit function becomes $P_2 = wV - C_1d - (C_2/n)$, and the partial derivative of profit with respect to the growth variable d is $\partial P_2/\partial d = -C_1$. These two partials or the economic weights for the growth variable d are different, yet the trait to improve or breeding objective has stayed the same.

However, these differences in the economic weights disappear if profit is set to zero. Note that the economic weights derived from P_1 (per female basis) and P_2 (per individual basis) differ by a factor of n. Setting $P_1 = 0$ and rewriting the equation, we obtain $P_1 = 0 = wV - C_1 - (C_2/n)$ which is the same equation as P_2 when it is set to zero.

Brascamp, Smith and Guy (1985) argue that if profit per female and per individual is set $P_1 = P_2 = 0$, then the first partials $\partial P_i/\partial d$ is equal to $-C_1$ for both bases, that is, per female or per offspring per year.

The assumption that profit is equal to zero is criticized by James (1986) who questioned the motives for genetic improvement if profit is not to be increased. In an economy where cattle producers are guaranteed a certain margin through government programs, profits in the long run may not necessarily be equal to zero. Moreover, asserting that profit is equal to zero implies a certain number of considerations; that is, perfect competition, homogenous products, and total absence of barriers to entry. A bull which produces calves with 450 pounds weaning weight and a bull whose calves weigh only 350 pounds are two different bulls to producers. The homogeneity assumption therefore is not a realistic one since these two bulls are not the same.

Efficiency Approach

The second method which is used to derive the relative value of animal traits is the efficiency of production. Dickerson (1970) and Cartwright (1970), measure the efficiency of animal production by setting up a ratio of total cost over total value of animal product. Total costs of an enterprise are decomposed into items of costs (i.e, breeding, feed costs, etc.) and compared to the enterprise products (economic equivalents). Traits or biological variables of great importance to the producers would be the ones which reduce costs of production or those whose marginal values are greater than the additional cost incurred. For example, an improvement in feed conversion ratio of an animal would reduce feed costs per unit of weight gained and total cost of feed per animal at a chosen market weight ceteris paribus.

Return to Investment Approach

The third method, return to investment, is the inverse of the efficiency of production approach, that is, total revenue over total costs. In order to determine the direction that selection should take for single or several characteristics, the change in net return associated with one unit change in each characteristic must be determined (Cartwright, 1970). Using return to investment approach[10], breeders ought to select traits whose returns are larger than the cost incurred or traits with positive net returns.

Other less common methods that have been used include cost-budgeting, gross revenues, and a multiple regression in which income is regressed against attributes (Ladd and Gibson, 1978; and Harris, 1970).

Limitations of Approaches used to Estimate Breeding Objectives

Three difficulties tied to using these methods to set up sound breeding objectives are apparent. First, they all rely on current or average market prices to determine the economic value of animal attributes. Kempster, Cuthbertson, and Harrington (1982) argue that it takes many years, 15 to 30, before cattle breeding programmes can have much effect on commercial herds. This means that market conditions, (government programs, supply and demand) and management practices which affect price levels, costs and revenues, have time to change, potentially biasing estimated economic values.

---

[10]Note that both approaches efficiency and return to investment use the same variables, costs and revenues. Return to investment is the inverse of the efficiency approach.

Second, all methods explicitly ignore the effect of exogenous variables upon cattle production. Ladd and Gibson (1978) note that none of the methods explicitly takes into consideration the fact that economic weights for cattle attributes can be affected by the change in selling prices in other industries or genetic change in other livestock products or by changes in prices of inputs used in other products. Beef products can in many cases be substituted for other animal products, such as chicken, fish and pork. Improvement in efficiency of production of those product substitutes can translate into relatively low prices affecting beef demand and beef producers' revenues.

Finally, all three methods, profit functions, efficiency technique and return to investment technique are production approaches. Estimates of economic weight of traits are derived from profit or income (gross revenue). User driven preferences are ignored. The next chapter develops the theoretical foundation for a consumer driven-approach of evaluating animal attributes.

CHAPTER III

THEORETICAL FRAMEWORK

The theoretical background of the study is discussed in this chapter. The chapter begins with a cursory review of the traditional theory of consumer behaviour which is followed by an extensive discussion of Lancaster consumer theory. The two approaches are then compared in the third section of this chapter. The last section of the chapter focuses on the development of the theoretical model of the study.

Traditional Consumer Theory

The traditional theory of the consumer is built on the premise that individuals derive satisfaction or utility from the consumption of goods (services). For example, a pound of beef, a vacation at the beach, and a can of beer all provide utility to a consumer. In a more general form, an individual's utility, U, is a function of the commodity bundle[11] X consumed, that is, $U = (X_1,...X_n)$, (Phlips 1990).

Because we live in a world of scarcity, consumers have to make choices as to how much of a good to consume. A rational consumer acting in self interest, would maximize utility by consuming as much of a good as allowed by the consumer's budget. Let Y be the amount of money available to a consumer, and let $\boldsymbol{P} = (\boldsymbol{P}_1,..,\boldsymbol{P}_n)$ and $\boldsymbol{X} = (\boldsymbol{X}_1,...\boldsymbol{X}_n)$ be a price vector and a commodity vector, respectively. The consumer's maximization problem can be written more generally as:

[11] Simmons (1974) defines commodity bundle as consisting of "a definite non-negative quantity of each of the goods, so that if X_i represents the quantity of the i'th good then a commodity bundle containing n goods is represented by a list $X = (X_i...X_n)$." (P.5)

$$\max_{X \geq 0} \quad U(X) = U(X^*)$$

$$s.t. \qquad \sum_{i=1}^{n} P_i X_i \leq Y \tag{3.1}$$

where $\sum_{i=1}^{n} P_i X_i \leq Y$ is a linear constraint. The choice variable X, is equal to X^* at maximum. That is, X^* is the optimal bundle that a consumer would choose given prices (P), and income (Y). Note that the choice of the functional form for utility representing the consumer's preference is independent of the choice of the X^*. Varian (1984) argues that any utility irrespective of its form must pick out X^* as a constrained maximum. The bundle X^* which maximizes the consumer's utility, also minimizes the expenditure function (Silverberg, 1978). And in the instance of the present study, if a bundle of inputs X^* maximizes a commercial cattle producer's utility, the same input minimizes the input expenditure. This issue will later be discussed further.

Economists have placed several restrictions on the utility function to make the implications derived from it irrefutable. Varian (1984); Silverberg (1978); and Phlips (1990) provide a complete listing of those assumptions. In order to proceed in solving the consumer problem, however, we need to state the assumption which asserts that a utility function is mathematically well behaved. That is, it is sufficiently smooth to be differentiated as often as necessary (Silverberg 1978).

The consumer's problem (3.1) can be solved using the Lagrange function:

$$L = U(X_j) - \lambda(\sum_{j=1}^{m} P_j X_j - Y) \qquad (3.2)$$

$$j = (1,..,m)$$

where λ is the Lagrangian multiplier, and X,P,Y are as already defined. Taking the first derivatives of (3.2) with respect to the choice variable X and λ yield (n+1) equations. Equating those equations to zero gives the first-order conditions which are also called necessary conditions in a constrained maximization problem. The sufficient conditions or the second order conditions are obtained by taking the second derivatives of the$n$ equations. Since (3.1) is a constrained maximization problem, we can assume that the bordered Hessian matrix is negative semi-definite (Chiang 1984).

Rewriting the first-order condition in equation form we have:

$$\frac{\partial U(x^*)}{\partial X_j} = \lambda P_j \qquad (3.2.1.a)$$

$$\sum_{j=1}^{n} P_j X_j^* = Y \qquad (3.2.1.b)$$

where $\lambda = \frac{\partial u(x^*)}{\partial X_j} / P_j$ or $\partial U(x^*)/\partial Y$ is the marginal utility of money and $\partial U(x^*)/\partial X_j$ is the marginal utility for commodity X_j. Substituting the marginal utility of money, $\partial U(x^*)/\partial Y$, into (3.2.1.a) and solving for P_j we get equation (3.3)

$$P_j = \frac{\partial U(x^*)/\partial X_j}{\partial U(x^*)/\partial Y} = U_{X_j}/\lambda \qquad (3.3)$$

Equation (3.3) states that at equilibrium, the price consumption for the j^{th} product, P_j, is equal to the marginal rate of substitution between good X and income Y. That is, the rate at which the consumer is willing to give up Y to obtain one additional unit of good X. Note that the amount of money a consumer is willing to pay for an additional unit of a good is not a function of the characteristics of the good but the good itself. Consequently, both the consumer's problem (3.1) and the equation (3.3) ignore the fact that the characteristics of a good affect individuals' preference or utility therefore influencing consumers' willingness to buy additional units. This is a direct result of the assumption that in the traditional theory of consumer behaviour goods are homogenous.

The relevance of good's characteristics in consumer's choice is easily understood when dealing with non-homogenous products. For example, animals are heterogeneous in their characteristics. A commercial beef producer does not buy a bull irrespective of its characteristics. The genotype and/or the phenotype of bulls have a significant effect on how much a commercial beef producer is willing to bid. This is even more so if one considers that bulls and bulls' semen could be used as substitutes in the reproduction process.

In sum, the intrinsic characteristics of a product affect consumers' utility and as such there are values associated with them. The traditional theory of consumer behaviour which fails to recognize the importance of good's characteristics in consumer behaviour has some serious flaws whenever consumers perceive good characteristics to be relevant arguments to their utility functions.

Lancaster's New Approach to Consumer Theory

In 1966, Lancaster introduced an approach which revolutionized the theory of consumer behaviour. Utility is conjectured to be a function of goods' characteristics instead of the goods themselves. In a comparative note, Lancaster (1991) argues that "the chief technical novelty lies in breaking away from the traditional approach that goods are the direct objects of utility and, instead, supposing that it is the properties or characteristics of the goods from which utility is derived" (p.12).

The approach can be defined more precisely as follows. Let U represent an individual's utility and S the good' characteristics. Lancaster writes this individual's utility function on characteristics as:

$$U = U(S_1, S_2, .. S_j) \tag{3.4}$$

where U represent the utility that an individual derives from a vector of j characteristics. Lancaster has made a certain number of assumptions to obtain a working model[12]. In the simplest version of the model, he assumes that the relationship between goods and characteristics is in fixed proportion and linear in parameter. That is, when a consumer doubles meat product intake, the amount of fat (characteristics) also doubles. Hence the *consumption technology* which determines the relationship between the collections of characteristics S_j and the collection of goods X available to a consumer is homogenous of degree one. A linear *consumption technology* can be represented in equation form as follows:

$$S_j = \sum_{g=1}^{n} \sum_{j=1}^{m} A_{gj} X_j \qquad g = (1,..n); \quad j = (1,..m) \tag{3.5a}$$

or in a simpler matrix form

$$S = AX \tag{3.5b}$$

[12] A complete listing of the assumptions is found in "Modern Consumer theory" by Lancaster, Kelvin, 1991.

where S_j represents the total amount of characteristics contained in the j^{th} good; A_g is an NxM matrix of constants which transforms the X_j goods into S_j characteristics.

Equations (3.5a) and (3.5b) can be viewed as a production activity where goods X_j are used as inputs into a process A in which characteristics S_j are the outputs. To illustrate, let us take a feedlot operator who uses concentrated rations to feed animals. Since concentrated feed, X, is consumed in the production process, it is called an input. The output, S, is the change in the phenotype of the animals, for example, weight gain as a result of the consumption of the concentrated feed. How much the animal weight gain would change as a result of the concentrated feed (feed efficiency) is a function of the genetic make-up of the animal *ceteris paribus*. In our example, the genetic make-up is represented by the matrix A. Therefore the matrix A which is *the consumption technology* of the economy is determined by characteristics of the goods and possibly the context of technological know-how in the society (Lancaster 1991). The relationship between goods and characteristics or the consumption technology is assumed to be objective.

Since the direct objects of utility are the properties of goods consumed, Lancaster argues that an individual who possesses an ordinal utility function would choose a level of characteristics to maximize satisfaction. Let U represent the utility on characteristics that a consumer wants to maximize subject to the consumption technology $S = AX$ and the budget constraint $P_j X_j \leq Y$.

The consumer problem can be rewritten more formally as:

$$\max = U(S) = U(S^*) \qquad (3.6a)$$

$$PX \leq Y \qquad (3.6b)$$

$$with \; S = AX \qquad (3.6c)$$

Before proceeding, it is worth mentioning that the consumer problem (3.6a-3.6c) is made of three components. The first one (3.6a) which Lancaster (1991) refers to as a maximand operates on characteristics-space. The second equation (3.6b) is a linear budget constraint and operates on goods-space, and the last equation (3.6c) is the transformation assumption which transforms goods X_j into characteristics S_j. Since the utility function and the budget constraint are in two different spaces, we need to rewrite the system (3.6a-3.6c) into a single space to be able to solve the maximization problem. Rewriting the system (3.6) into a good space we have:

$$Max \quad U(S(X)) \qquad (3.7a)$$

$$PX \leq Y \qquad (3.7b)$$

$$with \quad S = AX \qquad (3.7c)$$

with all the variables as previously defined.

Lancaster argues that there exists an optimal bundle S^* which is a solution to the consumer problem (3.7a-3.7c). The model implies that the consumer maximizes utility by choosing the combination of characteristics at the point where the highest indifference curve is tangent to the efficiency frontier. Ratchford (1975) defines the efficiency frontier as a locus of points representing the maximum combination of characteristics that can be obtained from a given expenditure.

Problem (3.7a-3.7c) can also be solved mathematically through the use of the Lagrangian function.

$$\max_{S\geq 0} \quad L = U(S(X)) - \lambda\left(\sum_{j=1}^{m} P_j X_j - Y\right) \tag{3.8}$$

Since utility in equation (3.7a) is a function of a function, that is, utility is a function of characteristics S which in turn is a function of goods, X_j, compound function rules have to be used when taking the derivatives of equation (3.8). The first partial derivatives of L with respect to X and λ yield $(n+1)$ equations. When set equal to zero, these equations constitute the first-order conditions for a utility maximization. These first-order conditions are:

$$\frac{\partial L}{\partial X_j} = \sum_{g=1}^{n}\sum_{j=1}^{m} \frac{\partial U(s^*)}{\partial S_{gj}} \frac{\partial S_{gj}}{\partial X_j} - \lambda P_j = 0$$

$$\frac{\partial L}{\partial \lambda} = P_j X_j - Y = 0 \tag{3.9}$$

where the $\partial U(s^*)/\partial S_{gj}$ or U_{gj} is the marginal utility of the g^{th} characteristic of the j^{th} good, and λ or U_y is the marginal value of money. Ladd and Suvannut (1976) define $\partial S_{gj}/\partial X_j$ as the marginal yield of the g^{th} characteristic by the j^{th} product. In other words, it is the change in characteristics produced (output) as a result of one additional unit of good (input). The term marginal physical product which is the change in output associated with a unit change in input can also be used to refer to $\partial S_{gj}/\partial X_j$. For example, the effect of a change in irrigation technique on wheat production which is defined as marginal physical product can be represented by $\partial S/\partial X$ where S and X are wheat output and irrigation techniques, respectively.

Assuming the second-order condition for maximization is met, the bordered Hessian is negative semi-definite, the efficiency consumption S^* is found by setting marginal utility of characteristics, $\partial U(s^*)/\partial S_i$ proportional to their marginal prices, $\partial P/\partial S_i$ (Ratchford 1975).

The marginal prices are derived from the following equations. Rewriting (3.9) and solving for P we get:

$$P_j = \sum_{j=1}^{m} \sum_{i=1}^{n} [\frac{\partial U(s^*)}{\partial S_{gj}} * \frac{\partial S_{gj}}{\partial X_j}] / \frac{\partial U(s^*)}{\partial Y} \qquad (3.10a)$$

When one divides the marginal utility derived from the g^{th} characteristic of the j^{th} good by the marginal utility of money, the product price P_j will be equal to the sum of the product of the term, $\partial S_{gj}/\partial X_j$ and $[\partial U(s^*)/\partial S_{gj}]/[\partial U(s^*)/\partial Y]$. In equation form we have:

$$P_j = \sum_{j=1}^{m}\sum_{g=1}^{n} \frac{\partial S_{gj}}{\partial X_j} * \frac{\partial U(s^*)/\partial S_{gj}}{\partial U(s^*)/\partial Y} \qquad (3.10b)$$

where $\partial S_{gj}/\partial X_j$, the first term, represents marginal yield of the g^{th} characteristic by the j^{th} product. Hereafter, this term will be represented by S. The second term of the product, $[\partial U(s^*)/\partial S_{gj}]/[\partial U(s^*)/\partial Y]$, is referred to as the marginal rate of substitution between the g^{th} product characteristic, and the expenditure. For convenience this term also will be represented by V. It is the marginal implicit or imputed price or shadow price for the g^{th} characteristic. The V's reflect, for example, the commercial beef producer's willingness to bid for the genetic attribute of the bulls which is accountable for the increase in, for example, the meat-to-bone ratio.

Rewriting system (3.10b) in a much simpler way, we have

$$P_j = \sum_{i=1}^{n} V_g S_{gj} \tag{3.11}$$

where V_g is the hedonic price or marginal price for the g^{th} characteristic; S_{gj} is the g^{th} characteristic contained in a unit amount of the j^{th} product; and P_j is referred to as the product price. That is, the sum of the different characteristics of product j^{th} weighted by the implicit or hedonic price for each product characteristics. It represents the price a commercial herd producer would be willing to bid for a bull.

The tangency solution of the problem (3.7a-3.7c) can be easily explained using the terminology from equation (3.11). It was said earlier that the consumer is in equilibrium when choosing the combination of characteristics at the point where the highest indifference curve is tangent to the efficiency frontier. This is equivalent to saying that a consumer in equilibrium will consume at level S^* where the marginal rate of characteristics substitution, $[\partial U(s^*)/\partial S_1]/[\partial U(s^*)/\partial S_2]$ equals their hedonic price ratios V_1/V_2.

Rosen (1974) econometrically defines hedonic prices as the estimates from a regression of product price on characteristics. Hedonic prices are not necessarily equal to market or equilibrium prices. Since a market price is the joint determination between how much producers are asking for their products and how much consumers are willing to give for the same product, equilibrium is reached only when these two prices are equal. In other words, the hedonic price for a complex good is equal to the market price only when the quantity of characteristic offered is equal to the quantity demanded (Ratchford 1975; and Rosen, 1974).

Cost Minimization

Earlier on, it was mentioned that in goods-space the optimal level X^* which maximizes an individual's utility also minimizes expenditure. A similar statement can also be made on characteristics-space. Lancaster (1991) argues that the efficiency choice for a characteristics vector S^* will be the solution of the canonical linear programme: minimize px, subject to $Ax = S$, $x \geq 0$. Note that utility maximization problems are subject to similar constraints: $p x_i \leq Y$, $S = AX$ and $X \geq 0$. Hence, we have one efficiency level, S^*, at equilibrium for both cost minimization and utility maximization problems.

The equivalence between utility maximization and expenditure minimization is a pertinent property to this study. Producers are generally thought of as being expenditure minimizers while consumers as utility maximizers. The equivalence property however states that a individual who is a utility maximizer is also an expenditure minimizer. Hence, the results of the study, although based upon utility maximization, are also valid for producers who are cost minimizing.

Lancaster's Theory Versus the Traditional Theory of Consumer.

The first part of the theoretical framework section of this study focused on the analysis of the two approaches, Lancaster's model and the traditional consumer theory.

Before deciding which method is more suitable to the objective of this study, we highlight some of the key differences between the two approaches.

The Lancaster Approach and the traditional theory of the consumer behaviour diverge fundamentally on what determines consumers' utility (Lancaster 1991). Traditional theory assumes that utilities are functions of bundles of goods $u = u(x)$, while the Lancaster approach conjectures that consumers derive their utilities from the consumption of the characteristics of goods, $u = u(s)$.

By taking this approach, Lancaster's method provides an easier and more plausible explanation of comparative static properties of consumer demand theory than the traditional approach. Lancaster (1991) argues that goods are not substitutes just because they provide the same utility, rather they are substitutes because they produce the same characteristics which generate equal levels of utilities. For instance, a bull and bull's semen used as input in cattle reproduction are substitutes because they can supply the same characteristics, genetic attributes. Equally convincing is his explanation about the complementarity between goods. A bale of hay and feeder cattle are complements because together they produce the same characteristics, e.g., beef, fat, etc. For both of these properties, the traditional model provides unclear explanations.

Another significant difference between the two models is the space upon which the consumer's problem is defined. In the traditional approach, both the budget constraint and the utility function are defined in goods-space. In the Lancaster approach however, utility is defined on characteristic-space while the budget constraint is on goods-space. Consequently, a transformation function which 'converts' one space (goods) into another space (characteristics) before solving the consumer's problem is required to solve the Lancaster model.

Without expanding too much on this comparison, there is one difference which is worth mentioning. Equation (3.3) and (3.10b) can be rewritten in an implicit form such as $P_x = (x,u,y)$ and $P_s = (s,u,y)$, respectively. The variable P in both equations represents consumers' willingness to pay or a bid function. In the first function, the willingness to pay P_x is associated with goods, income, and utility. Whereas in the second function, characteristics s of a good are arguments in the price function. Thus P_s is a function of utility, income, and the characteristics of the good demanded. The implication is that in the Lancaster approach, a commercial beef producer's bid price for any bull's characteristics is the first partial derivative of the bull's price with respect to any characteristics, or $\partial P_j / \partial S_{gj}$. As for the traditional theory, the hedonic prices of characteristics are non-existent.

Since the objective of this study is to assess the values that different commercial herd producers attach to different bulls' characteristics, Lancaster's approach is found to be more suitable than the traditional approach in providing the theoretical framework for the study.

Limitations of the Lancaster Model

Although the Lancaster model provides many important contributions to consumer demand theory, it has its limitations. Reviewers of the Lancaster model, Hendler (1975); Ratchford (1975); and Lucas (1975) have found the model to be restrictive. For instance, Hendler (1975) criticizes the nonnegative marginal utility (NNMU) assumption which basically states that the marginal utility of a characteristic is always positive, that is $\partial U/\partial S_g > 0$. He argues that while the marginal utility of a good may be positive, some of its characteristics may convey disutility. He used the calorie content in a hamburger as an example of a negative marginal utility. Another example of a negative utility is nicotine in a cigarette. While a smoker may feel better after smoking a cigarette, positive utility, the effect of nicotine on the smoker's health is expected to be negative.

Lucas (1975) questions the linear consumption technology assumption in the new theory of consumer. He argues that if a characteristic is physical in nature such as protein then twice as much meat yields twice as much protein. However, the same cannot be said when the characteristic is more abstract such as nourishment. Our bodies do not probably have the capacity to extract indefinite amounts of nourishment from a meal even if the nourishment is present (Lucas 1975). Since we are dealing with physical characteristics of animals in this study, the limitations of the linear consumption technology will not impact our results.

Lastly, Ratchford (1975) primarily directs his criticism to the inability of the Lancaster model to handle imperfect information. He argues that when information on product quality is not available a consumer may use prices as a surrogate measure of characteristics embodied in a product.

Despite all these limitations, Lancaster's model of consumer behaviour has various applications. Ratchford (1975) states that "...unlike the traditional economic model of consumer behaviour, it [Lancaster's model] provides a potentially useful framework for empirical demand analysis from survey data" (p.70). Hedonic price analysis and conjoint measurement are some of the empirical applications of the Lancaster model.

Theoretical Model Conjoint Analysis

Conjoint analysis was initially introduced into mathematical psychology by Luce and Tukey in 1964 (Green and Srinivasan 1978). In 1971, Green and Rao published a detailed paper adapting the method to consumer-oriented research (Green and Srinivasan 1978). Since then conjoint analysis has gained popular attention as a technique for estimating the value that individuals attach to attributes of products. Cattin and Wittink (1989) reported about 400 commercial applications of conjoint analysis per year during the early 1980s, with the majority of the applications (59 percent) in consumer goods. This section of the chapter focuses on the theoretical aspect of the conjoint analysis.

Let U represent the utility of a product to an individual. This utility is hypothesized to be a function of various factors including the characteristics of the product S, the individuals' socio-economic backgrounds Z, and an interaction term between the individuals' backgrounds and the product characteristics π. Since a decisionmaker obtains some relative happiness from each product chosen, Train (1986) argues that the decisionmaker would choose the product which provides the greatest utility. That is, the decisionmaker will choose product j over $(j+1)$ only if $U_j > U_{j+1}$.

The decisionmaker's theoretical utility model can be formally written as:

$$U_j = f(S_{1j}, S_{2j}, \ldots S_{gj} \; ; \; Z_1, Z_2, \ldots, Z_i \; ; \; \pi_1, \pi_2, \ldots \pi_g \,|\, \Theta_g) + e$$

$$j = i = 1,2,\ldots..m; \qquad g = 1,2,\ldots..n. \tag{3.12}$$

The variables S and Z are main effect variables representing product attributes and individuals' profiles, respectively. The term $\pi_g = S_{gj} * Z_i$ is the interaction variable between individuals' profiles and product characteristics. The parameter estimates are represented by the vector Θ_g. Since only some of the arguments in equation (3.12) are observed, the equation is stochastic and the ***e*** is a spherical disturbance term (Kennedy 1985). Because the utility model (3.12) is composed of two parts, a deterministic component and a nondeterministic component (random variable e) to represent deviations in tastes and preferences across individuals, the model is sometimes referred to as a random utility model (Greene, 1990; Hausmane and Wise, 1978).

Market researchers have used different approaches, compositional and decompositional, to estimate the vector Θ_g or the marginal values of product characteristics[13]. Holbrook (1981) explains that the compositional or build-up approach, begins with a set of explicit perceptions or beliefs about a product's characteristics or attributes and uses them as the basis for predicting product

13 Marginal value of product characteristics and hedonic prices are similar. The former is obtained by regressing preference on characteristics while the latter is by regressing market prices on characteristics.

preferences. On the other hand, the decompositional approach commences with measures of preference (e.g., rating or ranking) for multiattribute alternatives or products and uses them to estimate the values attached to underlying characteristics. Since the objective of the study is to estimate the values that cattle producers attach to animals' attributes by using preference ratings, the decompositional approach will be used in this study.

Critical information on consumers' behaviour could be obtained from the decompositional multiattribute theoretical model (3.12). First, by taking the partial derivative of the consumer's utility of the j^{th} product with respect to the $\boldsymbol{g}^{th}$ product characteristic, $\partial U(u^*)/\partial S_g$, we obtain the value or the part-worth that the consumer assigns to the g^{th} characteristic level of the j^{th} product (Louviere 1990). Because we hypothesized that the utility of a product to an individual is subject to both product characteristics and an individual's profile, the part-worth is a joint effect of two variables. That is, the magnitude of changes in preferences as a result of variations in attribute levels is partly determined by an individual's background. Hence a part-worth could be more precisely defined as a composite of the individuals' background and the effects of the product attributes preference. More formally,

$$\frac{\partial U(u^*)}{\partial S_g} = \frac{\partial f(.)}{\partial S_g} + \frac{\partial f(.)}{\partial \pi_g} * \frac{\partial \pi_g}{\partial S_g} \qquad (3.13)$$

where $\partial U(s^*)/\partial S_g$ is the partworth of the g^{th} level of characteristic of the j^{th} product to a given individual. It is composed of two parts. The first part, $\partial f(.)/\partial S_g$ or the marginal value of the g^{th} product attribute measures the changes in individuals' utility when only product attribute levels are allowed to vary. For convenience this partial hereafter will be referred to as V_g. The second part of the equation (3.13) is subsequently divided into two partials. The first term $\partial f(.)/\partial \pi_g$, or b_g measures the variations in the utility associated with the changes of the interaction term, product characteristics and an individual's socio-economic background. It is also referred to as a weight factor. The second term of the combination, $\partial \pi_g/\partial S_g$ or Z_i represents an individual's socio-economic background.

In general, the partworths of a product attribute to an individual can be represented easily by the following function:

$$\frac{\partial U(s^*)}{\partial S_g} = V_g + Zb \tag{3.14}$$

where V_g is the intercept or the grand mean of the part-worth function. It represents the 'average' value of the g^{th} characteristic to all the individuals irrespective of their socio-economic backgrounds. The factor b or the slope of the function determines an individual's deviation from the 'average' value. The coefficient $\boldsymbol{b}$ is hypothesized to take any value from negative infinity to positive infinity. It is determined by differentiating equation (3.12) with respect to the interaction term, $\partial U_j(s^*)/\partial \pi_g$ or by taking the derivative of the marginal value of the g^{th} characteristic with respect to individuals' socio-economic backgrounds, $\partial U(s^*)/\partial S_g Z_i$. Hence the coefficient $\boldsymbol{b}$ captures the variability in preferences for a product due to a person's background. This is a direct measure of segmentability of the market.

The basic premise of equation (3.14) is that the partworths of a product characteristics to an individual are determined by adding the marginal values of the product attributes V_g to the weighted socio-economic variables. For example, two individuals facing the same attribute but different weight factors can have different partworth estimates.

Partially differentiating equation (3.12) with respect to individuals' profiles, $\partial U(s^*)/\partial Z_i$, gives variations of the utility which are accounted for by changes in the individual's socio-economic variables. Finally, the relative importance of products to individuals can be computed by using estimates from equation (3.12). That is, which of the product attributes does a respondent perceive to be the most important. For example how important is calving ease to a cow-calf operator relative to other genetic characteristics? The formula for the relative importance is written as follows:

$$\psi_a = [(\max(v^*_{ga}) - \min(v^*_{ga}))]/\Sigma\omega_a \qquad (3.15)$$

where v^*_{ga} is the marginal value of the g^{th} level of the a^{th} attribute; ψ_a represents the relative importance of the a^{th} attribute; $\sum \omega_a$ is the sum of the ranges, $[(\max(v^*_{ga}) - \min(v^*_{ga}))]$, across all attributes. Jain et al. (1979) argue that ψ_a for a consumer may be normalized to ascertain its relative importance with regard to the other attributes and across consumers.

Although the relative importance measure could be useful in determining which attribute decision makers should focus on, it is useful to mention that its magnitude is related to the levels used in the design. That is, the relative importance of a product would change if the levels of maxima and/or minima have been varied (Green and Wind 1975).

Comparing Conjoint Analysis and Contingent Valuation

The contingent valuation method is frequently used in resource economics. Bishop and Heberlein (1990) refer to contingent valuation as a method that employs survey techniques to elicit people's preferences for non-market commodities. Mitchell and Carson (1989) citing Brooksire et al. (1978) state that because the elicitation of preferences is contingent upon the particular hypothetical market described to the respondent, the approach is therefore called, contingent valuation method. It aims at finding the willingness to pay in dollar amounts for a particular non-market good or service, which is then regressed against demographic characteristics in an attempt to explain choices.

Although both conjoint analysis and contingent valuation methods deal with the estimation of preferences for products outside the classical market system, there is a fundamental difference between these two approaches. The primary goal of conjoint analysis is to estimate marginal values (utilities) using respondents' evaluations of limited sets of attributes. For example, a cow-calf operator is asked to rate a bull based on three attributes. Contingent valuation, on the other hand, estimates values (dollar values) based on appraisal of a whole product (e.g., a specific bull) and relates these values to respondent characteristics. Since this project involves assessing predetermined sets of attributes, conjoint analysis will be employed to assess preferences.

Before going into the discussion of conjoint analysis in the next chapter, a brief comparison between hedonic prices and conjoint analysis may increase readers' understanding of the proposed method.

Conjoint analysis model versus hedonic price model

Conjoint analysis model is very similar to a hedonic price model. They are both empirical applications of Lancaster's theory of consumer behaviour and operate on a characteristics-space. The two methods have the same aim, that is, to estimate weights associated with product characteristics. However, hedonic price methods use observed prices as dependent variables, whereas conjoint analysis uses evaluative assessment techniques such as ratings or rankings of product attributes and levels.

CHAPTER IV

EMPIRICAL METHOD

This chapter discusses conjoint analysis through an empirical example. Two econometric models, regression analysis and ordered probit, are developed and to used for the estimation of marginal values or partworth values of the conjoint analysis method.

Conjoint Analysis Method

The conjoint analysis method is an empirical application of the Lancaster theory of consumer behaviour. The method looks at the joint effect of situation variables and individuals' characteristics on preference for a given stimulus (product).

The method can be summarized into two steps: (1) a survey to collect information on individuals and (2) the analysis of that information. In the first step, individuals' socio-economic variables and their revealed preference for (rating or ranking) hypothetical stimuli are collected. The number of hypothetical stimuli to be evaluated is different depending on the experiment design. For example, an experiment with three attributes at two levels and two attributes at three levels in full factorial design would yield $3^2 \times 2^3$ or 72 stimuli. Since the number of stimuli expands quickly under the full factorial design approach, Green (1974) suggests the use of fractional factorial designs which reduce the number of combinations to a manageable size without affecting the orthogonality of the design. In the second step, data from surveys are incorporated into a statistical model for coefficients or partworths estimation.

An Empirical Example

The essence of the conjoint analysis method can be understood through an illustrative application. Assume that a purebred breeder decides to select a bull with characteristics that are desirable to commercial producers. Instead of choosing the characteristics to select for using economic weights, the purebred breeder decides to survey bull customers (commercial herd producers) to discover the values they place on specific genetic characteristics of bulls. The purebred breeder assumes that producers' preferences are less volatile than economic variables (e.g., prices, profits, etc.), used to compute the economic weight of cattle characteristics. What the seed stock producer hopes to estimate are producers' preferences for predetermined attributes and the relative importance of these attributes. Furthermore, given a commercial herd producer's background, the seed stock producer would like to be able to predict the preference for specific bull attributes[14].

The first step that the seed stock producer has to take is to make a list of important attributes[15]. For the purpose of this example, three attributes will be used: weaning weight (lbs), average daily gain, ADG (lbs/day), and gestation length (months). An extension to a larger number of variables is straightforward. Each attribute is

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[14] To keep the illustration simple and easy to understand, only data from two respondents are analyzed. With only two observations, contingent valuation estimates do not provide meaningful information due to data limitation on respondents' backgrounds. Thus the example is focused on conjoint analysis.

[15] We assume that the purebred breeder has conducted a preliminary survey where producers have identified important attributes.

represented by categorical choices referred to as levels. To keep the illustration simple, each attribute has three levels (see table 4.1).

Table 4.1 Charolais Genetic Attributes and their Levels

Levels	Attributes		
	Gestation length (month)	Weaning weight	ADG
1	9 1/4	605	3.84
2	9	697	3.00
3	8 3/4	563	2.50

Once the attributes and their levels are identified, the seed stock producer sets up a factorial design[16]. The total number of stimuli (bulls) that a surveyed commercial herd producer might have to choose from is the product of a full factorial combination. In our example that number is 3^3 or 27 bulls. For more realistic cases the number of stimuli would be larger so that the full factorial combination would become quite large. A fractional factorial is used to reduce the number of combinations to a manageable size. In our example, it is reduced from 27 to 9 bulls or cards. On each card appears three attributes, each at one of three levels: weaning weight, an average daily gain, and a gestation length (see Table 4.2 for more details).

[16] Factorial design is a design in which more than one factor is investigated simultaneously (Cochran and Cox, 1957)

Table 4.2 **Charolais Experimental design**

Bull (cards)	Weaning Weight	ADG	Gestation length
1	563	2.50	9 1/4
2	605	3.00	8 3/4
3	697	3.84	8 3/4
4	563	3.00	9
5	605	3.84	9 1/4
6	697	2.50	8 3/4
7	563	3.84	8 3/4
8	605	2.50	9
9	697	3.00	9 1/4

Each respondent is required to rate each of the 9 bulls from table 4.2 on a scale from 0 to 11 to indicate the degree of preference[17], where a higher rating (maximum of 11) represents greater preference and a lower rating (minimum of 0) represents less preference. Once the preference ratings are collected, the weight for each attribute is estimated using different decompositional estimation techniques, Ordinary Least Squares (OLS), probit etc..

Econometric Models

The probability that a commercial producer chooses a bull J from a choice set A can be hypothesized to be a function of the overall utility U associated with the bull. More formally we have:

[17] For convenience, Louviere (1988) recommends the use of 11-category scales for cards that are 16 or fewer and 21-category scales for larger numbers of treatments.

$$P(J|A) = f(U_j) \tag{4.1}$$

Where $P(J|A)$ represents the conditional probability of choosing j^{th} bull from a choice set A of bulls ; U_j represents commercial beef producers' overall value or preference for the j^{th} bull. Because utility is not observable, a variable $\boldsymbol{R}$ which represents preference rating is used as a proxy (Louviere, 1988).

The primary interest of market researchers is to decompose the preference ratings R into attributes and to estimate the unknown marginal utilities associated with each one of them. In other words, researchers would want to know the part-worth of those attributes which had an impact on the producer's choice. Different decompositional estimation methods are available (e.g. Monotone Analysis of Variance (MONANOVA), JOHNSON, LINMAP, OLS, LOGIT, PROBIT, etc.). Jain et al. (1979) did a comparative study of the different methods and found that "the OLS procedure is the most efficient procedure in predicting the least preferred choices using tradeoff data. ....whereas the logit procedure [stochastic modelling methods] appears most efficient when using the full-profile data" (p.319).

Recent studies, Kennedy (1990); Hausman and Wise (1978) have found logit models to be inappropriate whenever there are alternatives which are close substitutes. This problem which is known as the *independence of irrelevant alternative* is easily explained using the *red-bus-blue-bus* problem. Mcfadden has found that if the probabilities for a commuter to drive or to take a red bus is 2/3 and 1/3, respectively, adding a 3rd alternative, riding a blue bus, would change the probabilities of driving to 1/2 and each of the buses would be chosen with probability 1/4 (Hausman and Wise 1978). For the independence of irrelevant alternative to hold, the colour of the bus is here assumed to have no effect on the personal wellbeing of the traveller. To avoid this limitation we will not be using the logit model, instead the OLS method and probit models will be used in this study.

OLS Technique: A Regression Model

Let R_r represent producers' preference ratings for a set of bulls. These preference ratings are hypothesized to be a function of the bulls' attributes, S_g, individuals' socio-economic variable Z_i, and $\pi_g = S_{gj} * Z_i$ representing interaction terms between animal characteristics and producer socio-economic backgrounds. The regression model postulates that there is a linear relationship in parameters, not in variables, such that:

$$R_{rj} = \alpha + \sum_{g=1}^{n} \sum_{j=1}^{m} V_g S_{gj} + \sum_{i=1}^{m} \sum_{j=1}^{m} \beta_g (Z_i S_{gj}) + e \qquad (4.2)$$

$$e \sim N(0,1)$$

where R_{rj} represents the rating r^{th} given to the bull j^{th}; S_{gj} is a matrix of nonstochastic effect coded variables (0,1,-1) of g^{th} attribute level for the j^{th} product, and $\pi_{gj} = S_{gj} * Z_i$ is another matrix of nonstochastic interaction variables of the i^{th} socio-economic variable and the g^{th} product characteristic. The interaction variables are effect coded (-1,1,0). Equation (4.2) has α, a column vector of constants, as an intercept, V and β as vectors of coefficient estimates for the g^{th} characteristic levels and the interaction term, respectively and e as the stochastic variable of the model.

Note that the main effect of respondents' profiles, Z, is left out of the equation (4.2). Moore (1980) used a similar model to compute overall utility for car attributes. He exclusively focused on the interactions between an individual's background and car attributes to show that people in suburban/rural areas place a greater weight on higher gas mileage than those who live in cities. Green and DeSarbo (1979) argue that "In many cases we are not interested at all in the main effects due to person variables, since these main effects may only reflect response biases, for example, the tendency of some respondents to give higher evaluative ratings, regardless of the product description"(p.85).

Effect Coding

All the variables in the matrices $[S, \pi]$ are conceptualized to be qualitative variables. The use of categorical variables in a regression analysis requires prior coding of the regressors (Johnson 1984). Even if any set of numbers can be used as a code, the interpretation of the coefficients and the statistical tests of significance vary depending on the method used (Pedhazur 1982, Cohen and Cohen 1975). There is a general tendency to regroup the technique of coding qualitative variables into three methods referred to as dummy, effect, and orthogonal codings (Pedhazur 1982).

Effect coding has been widely used by market researchers, Jain et al. (1979) and Louviere (1988). CONJOINT ANALYZER, a software package for conjoint analysis parameter estimation by Breton-Clark (1987), uses an effect-coding technique. The popularity of effect coding among market researchers is probably due to the simplicity of the interpretation of the regression coefficients. Pedhazur (1983) states that it is named effect coding because the method yields regression coefficients which represent the effects of the changes in the independent variables on the dependent variables.

The effect-coding method uses three number coding (trichotomous) 1's, 0's and -1's rather than two numbers (dichotomous) 0's and 1's as in dummy coding. The -1's which constitute the fundamental difference between these two methods are assigned to group variables which would have been assigned 0's in a dummy coding system. Even though there is no difference to which attribute levels the -1's are assigned, it helps to assign them to those group of variables which are 'omitted' from the regression analysis to avoid the dummy-variable trap.

Recall that in the seed stock producer's example, at the beginning of this chapter, each attribute is represented by a group of three regressors called levels. Since one level has to be dropped across the attributes to make OLS estimation possible, they are assigned the -1's and the rest of the regressors are assigned the 1's and the 0's (see table 4.3). Level two was dropped off the regression analysis to facilitate the computation of the coefficients. In the end, each attribute is represented in the regression analysis by a group of two levels. The column rating in table 4.3, represents respondents' evaluations of the 18 bulls.

Table 4.3 **Respondents' Rating and Effect Coded Variables**

	Attributes Levels					
	Weaning weight		Average Daily gain		Gestation length	
Rating	697	563	3.84	2.50	8 3/4	9 1/4
1	0	1	0	1	0	1
9	-1	-1	-1	-1	1	0
11	1	0	1	0	1	0
2	0	1	1	0	-1	-1
8	-1	-1	1	0	0	1
6	1	0	0	1	1	0
5	0	1	1	0	1	0
7	-1	-1	0	1	-1	-1
10	1	0	-1	-1	0	1
1	0	1	0	1	0	1
8	-1	-1	-1	-1	1	0
11	1	0	1	0	1	0
3	0	1	1	0	-1	-1
9	-1	-1	1	0	0	1
6	1	0	0	1	1	0
8	0	1	1	0	1	0
5	-1	-1	0	1	-1	-1
9	1	0	-1	-1	0	1

Parameter Estimation

Ordinary Least Squares (OLS) technique will be used to estimate the coefficients of equation (4.2). Johnston (1984) argues that because there exists perfect multicollinearity among the regressors, the OLS estimation will break down, even without an intercept. Consequently, $\partial R/\partial S = V + \beta Z$ or the partworths cannot be computed directly from equation (4.2).

This problem is, solved, however, if one creates a number of coded variables equal to the number of explanators minus one (Johnston 1984; Kelejian and Oates 1989). More explicitly, we know that g and i are conceptualized to represent levels of a bull's attribute and producers' socio-economic variables, respectively. Hence, to eliminate multicollinearity, one has to drop the g_0 level across the attributes and i_0 for each producer's characteristics. In the example, this translates to dropping level three for each attribute (e.g., ADG, weaning weight and gestation length) from the regression analysis. Thus $(g-1)$ attribute levels for each bull and $(i-1)$ characteristics for each producer will be defined.

A reformulation of equation (4.2) with defined regressors using matrix notation gives:

$$R = \alpha + XV + D\beta + \mu \qquad (4.3)$$

where X is the same as S in equation (4.2) except that it is defined in $(g-1)$ attribute levels, D is a matrix with $(i-1)$ producers' characteristics; α and μ are the intercept and the stochastic variables of the model, respectively. Explanatory variables in equation (4.3) are now orthogonal, hence, coefficients V and β can be estimated.

The use of effect coding (1,0,-1) generates estimates with interesting properties. Pedhazur (1982) argues that the regression coefficients, V's and β's, measure the changes in α, the mean of the dependent variable, associated with a unit change in the value of the regressors assigned 1's. That is, the V's and β's respectively represent the effects of changes in bulls' attribute and the interaction variables on preference ratings.

To get the coefficient estimates of the dropped variables g_0 and i_0 or the variables assigned -1's, one needs first to consider the constraint that sets the sum of the estimated coefficients of a group of variables in a linear model equal to zero (Jain et al. 1979; Pedhazur 1983). The direct result of this assumption is that the value of the dropped variable g_o or ($\boldsymbol{V_{go}}$) is the negative of the sum of the (g-1) variables. More formally we have:

$$\sum_{l=1}^{n} V^*_{ga} = 0$$

$$V^*_{g0} = -\sum V_{(g-1)} \qquad (4.4)$$

where V^*_{ga} are the marginal values of the $\boldsymbol{g}^{th}$ levels of the $\boldsymbol{a}^{th}$ attributes; V_{g0} are coefficient estimates for the omitted variables or variables assigned -1's; and $V_{(g-1)}$ represent estimates of variables assigned 1's. In general, the weight for variables assigned -1's is computed by finding the negative value of the sum of the (g-1) attribute levels or attribute levels coded with 1's. To illustrate this point let us go back to our seed stock producer's example.

An OLS estimation technique was applied to data on Table 4.3 to estimate the weights that the two producers attach to the three bull attributes. The results, the estimates for the (g-1) and the computation of the g_o attribute levels, are shown in Table 4.4. A calf at 697 lbs. weaning weight is more preferred than a 563 lbs. calf. The value attached to a 605 lbs. calf weaning weight is found by taking the negative of the sum of the values attached to a 697 lbs. calf and a 563 lbs. calf. That is, -[(+2.04)+(-3.19)] or +1.15. The negative sign means that if a weaning weight of 563 lbs is added as calf attribute, a commercial producer's utility would decrease by -3.19 (see Table 4.4 for more details).

Coefficient estimates are combined to form an overall utility U_j for the j^{th} product. Various combination techniques are used. Louviere (1988) mentions additive, multiplicative, and dual-distributive models as potential preference mapping. However, he stressed that "adding models are widely assumed in applications of conjoint analysis. That is, they are the most often assumed [preference] mapping" (p.16).

It should be mentioned here that utility is an ordinal measure, that is, the amount of utility derived from commodity j_1 has a meaning only when it is compared to the amount of utility derived from commodity j_2 (Henderson and Quandt 1980). Hence it is meaningless to say that commodity j_1 is preferred n times as much as commodity j_2.

Table 4.4 Part-worth estimations

Attribute	Level	Weights	calculated
Weaning weight	697	+2.041	= +2.04+(-3.19)
	605		= + 1.15
	563	-3.188	
ADG	3.84	+1.875	= +1.87+(-2.19)
	3.00		= +0.313
	2.50	-2.19	
Gestation length	8 3/48	+0.500	= +0.50+(-0.19)
	9		= -0.31
	9 1/4	-0.188	

Limitations of the OLS Estimation Technique

Although OLS estimation technique is popular among conjoint analysis users, it has severe limitations when it comes to analyzing data with categorical[18] dependent variables (Doyle 1977). The properties of OLS estimates, unbiased, and linear still hold. However, due to the heteroscedasticity of the error term which is a direct result of the discrete dependent variable, the OLS estimates are not efficient (Kmenta, 1986; Johnston, 1984; McKelvey and Zavoina, 1975). According to Aldrich and Nelson (1984), these limitations are present whether the dependent variable is dichotomous (0,1) or polytomous (e.g. 0,1,2,..n).

These violations have some serious consequences on analyzing the coefficients. The assumptions that the error term (the dependent variable) is normally distributed cannot be sustained. Hence the validity of any hypothesis tests or confidence intervals

[18] Maddala (1983) refers to preference measured on a scale 1,2,...5 with 1 being intensely disliked and 5 being intensely liked as an ordered categorical variable.

based on the variance of the error term is questionable (Nelson and Aldrich 1984; Kmenta 1986). Note that these limitations do not affect the unbiasedness of the estimates. That is, the partworths represent the 'true' partworths of the individuals.

A Nonlinear Estimation Technique

Because of these OLS limitations, a stochastic statistical model, probit, will be used in this study. Probit provides a theoretically attractive framework for mapping many aspects of consumer behaviour (Doyle 1977). The model has significant advantages over the linear models. First and foremost it provides a solution to the statistical problems (heteroscedasticity) which occur when regression is used to analyze discrete dependent variables (Nelson and Aldrich 1984). Unlike the OLS estimation technique which directly relates dependent variables to independent variables, probit estimation technique portrays a more complex relationship between regressors and dependent variables. First the model distinguishes between a dependent variable of theoretical importance which is not observed (e.g., U) and the observed dependent variable (e.g. R or the preference ratings). The model then conjectures that the independent variables are linearly related to the unobserved dependent variable which in turn is related to the observed dependent variable via a cut-off or threshold variable (Maddala 1983; Pindyck and Rubinfeld, 1991). In other words, a change in bulls' attributes affects producers' utility function first, then their preference ratings through the threshold variable.

Ordered Probit Model

In 1975, Zavoina and Mckelvey developed a model called ordered probit which is an extension of the probit model. The fundamental difference between ordered probit and the probit model is that the choice alternatives are unlimited R_r, $r = 0,1,2,3,...,w$ for the former and limited to two R_r, $r = 1, 0$ for the latter.

An ordered probit model consisting of U as an unobservable dependent variable, R_r choice alternative or observable dependent variable, S,π as blocks of independent variables and γ threshold level can be formulated as[19]:

$$U = \alpha + SV + \pi\beta + e$$
$$e \sim N(0,1) \tag{4.5}$$

and,

$$
\begin{aligned}
R &= 0 \quad if\ U<0 \\
R &= 1 \quad if\ 0<U<\gamma_1 \\
R &= 2 \quad if\ \gamma_1<U<\gamma_2 \\
&\ \ \vdots \\
R &= w \quad if\ \gamma_{w-2} \leq U \\
r &= 0,1,2,3,....,w
\end{aligned}
\tag{4.6}
$$

[19] Note that equation (4.5) is similar to equation (4.2). They both have the same arguments. Because OLS estimation technique cannot handle unobserved dependent variables, preference rating which is a proxy to utility is used as dependent variable. This problem does not exist when one uses ordered probit which requires an observable and an unobservable dependent variable.

where U is a J X 1 vector of unobservable utility of a bull to a producer; and R_{i} is a vector of preference ratings. The γ_r's are threshold variables or cut-off points which provide the ratings of the alternatives.

Note that an ordered-probit model assumes that the underlying model or equation (4.5) is linear. This assumption is in line with Louviere's assumption that the utility is linearly related to product attributes (Louviere 1988).

The threshold concept is central to economic theory of consumer behaviour (Doyle, 1977). The theory asserts that a buyer responds (buys or rates alternatives) when utility exceeds a threshold or critical level of 'satisfaction'. For example, variations in the independent variables of equation (4.5) would change a producer's utility which when it reaches a certain level, $U>\lambda_{i}$, triggers the rating to switch from one level to another.

The cut-off points vary with individuals. Individuals with similar tastes and background are expected to have similar cut-off points. Hence via the central limit theorem, the threshold level is assumed to be normally distributed with mean zero and variance one (logit models assume that the threshold variable are logistically distributed). The implication of the normal distribution is that the relationship between the dependent variable and the independent variable is nonlinear. Aldrich and Nelson (1984) state that the regression coefficient determines the direction of effect, but the magnitude effect depends on the magnitude of the utility and that depends in turn on the magnitude of all the independent variables. In other words, the change in the dependent variable is a composite of the effect of the size of the estimated coefficient and also its level.

The system of equations (4.6) shows the relationship among the preference ratings, the utility and the threshold variable. It demonstrates that a producer would rate a bull r^{th} only if the utility of that bull to the producer belongs to the r^{th} category (Maddala 1983). For example, a producer would rate a bull zero (e.g strongly dislike) if the utility derived from that bull is 'negative'. On the other hand, a bull would be rated w^{th} (e.g. strongly like) if the utility derived from that bull is greater than any other utility from other bulls in the set.

The system (4.6) can be written in a probability formula as follows:

$$
\begin{aligned}
&P(R=0)=F(-\alpha-Sv-\pi b)\\
&P(R=1)=F(\gamma_1-\alpha-Sv-\pi b)-F(-\alpha-Sv-\pi b)\\
&P(R=2)=F(\gamma_1-\alpha-Sv-\pi b)-F(\gamma_2-\alpha-Sv-\pi b)\\
&\quad\vdots\\
&P(R=w)=1-F(\gamma_{w-2}-\alpha-Sv-\pi b)
\end{aligned}
\qquad (4.7)
$$

where $P(.)$ is the probability that a bull gets an r^{th} rating and $F(.)$ is a cumulative normal distribution. Hence the sum of the probabilities in equation (4.7) is equal to one, $\sum_{r=0}^{w} p(R=r) = 1$; $r \geq 0$. Maddala (1983), and Zavoina and McKelvey (1975) define a random variable Z_{jr}, which can take values **0** and **1** and then argue that R_r can be regrouped as a series of dichotomous variables such that $Z_{jr} = 1$ if R_r falls in the r^{th} category, and $Z_{jr} = 0$ otherwise. For example, if a bull is rated least favourable or zero then $Z = 1$ otherwise, that is, if a bull is in any other category other than the least favourable one then $Z = 0$. The probability for each bull to be part of r^{th} category is written as follows (Zavoina and Mckelvey 1975):

$$P_r[Z_{ji} = 1] = \phi[\gamma_k - Sv - \pi b] - \phi[\gamma_{w-1} - Sv - \pi b] \qquad (4.8)$$

where ϕ is the cumulative standard normal distribution. Based on a set of independent variables, that is, bull characteristics and individuals' backgrounds, equation (4.8) gives us the probability that the rating of a bull will fall in each of the r^{th} categories (Mckelvey and Zavoina 1975).

Since the probabilities in equation (4.8) are independently distributed the likelihood function L can be written as:

$$L = \prod_{j=1}^{m} \prod_{r=1}^{w} [\phi(\gamma_{w} - Sv - \pi b) - \phi(\gamma_{w-1} - Sv - \pi b)]^{Z_{jr}} \tag{4.9}$$

For parameter estimation it is easier to find the values of the parameters that maximize the $\log L$ or L^* rather than L. The log likelihood of (4.9) is:

$$L^* = Log\, L = \sum_{j=1}^{m} \sum_{r=1}^{w} Z_{jr} \log[\phi(\gamma_{w} - Sv - \pi b) - \phi(\gamma_{w-1} - Sv - \pi b)] \tag{4.10}$$

A compact notation of the equation (4.10) is:

$$L^* = \sum_{j=1}^{m} \sum_{r=1}^{w} Z_{j,r} \log(\phi_{j,w} - \phi_{j,w-1}) \tag{4.11}$$

where ϕ is the cumulative standard normal distribution.

Maximum likelihood is used to estimate the parameters (Kmenta 1986; and Mckelvey and Zavoina 1975). Since independent variables are related to the observed dependent variables (ratings) through the threshold variable, estimating the probability of r^{th} rating leads to the estimation of the coefficients attached to the set of independent variables. Maddala (1983) argues that $\gamma_1 \leq \gamma_2 \leq \ldots \leq \gamma_{w-2}$ and they must be positive. A negative γ would imply specification error in the model. The estimates v and b measure the impact of changes in bulls' characteristics and producer socio-economic backgrounds on the utility, respectively (Aldrich, Nelson 1984; Mckelvey and Zavoina, 1975).

Testing the Parameters for Significance

Economic theory does not provide information as to what attribute is a relevant argument to a utility function. Hence it is important to compute the closeness-of-fit of the model. The likelihood ratio will be used to determine if producers' utilities are independent of the values of the explicatory variables of the model. De Donnes (1971) argues that if the null hypothesis $v=b=0$ is rejected, then the maximum likelihood estimates will be the value that maximizes the likelihood function of the sample.

The advantages of the ordered model over the regression model are substantial. First, the ordered model provides a solution to the statistical problem (heteroscedasticity) which occurs when regression is used to analyze discrete dependent variables (Nelson and Aldrich 1984). Second, the v and b coefficients measure the direct effects of a change of explanatory variables on the unobserved variable, utility. Hence the partial derivatives $\partial U/\partial s$ actually represent the partworth of the bulls' characteristics, not a proxy partworth as in the OLS, $\partial R/\partial S$. Finally, maximum likelihood estimates are under general conditions consistent, asymptotically efficient, and asymptotically normal (Judge et al. 1982). As a result, hypotheses testings can be performed even if the distribution of the estimates is not known for a small sample case.

CHAPTER V

DATA AND EMPIRICAL MODEL

This chapter describes the research design and explains the approach used to collect data. It has two main sections, a description of the survey instrument used in the study and section two focuses on defining the variables of the models developed in chapter III.

Mail Survey

A mail-survey instrument was developed and used to collect data. Dillman (1991) found mail-surveys to have low cost and ease of implementation compared to telephone or face-to-face interviews. Participants of the mail-survey were asked to rate sets of bulls and steers based upon the importance of these animals on their farms. The animals were presented to survey participants in a characteristic format or cards. A preference rating was chosen because it has more superior qualities than other ordering techniques (rankings). Green and Srinvisan (1978) argue that there is more potential information present in a rating scale than there is in an order ranking. Moreover, rating is believed to be more suitable for a self-administered survey than a ranking which may require presence of an interviewer to explain the procedure.

A total of 1,115[20] questionnaires were sent out on August 6 and October 9, 1993 by mail to beef cattle producers across Manitoba. After two follow-up letters to survey

[20] This number does not include questionnaires that were returned because of bad addresses or addressees of producers that were no longer in the cattle business.

participants a total of 252 responses were received, which represented a response rate of 23 percent.

Designing The Survey Instrument

The survey instrument was designed using three steps. The first step was to identify relevant characteristics and their levels which describe the animals. This step, by far the most involved, has several sub-steps. An extensive review of the available literature on beef production was done followed by a series of meetings with an animal scientist to identify animal traits or characteristics that are potentially important to producers. The research team[21] established a list of 30 characteristics comprising of 18 characteristics of bulls and 12 characteristics of steers. Since all the 30 characteristics could not be used in the study (due to technical limitations), the next objective was to collaborate with cattle producers to develop a short list of the number of characteristics and reduce it to a reasonable size.

Three meetings with producers were held in three different locations in rural Manitoba in the towns of Delorene, Carman, and Woodland from February to May of 1993. A total of 40 producers participated in those meetings. In each meeting, producers received from the research team two lists, one containing characteristics of bulls, and the other one containing characteristics of steers. The list for bulls included traits such as weaning weight; post-weaning weight; slaughter weight; carcass grade; carcass yield; temperament (see appendix 1 for a complete listing of the characteristics in the two lists).

[21] The research team included three agricultural economists and an animal scientist.

For each list, producers were asked to rank[22] the characteristics according to the importance each trait would have on their operations. A ranking scale of 1 to 5 was included in the survey where (1) is very important and (5) is not important, (2), (3) and (4) rank importance between the two extremes.

Included in the questionnaire also was a set of question formats on producers' operations (i.e., type and size) and their personal backgrounds (i.e., age, sex, level of education). The intention was to pre-test the formulation of the question formats. Producers' background is postulated to impact producers' perception of animal characteristics, hence it is an important part of the study and occupies two sections in the final survey instrument.

After producers ranked animal characteristics and filled out the question formats, the research team asked them to participate in group discussions. They were divided into small groups of less than 10 people and members of the research team monitored the discussion group. The discussions were open ended. Producers in each small group were invited to comment on the clearness, wording and the meaning of each component of the questionnaire.

Following each discussion group session, members of the research team held a meeting to compare notes. They reviewed and evaluated comments and suggestions from the focus groups before using them to revise the survey instrument. After the third meeting, there were 40[23] producers in total who filled out the questionnaire and

---

[22] Ranking was used in the identification of the relevant traits. The assumption was that with the help of the research team, producers would easily rank the array of attributes.

[23] Out of this number, 20 producers were from Woodland, 15 from Delorene, and 5 from Carman.

participated in the group discussion. A general consensus regarding the ranking of the animal traits emerged and the research team decided that final lists would be prepared. The same conclusion was reached for the question formats which had been improved by comments and suggestions from the producers.

Identifying relevant traits. Once the ranked traits were collected, the next major task was to analyze them and choose those attributes that producers regarded as the most important. This task was achieved using both an analysis of variance and a cross tabulation technique. The analysis of variance was primarily used to evaluate the significance of the differences in ranks across traits. In other words, were the ranking of bulls' characteristics depicted in Table 5.1 (see discussion below) significantly different across the 40 respondents? There were two hypotheses set up to test the rank attributes: the null hypothesis, H_o: all traits are equally preferred by respondents across groups; and the alternative hypothesis, H_a: all traits are not equally preferred by respondents across groups.

A formula by Friedman (1937) was employed to test the hypotheses. This formula is approximated by Chi square, χ^2, with $(k-1)$ degree of freedom and expressed as follows:

$$\chi_r^2 = \frac{12}{Nk(k+1)} \sum_{i=1}^{k} (R_i)^2 - 3N(K+1) \qquad (5.1)$$

where N represents number of participants, K is the number of animal traits, and R_i is the sum of ranks of each trait. Applying equation (5.1) on data from Table 5.1 the value of χ^2 is 138.38, with 40 degrees of freedom the critical value is 55.75. The hypothesis that the 18 bull traits are equally preferred by the 40 producers does not hold.

A similar test was done for the 12 characteristics of steers listed in Table 5.2. The value of the χ^2 is 110.12 with 38.89 degree of freedom. Here again the hypothesis that traits of steers are equally preferred by survey participants, [24] was rejected.

[24] Initially, the focus of the study was on characteristics of bulls. After the first meeting with producers in Delorene the idea to extend the study to cover characteristics of steers was adopted. Hence only producers from Woodland and Carman, 26 in total, evaluated the steers' characteristics.

Table 5.1 Respondent Rankings of Bulls' Characteristics

Respondents	Calving ease	Birth weight	Weaning weight	PADG	Slaughter weight	Carcass grade	Carcass yield	Tempe-rament	Milking ability
Resp-1	2	3	1	2	1	2	2	1	1
Resp-2	2	2	1	2	2	2	2	2	3
Resp-3	3	3	2	2	2	1	1	4	3
Resp-4	3	4	4	2	4	4	4	4	2
Resp-5	2	2	2	5	5	5	5	4	5
Resp-6	1	1	1	2	2	2	2	2	2
Resp-7	1	2	3	2	4	1	4	1	1
Resp-8	1	3	1	2	4	4	3	4	1
Resp-9	2	4	2	4	1	4	3	3	4
Resp-10	2	2	2	4	4	2	2	2	4
Resp-11	1	4	2	4	4	3	4	4	4
Resp-12	2	2	1	2	2	3	2	1	1
Resp-13	3	2	3	3	4	4	4	2	2
Resp-14	3	3	2	2	2	1	1	3	1
Resp-15	1	3	1	3	1	1	1	1	1
Resp-16	1	3	2	2	4	4	4	1	2
Resp-17	1	1	3	2	4	4	3	1	2
Resp-18	1	2	2	3	1	1	2	2	3
Resp-19	1	5	2	3	1	1	1	2	2
Resp-20	1	3	2	2	1	1	1	1	1
Resp-21	2	2	2	3	2	3	1	3	2
Resp-22	1	1	1	3	3	3	3	1	1
Resp-23	1	1	1	1	1	1	1	2	1
Resp-24	1	3	1	1	3	3	3	1	3
Resp-25	1	2	1	1	1	1	2	2	1
Resp-26	1	2	3	3	4	4	4	1	2
Resp-27	1	1	2	2	2	1	1	2	1
Resp-28	1	1	2	2	1	2	1	3	3
Resp-29	2	2	2	2	3	2	1	1	2
Resp-30	2	2	1	2	2	1	1	4	2
Resp-31	2	2	1	1	1	1	1	1	1
Resp-32	1	3	1	3	1	2	1	3	1
Resp-33	2	3	2	3	1	1	5	4	3
Resp-34	1	1	1	1	1	5	5	3	1
Resp-35	1	2	3	2	1	1	1	3	
Resp-36	1	1	3	3	3	3	3	1	1
Resp-37	1	3	2	3	2	1	1	3	1
Resp-38	1	2	2	2	3	2	2	2	1
resp-39	1	1	1	2	2	1	1	1	1
Resp-40	2	2	1	1	3	3	2	2	2
Total	60	91	72	94	93	91	91	88	75

Table 5.1 Continued

Respond-dents	Fertlty of cow	Fertlty of bull	Hardi-ness	Confor-mation	Colour	Maintce. effcy. of cow	Cow size @ matur.	Feed effi-ciency	Breed
Resp-1	1	1	3	2	4	2	3	2	3
Resp-2	1	1	2	2	3	3	3	1	4
Resp-3	2	1	2	2	4	3	3	2	3
Resp-4	2	4	4	1	4	1	2	4	4
Resp-5	5	5	1	5	5	3	5	3	5
Resp-6	2	1	2	2	1	1	2	2	1
Resp-7	1	1	1	1	2	4	2	1	2
Resp-8	2	2	2	1	3	2	3	1	4
Resp-9	3	2	4	4	4	4	4	4	4
Resp-10	4	4	3	4	4	4	4	4	4
Resp-11	1	1	4	2	4	4	2	4	4
Resp-12	1	1	2	3	4	2	2	2	3
Resp-13	4	3	3	4	4	4	4	3	4
Resp-14	1	1	2	1	5	2	2	1	3
Resp-15	1	2	3	5	3	3	1	1	1
Resp-16	1	1	2	1	5	2	3	2	2
Resp-17	1	1	2	3	3	3	3	2	1
Resp-18	1	2	3	1	4	5	2	2	1
Resp-19	1	1	2	2	5	2	2	1	4
Resp-20	1	3	3	4	4	2	2	2	3
Resp-21	2	2	3	2	5	2	2	2	1
Resp-22	1	1	1	1	3	2	2	3	3
Resp-23	1	1	1	2	3	2	2	2	3
Resp-24	1	1	3	3	3	3	1	3	5
Resp-25	1	1	2	5	4	1	1	1	1
Resp-26	1	1	2	2	4	2	3	3	3
Resp-27	2	1	2	2	3	1	2	1	3
Resp-28	2	1	2	3	4	3	3	2	3
Resp-29	2	2	2	2	3	2	3	1	4
Resp-30	2	1	1	1	5	3	2	1	3
Resp-31	1	1	2	1	5	3	1	1	5
Resp-32	2	1	1	3	4	3	2	3	2
Resp-33	1	1	3	4	5	3	5	4	3
Resp-34	1	1	1	3	3	1	3	2	3
Resp-35	1	1	2	1	5	2	2	2	3
Resp-36	1	1	2	2	2	3	2	2	1
Resp-37	2	1	2	3	5	2	4	1	5
Resp-38	1	1	2	2	4	2	3	2	3
resp-39	1	1	1	1	2	1	3	1	1
Resp-40	1	1	2	2	5	3	3	2	1
Total	63	60	87	95	152	100	103	83	116

Table 5.2 **Respondent Rankings of Steers' Characteristics**

Respondents	Weaning weight	PADG	Slaughter weight	Carcass grade	Carcass yield	Temperament	Hardiness	conformation	Color	Ssteer	Feed effcy.	Breed
Resp-1	1	1	1	1	1	1	1	1	1	1	1	1
Resp-2	2	3	4	4	4	3	2	2	5	3	2	4
Resp-3	1	2	1	1	1	1	2	2	4	2	1	2
Resp-4	1	1	2	5	2	2	3	2	1	1	1	1
Resp-5	2	3	1	1	1	2	2	2	5	2	1	4
Resp-6	2	2	2	1	1	2	2	2	3	1	1	3
Resp-7	2	2	2	3	1	3	3	2	3	2	2	1
Resp-8	1	1	1	1	1	1	1	1	3	1	1	3
Resp-9	2	2	2	2	2	2	2	2	2	2	1	2
Resp-10	3	1	1	1	1	1	3	3	3	1	2	2
Resp-11	1	2	1	1	1	2	2	5	2	1	1	2
Resp-12	2	2	3	3	3	2	3	3	4	4	2	4
Resp-13	2	1	2	1	1	1	2	1	3	2	1	3
Resp-14	2	2	2	2	2	4	2	3	4	2	2	2
Resp-15	2	2	1	1	1	2	3	3	3	2	1	4
Resp-16	1	2	1	1	1	3	1	2	4	2	2	3
Resp-17	1	2	1	1	1	3	3	2	5	2	2	4
Resp-18	2	1	3	2	1	2	2	1	3	1	1	2
Resp-19	2	3	1	1	2	4	3	4	5	2	2	3
Resp-20	1	1	3	3	3	2	1	3	3	3	1	2
Resp-1	2	2	1	1	1	3	2	2	5	2	2	5
Resp-2	2	2	2	3	3	2	2	2	4	3	3	3
Resp-3	4	5	2	1	1	4	1	1	5	3	1	5
Resp-4	1	2	3	2	2	2	1	2	4	3	2	4
resp-5	1	2	4	1	1	1	1	1	3	2	1	1
Resp-6	2	1	2	2	2	4	3	2	4	3	2	4
Total	45	50	49	46	41	59	53	56	91	53	39	74

Once the preferences for animal attributes were found to be statistically different, the next logical task was to identify the traits of animals that participants chose as being the most important. Table 5.3 shows results of the cross tabulation between survey participants (all 40 participants) and the characteristics of bulls. The number of participants ranking each trait of bulls was added and reported in Table 5.3. The trait "fertility of bulls" was ranked first by 29 out of the 40 participants, second by six, third by two, forth by two and fifth by one participant. Similarly, slaughter weight of steer in

Table 5.4 was ranked first by 11 individuals out of the 26 survey participants; second by nine; third by four; and fourth by two.

Table 5.3 Frequency Distribution of Respondents Ranking Characteristics of Bulls (Number of respondents = 40)

Characteristics	Ranks				
	1	2	3	4	5
	Frequency Distribution of Ranks				
Fertility of bulls	29	6	2	2	1
Fertility of cows	25	11	1	2	1
Calving ease	24	12	4	0	0
Carcass grade	16	8	7	7	2
Carcass yield	16	9	6	6	3
Weaning weight	16	17	6	1	0
Temperament	14	11	8	7	0
Slaughter weight	14	10	6	9	1
Feed efficiency	13	16	6	5	0
Conformation	11	14	7	5	3
Birth weight	9	16	11	3	1
Breed	9	3	15	9	4
Hardiness	8	20	9	3	0
Post-weaning av. daily gain	6	19	11	3	1
Maintenance efficiency of cows	6	15	13	5	1
Size of cows maturity	4	17	13	4	2
Colour	2	3	10	15	10
Milking ability	1	18	11	6	3

Table 5.4 Frequency Distribution of Respondents Ranking Characteristics of Steers (Number of respondents = 26)

Characteristics	Ranks				
	1	2	3	4	5
	Frequency Distribution of ranks				
Carcass yield	16	6	3	1	0
Carcass grade	15	5	4	1	1
Feed efficiency of feedlot cattle	14	11	1	0	0
Slaughter weight	11	9	4	2	0
Weaning weight	10	14	1	1	0
Post-weaning weight	8	14	3	1	0
Size of steer at maturity	7	12	6	1	0
Hardiness	7	11	8	0	0
Conformation	6	13	5	1	1
Temperament	6	11	5	4	0
Breed	4	7	6	7	2
Colour	2	2	9	7	6

The frequency distribution of the rankings of bulls' and steers' characteristics as summarized in Tables 5.3 and Table 5.4, clearly indicates which attributes producers preferred the most. Traits which were the most preferred or ranked number one by the largest number of producers were included in the set of animal characteristics to be studied.

However, due to correlation[25] and heritability for certain attributes, some small adjustments on the selection of the most preferred traits were made. There was no need to include both fertility of bulls and cows in the study. Fertility is hereditary, although reproductive traits have low heritability (5 to 10 percent).[26] The presence of one type of fertility is expected to capture producers' preference. The choice of fertility of cows over fertility of bulls is merely practical. It was postulated that fertility of cows which is measured in terms of percentage of calf crop or pregnancy rate was a more **familiar variable** to cow herd than fertility of bulls. In the same token, carcass yield of steers in Table 5.4 was chosen over carcass grade (in the same table), though these two characteristics were equally preferred, that is, 16 producers gave a rank of one for both attributes. Finally, three traits: milking ability, temperament and conformation that were believed to be preference-specific to some producer groups (purebred, cow-calf, and feeders) were added to the final selection to study behavioral differences across producer groups with respect to these characteristics.

After all the adjustments were made, six traits of bulls and six traits of steers were retained[27]. The traits of bulls included calving ease of offspring; weaning weight; feed efficiency of offspring; carcass yield of offspring; fertility of female; and milking ability of offspring. For steer, the six characteristics chosen were: carcass yield; conformation; weaning weight; slaughter weight; feed efficiency; and temperament.

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[25] Attributes should be kept orthogonal as much as possible.

[26] Manitoba Agriculture *Beef'85 A Manitoba Homestudy Course* estimates the heritability of reproductive trait to be 5 percent. While Alberta Agriculture *Beef Herd Management assesses the heritability* to range from 5 to 10 percent.

[27] The number of animals to be ranked increases exponentially in relation to characteristics and levels. It is necessary to limit the number of characteristics and the levels in order to keep the number of animals to be rated at a manageable level.

Identification of Attribute levels: After the identification and selection of the most important attributes to producers, the next task was to choose levels for each attribute. A basic rule was followed, that is, levels should be different enough from each other for producers to see that there are not the same and realistic enough to make sense to producers. The research team identified the number of levels for all the characteristics.

Table 5.5 and Table 5.6 list the relevant characteristics and their levels for both bulls and steers. Each Table has two columns, one that contains characteristics of animals and the other column that has the corresponding levels. Except for calving ease of offspring and temperament (respectively selected as characteristics of bulls and steers) which are two-level characteristics, all the rest of the characteristics of bulls and steers are three-level attributes. For example, weaning weight of offspring in Table 5.5 is represented by three levels, calves weaned at 650 lbs., 550 lbs., and 450 lbs. The same goes for conformation of steers in Table 5.6 which has three levels, light, medium, and heavy muscling.

Table 5.5 Relevant Characteristics of Bulls and their Levels

Characteristics	Levels
Calving ease of offspring	Many assisted
	Few assisted
Weaning weight of offspring	650 lbs.
	550 lbs.
	450 lbs.
Feed efficiency of offspring	8 lbs. of dry matter/lb. gain
	9 lbs. of dry matter/lb. gain
	10 lbs. of dry matter/lb. gain
Carcass yield of offspring	61 percent
	59 percent
	57 percent
Fertility of female of offspring	95 percent
	90 percent
	85 percent
Milking ability of offspring	High
	Medium
	Low

Table 5.6 **Relevant Characteristics of Steers and their Levels**

Characteristics	Levels
Temperament	Difficult to handle
	Easy to handle
Weaning weight	650 lbs.
	550 lbs.
	450 lbs.
Feed efficiency	8 lbs. of dry matter/lb. gain
	9 lbs. of dry matter/lb. gain
	10 lbs. of dry matter/lb. gain
Carcass yield	61 percent
	59 percent
	57 percent
Slaughter weight	1,400 lbs.
	1,200 lbs.
	1,000 lbs.
Conformation	Light muscling
	Medium muscling
	Heavy muscling

The second step in the design of the survey instrument involved the construction of the hypothetical animals or cards to be evaluated was constructed. With the help of Conjoint Analyzer, a software package, eighteen different cards or bulls were drawn using a fractional factorial design with five attributes at three levels and one attribute at two levels. Attributes and their levels were determined in step one. Each bull was described using the six attributes and their levels. For example, card one or bull one has:

- Calving ease of offspring (many assisted)[28]
- Weaning weight of offspring (450 lbs.)
- Feed efficiency of offspring (9 lbs. of dry matter per lb of gain
- Carcass yield of offspring (57%)
- Fertility of female offspring (95%)
- Milking ability of offspring (medium)

The same drawing was also done for the eighteen cards representing eighteen different steers. The cards representing the eighteen steers and eighteen bulls are listed in appendix B.

In the end, the survey instrument had four sections labelled A,B,C,and D (see appendix B for more details). Section A, had a list of eighteen hypothetical bulls and asked respondents to evaluate the described bulls with respect to the performance of their offspring. That is, to consider the importance of the bulls in terms of how their offspring would affect the respondent's operation. Also included in the section A of the instrument was an eleven-point rating scale, 0 to 10, and instructions on how to use it. Respondents were asked to give a rating of (10) for bulls whose offspring were the most desirable to have in the respondent's operation and (0) for bulls whose offspring were the least desirable to have in the respondent' operation. Bulls' offspring whose desirability falls in between (10) and (0) would be rated using a number between (1) and (9).

[28] levels of characteristics are in parenthesis

Section C was similar in form to section A. Here producers were asked to evaluate steers based upon their characteristics. Respondents were asked to focus on the importance of the steers' characteristics in terms of how they would affect the operations. Section B and Section D dealt, specifically, with respondents' socio-economic background: farm size, type of operation, profile of respondents.

In order to improve the quality of the data collected two precautionary measures were undertaken. Sections A and C, which dealt with the ratings of the animals, were separated by the section B (producer background) to avoid respondents' fatigue which could impair the ratings thus the quality of data. Another measure that was implemented to improve the quality of the data involved shuffling[29] the cards to be rated so as to reduce 'starting bias' which could happen if everybody started the rating with the same card.

The final step in the design of the survey instrument involved the pre-testing of the survey. The survey was administered at producer meetings. Twenty two producers participated in the pre-testing. After talking to some of the participants, a potential problem source was detected. One of the respondents inverted the scale of the preference rating. That is, instead of using (10) to rate the best animal he used (10) to rate the animal he preferred the least and (0) for animal he preferred the most. To prevent this serious problem from happening, two revisions were made on the questionnaire. A scale reminder was put on every other page in both sections A and C (sections that listed bulls and steers). Then a question-check was added at the end of

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[29] When CONJOINT ANALYZER generates the cards, they are not in random order. Consequently, all the cards or animals do not have the same chance to be in the first position. To reduce the bias in the rating, the cards were randomized.

both sections A and C asking respondents to state the rating they gave to the least desirable animal and to the most desirable animal. Knowing the scale the producer used to rate the animals would allow us to make any corrections so as to have the same scale used across all the participants.

These two changes (a scale reminder and a question-check) seem to have worked. A second pre-test was administered to cattle producers during other producer meetings in July. This time, there seemed to be no flaw in the survey instrument, that is, the survey instrument was ready to be sent out to beef cattle producers in its final form. In August 1993, upon receipt of the mailing lists from the Manitoba Cattle Producers Association the mail-survey began.

Data Collection

The actual mail-survey began on August 6, 1993. Because mailing addresses of the different breed associations were not received at the same time, the mail-survey was done in two time periods[30]. On August 6, 1993, about 600 questionnaires were sent out to members of the Manitoba Cattle Producers Association (MCPA). Two months later, on October 9, 1993, about 515 questionnaires were sent to three of the four largest breeder associations and feeders following the acquisition of three mailing lists from breed associations in Manitoba and a list of feeders' addresses. The breed associations were, Hereford, Simmental, and Angus. In total 1,115[31] questionnaires were sent out (first and second mailing) to beef cattle producers across Manitoba.

[30] Mailing lists from different breed associations were not received until September.

[31] Numbers do not include questionnaires that were returned because of bad addresses or addressees are no longer in the cattle business.

Table 5.7 summarizes responses and response rates per week of the first and the second mailing of the questionnaire. For the first mailing (August) 109 questionnaires were returned filled, which represented an 18 percent response rate. The second mailing (October) brought in 142 responses (25 percent) or up 7 percent from the response rate of the August mailing. The final response rate of the survey was 22.5 percent.

Table 5.7 Responses and Response rates of the First and Second Mailing of the Questionnaire by Week

Period	Responses from Aug. mailing	Response rates in percent	Responses from Oct. mailing	Response rates in percent
week 1	12	2.00	4	0.78
week 2	27	4.50	50	9.71
week 3	10	1.67	20	3.90
week 4	14	2.33	13	2.50
week 5	31	5.17	22	4.30
week 6	3	0.50	15	2.90
week 7	3	0.50	12	2.30
week 8	5	0.83	6	1.20
week 9 and after	4	0.67	0	0.00
Total	109	18.17	142	27.57

The response rate of the August mailing was below expectations which caused some concern. Because the survey was conducted during August to September, a harvesting time in Manitoba, it was thought that the timing negatively impacted producers' participation. A moratorium was put on the second mailing until the beginning of October. An early October date was suggested to us by a representative of a breed association in Manitoba. The argument was that the wet summer would keep farmers in fields longer than usual and October might be a better time for sending out the questionnaire.

Although a larger response rate was reported, 7 percent higher than the response rate of the first mailing, it could not be concluded that the change to the October date accounted solely for the increase in the response rate.

The mailing of the second group of questionnaires on a different date was not the only major change that took place. The breed associations, which provided the list of addresses used in the October mailing, were smaller organizations in terms of membership, between 89 to 1,000 members, compared to the MCPA which has more than 12,000 members. The limited membership in the breed associations might have helped associations to better manage their mailing lists and keep them more up-to-date than that of the MCPA[32]. In the end, the higher rate of return of the October mailing may have been a combination of the changes in mailing time, and more up-to-date lists.

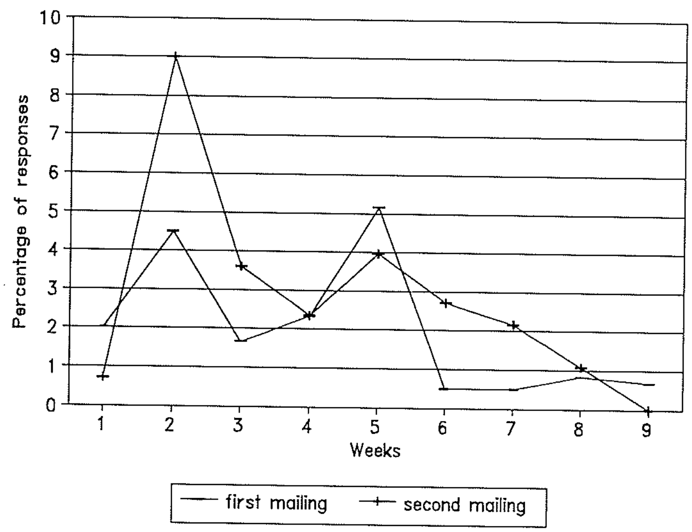
If the October mailing had a positive impact on the response rate, it did not seem to affect the response pattern. Figure 5.1 depicts the response curves on a weekly basis. Returns in each week for the first 8 weeks following the mailing are reported in that figure. In both mailings, the responses peaked in week 2 and week 5 following the mailing out of the questionnaire. The second peak[33] (i.e. week 5) happened one and two

[32] Returns from bad addresses and individuals who are no longer involved in the cattle business accounted 16 percent of the sample size from MCPA. This number was 5 percent of the lists of breed associations and feeders.

[33] The second peak of the August mailing was higher than the first peak. On the other hand, the second pick of the October mailing is much smaller than the first peak.

weeks after the first follow-up letters[34] were sent to producers. The cumulative increase in the response rate subsequent to the first follow-up letters is estimated at 8 percent for the August mailing and 6 percent for the October mailing. The second follow-up letters, in both mailings, did not produce any peak which may explain their relative limited effect on beef cattle producers.

Figure 5.1 Response Curves to the August and October Mailing



Econometric Models and Variables

Ordered probit technique is used to estimate partworth values of animal attributes. It has two models[35], an underlying model with an unoberservable dependent variable U and a second model with an observable dependent variable, R.

[34]The first follow-up letters were sent three weeks after the August mailing and four weeks after the October mailing.

[35] For a complete discussion on the ordered probit technique refer to empirical method, chapter IV.

$$U = XB + e \quad (5.1)$$

$$R = i \quad (5.2)$$

where:

U unobserved dependent variable

X independent variables (animal attributes and interaction variables)

B estimated coefficients or partworth values

e an error term

R preference ratings of producers

i value of the ratings (0,1,2,...10)

Because the independent variables were in two sets, steer and bull attributes, there is a model for bulls and a model for steers. Each model has ratings as dependent variables and animal attributes and interaction variables as independent variables. Independent variables of the bull equation and steer equation are shown in Tables 5.8 and 5.9, respectively.

Table 5.8 Independent variables (attribute levels) of the bull equation

Attributes of bulls	Independent variables
Calving ease of offspring	Many assisted
	Few assisted
Weaning weight of offspring	650 lbs.
	550 lbs.
	450 lbs.
Feed efficiency of offspring	8 lbs. of dry matter/lb. gain
	9 lbs. of dry matter/lb. gain
	10 lbs. of dry matter/lb. gain
Carcass yield of offspring	61 percent
	59 percent
	57 percent
Fertility of female of offspring	95 percent
	90 percent
	85 percent
Milking ability of offspring	High
	Medium
	Low

Table 5.9 Independent variables (attribute levels) of the steer equation

Attributes of steers	Independent variables
Temperament	Difficult to handle
	Easy to handle
Weaning weight	650 lbs.
	550 lbs.
	450 lbs.
Feed efficiency	8 lbs. of dry matter/lb. gain
	9 lbs. of dry matter/lb. gain
	10 lbs. of dry matter/lb. gain
Carcass yield	61 percent
	59 percent
	57 percent
Slaughter weight	1,400 lbs.
	1,200 lbs.
	1,000 lbs.
Conformation	Light muscling
	Medium muscling
	Heavy muscling

CHAPTER VI

RESULTS AND DISCUSSION

This chapter summarizes the results of the study. It is divided into three sections. The first section discusses the coefficient estimates of the ordered probit model. The second section relates the coefficient estimates, including the attributes which were deleted for statistical reasons, to partworth values of animal attributes, In the third section, partworth values from different estimation techniques were compared against those derived using ordered probit.

Estimated coefficients

Results of the ordered probit model are reported in Table 6.1 and Table 6.2. Table 6.2.1 contains major statistical properties of the model. Three tests were conducted. The first test was a specification test using estimates of the threshold variables listed in the first part of Table 6.2.1. According to Maddala (1983) the threshold coefficients or γ_i should exhibit the following relationship $\gamma_1 \leq \gamma_2 \leq \ldots \leq \gamma_{w-2}$ and must be positive. Failure to exhibit any of these conditions would imply specification error of the model. All threshold coefficients of this analysis were positive and statistically significant at the 95 percent confidence level which implies there was no misspecification error.

A second test was done, this time to look at the overall significance of the independent variables (levels of animal attributes and producer profiles) in explaining the variations in the dependent variable, ratings. A log-likelihood test using a $\chi^2_{2915,5\%}$

with a critical value of 18.493 was conducted. The null hypothesis of the test $v=b=0$ was rejected, at 95 percent confidence level. This means that the animal attributes and producer profile variables, are relevant in explaining variation in producer preferences.

Lastly, estimated coefficients listed in all three Tables were tested using a t-test. The critical value of the two-tailed t-test, $t_{2915,.975}$, was 1.645. All coefficients in table 6.1 were found to be statistically significant at the 10 percent level, except for three attribute levels in the bull equation (e.g., fertility at 90%, weaning weight at 550 lbs., carcass yield at 59 %) and one attribute level (feed efficiency at 9 lbs) in the steer equation. Most coefficients in both the bull and steer equation are significant at one-percent level. The non-significance of a coefficient does not mean that the attribute or the level of attribute is not important to producers. Rather, it implies that producers are indifferent to the proposed range of variation in the levels of attributes. This issue is discussed further in later sections.

Heteroscedasticity which most often arises in the analysis of cross-section data is not a concern when using non-linear techniques such as probit model (Johnston, 1984).

Estimates in Table 6.1 are main effect coefficients of animal attributes. They were obtained by differentiating producers' utility with respect to animal attributes. Because they were derived without considering producers' background, main effect coefficients represent marginal values or partworths that a 'typical' producer places on attributes of bulls and steers. To illustrate, a steer with a weaning weight attribute of 650 lbs has a marginal value of 0.286 to an average producer.

Table 6.1 Main effect estimates using ordered probit

Variables	Bulls	Steers
Constant	1.846*** (0.0354)	2.0919*** (0.0551)
Calving ease	0.770*** (0.0311)	
Fertility 90%	-0.0284 (0.0275)	
Fertility 95%	0.134*** (0.0375)	
Milking ability medium	0.224*** (0.0285)	
Milking ability high	0.273*** (0.0367)	
Weaning weight 550 lbs.	0.008 (0.0290)	-0.0538* (0.0285)
Weaning weight 650 lbs.	0.597*** (0.0424)	0.286*** (0.0375)
Feed efficiency 9 lbs.	0.077*** (0.0280)	0.005 (0.0270)
Feed efficiency 10 lbs.	-0.268*** (0.0381)	-0.242*** (0.0379)
Carcass yield 59%	-0.020 (0.0278)	-0.046* (0.0267)
Carcass yield 61%	0.152*** (0.0380)	0.188*** (0.0365)
Muscling medium		0.084*** (0.0275)
Muscling heavy		0.157*** (0.0377)
Slaughter weight 1200 lbs.		0.144*** (0.0278)
Slaughter weight 1400 lbs		0.235*** (0.0361)
Temperament easy		0.323*** (0.0290)

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 6.2 Estimated coefficients of the interaction effect (segments of industry and animal attributes) using ordered probit

Bull attributes	Breeders	Cow-calf	Feeders
Calving ease	+0.0084 (0.0212)	+0.0436** (0.0206)	+0.0389* (0.0271)
Weaning weight 650 lbs.	+0.0949*** (0.0277)	+0.0546** (0.0267)	-0.0589** (0.0357)
Feed efficiency 10 lbs.	-0.0304 (0.0263)	-0.0145 (0.0251)	-0.0469* (0.0334)
Carcass yield 61 %	-0.0005 (0.0263)	+0.0106 (0.0255)	+0.0018 (0.0335)
Fertility 95%	-0.0041 (0.0257)	+0.0251 (0.0252)	-0.0423* (0.0332)
Milking ability high	0.0359* (0.0252)	+0.0076 (0.0246)	-0.0515* (0.0327)

steer attributes	Breeders	Cow-calf	Feeders
Carcass yield 61 %	-0.0367* (0.0248)	0.0016 (0.0246)	-0.0341 (0.0334)
Muscling heavy	-0.0306* (0.0247)	-0.0117 (0.0243)	0.0032 (0.0333)
Weaning weight 650 lbs.	0.0480** (0.0257)	0.0364* (0.0254)	-0.0014 (0.0347)
Slaughter weight 1400 lbs.	-0.0352* (0.0243)	0.0429** (0.0241)	0.0445* (0.0321)
Feed efficiency 10 lbs./lb gain	0.0237 (0.0248)	-0.0028 (0.0245)	0.0107 (0.0338)
Temperament easy	-0.0626*** (0.0253)	0.0012 (0.0203)	-0.0488** (0.0271)

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 6.2.1 Major Statistical Properties of the ordered probit models

Properties	Bull equation	Steer equation
Coefficients of the threshold variables		
γ_1	0.3666*** (0.2364)	0.2915*** (0.0379)
γ_2	0.7611*** (0.0300)	0.7210*** (0.0498)
γ_3	1.2061*** (0.0339)	1.1263*** (0.0543)
γ_4	1.7429 (0.0378)	1.6098*** (0.0567)
γ_5	2.2722*** (0.0423)	2.0790*** (0.0580)
γ_6	2.7775*** (0.0477)	2.6136*** (0.0595)
γ_7	3.3254*** (0.0560)	3.1740*** (0.0621)
γ_8	3.9287*** (0.0681)	3.8932*** (0.0688)
γ_9	4.7375*** (0.0975)	4.6360*** (0.0834)
Log-Likelihood	-5805.418	-5931.937
Restricted (slopes=0) Log-L.	-6621.163	-6341.816
Chi-Squared (11)	1631.489	819.757
Significance level	0.000	0.000
Degrees of freedom	2915.000	2915.000

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

The strength of the conjoint valuation technique is to break down preference ratings of surveyed individuals into marginal values[36] or partworths of attributes. For example, slaughter weight of 1,400 pounds has a partworth value of 0.235, while a

[36]The use of effect coding (1,-1) instead of dummy coding (0,1) lead to marginal effect coefficients being equal to partworths. See discussion on the difference of these two alternative ways of coding variables in chapter IV.

slaughter weight of 1,200 pounds has a partworth value of 0.144 partworth. Negative partworths mean that producers' preferences would decrease when attribute levels are varied. When weaning weight of steers is decreased from 650 to 550 pounds producers' preferences drop by -0.054. Similarly, when milking ability of pedigree of a bull is decreased from being high to low, producers' utility drops from 0.273 to -0.497. What it means is that producers would discount animals with undesirable attribute levels such as low milking ability relative to animals with high milking ability. The negative sign of the partworth for low milking ability means that producers are not insensitive to the difference between animals with high milking ability and those with low milking ability. However, since utility or preference is an ordinal measure what is important is not so much the magnitude of the coefficients, rather the relative importance of those coefficients.

Table 6.2 contains estimates of the interaction variables. These estimates will be discussed in depth later.

Comparing partworth values of attribute levels

Producers' highest preferences for a particular level of attribute are found by comparing all partworths of a given attribute. Table 6.3 shows the partworths of all the attribute levels to a typical producer. Partworth values for attributes that were deleted for econometric analysis[37] were computed and included in Table 6.3. A large partworth value associated with an attribute level indicates high preference for that particular level while a small partworth value for an attribute level means a low level of preference. For

[37] See equation 3.44 for the derivation of the partworths of the dropped variables. On Table 6.3 insignificant partworths are enclosed in brackets ([]).

example, bulls whose offspring have the following characteristics: easy calving, a fertility rate of 95%, high milking ability, weaning weight of 650 lbs., high feed efficiency, and carcass yield of 61%, have the highest utility and, therefore, are highly valued by producers. Similarly, steers with heavy weaning weight, high feed efficiency, high carcass yield, heavy slaughter weight and easy handling were chosen as the most preferred.

These results are consistent with expectations. For example, trends toward large-framed and feed efficient cattle in the Canadian industry are reflected in these results. The attribute weaning weight of 650 pounds for offspring of bulls and also for steers has a relatively large coefficient which is statistically significant. This indicates that producers place high value on animals with heavy weaning weight. Producers are not only interested in young heavy animals but also in heavy mature animals. Slaughter cattle with 1,400 pounds were found to be more valued than lighter animals by cattle producers.

Table 6.3 Partworth values of animal attributes to a 'Typical producer'

Attributes	Bulls	Steers
Calving of offspring:		
few assisted	0.770	
many assisted	-0.770	
Fertility:		
85%	-0.134	
90%	[-0.028]	
95%	0.134	
Milking ability:		
low	-0.497	
medium	0.224	
high	0.273	
Weaning weight:		
450 lbs.	-0.597	-0.232
550 lbs.	[0.008]	-0.054
650 lbs.	0.597	0.286
Feed efficiency:		
8 lbs.	0.191	0.242
9 lbs.	0.077	[0.005]
10 lbs.	-0.268	-0.242
Carcass yield:		
58%	-0.152	-0.142
59%	[-0.020]	-0.046
61%	0.152	0.188
Muscling:		
low		-0.241
medium		0.084
heavy		0.157
Slaughter weight:		
1,000 lbs.		-0.379
1,200 lbs.		0.144
1,400 lbs.		0.235
Temperament:		
easy to handle		0.323
difficult to handle		-0.323

[ ] Coefficients not significantly different from zero

Feed efficient animals also are of high value to producers. Feeding efficiency (expressed in pounds of dry matter feed per pound of gain) has a large and statistically significant coefficient in both bulls' and steers' equations which indicates high preferences of producers for animals that are feed efficient. Another result which is consistent with expectations is the preference of producers for high carcass yield. Carcass yield is associated with meat grades. Yields of over 59 percent, 54 to 58 percent, and up to 53 percent are designated under the new grading system as A1, A2, and A3, respectively. Though carcass yields included in this study (yields 61%, 59% and 57%) determine only two grades, A1 and A2, it was found that producers have high preference for carcass yield of 61 percent. This is interesting because 59 percent is the threshold for A1 and packers do not pay more on the basis of higher yield grades.

By standardizing partworths of attribute levels on a 0 to 1 scale, (Fletcher, 1988), it becomes possible to compare producer preferences for levels across attributes. Figure 6.1, figure 6.2 and figure 6.3 show the relationship between utility[38] and attribute levels of bulls and steers using the same scale. Previous results on producer preferences for a particular level of attribute can be read from the utility graphs. For instance, a slaughter weight for steers of 1,400 pounds is more valued by producers than slaughter weights of 1,200 and 1,000 pounds[39].

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[38] Partworths or utilities from Table 6.2 were standardized on a scale between 0 to 1. The choice of 0 is arbitrary and does not affect the analysis.

[39] Note these results did not change as a result of standardizing the partworths.

Figure 6.1 Slaughter weight of steers

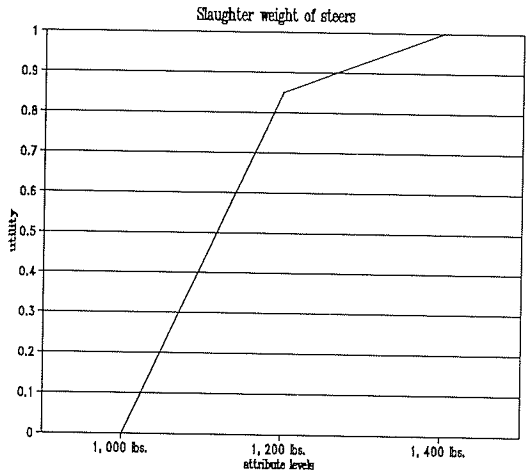


Figure 6.2.Fertility of bulls' offspring

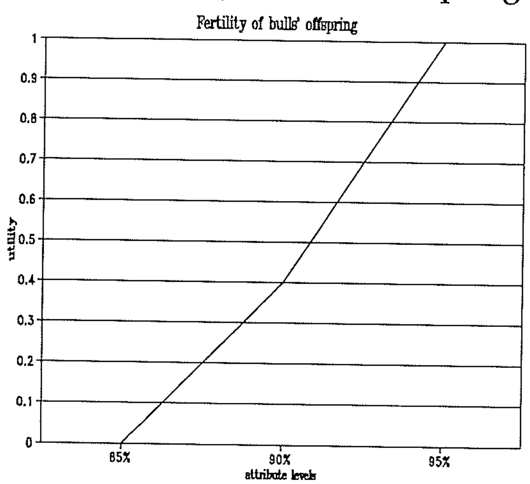
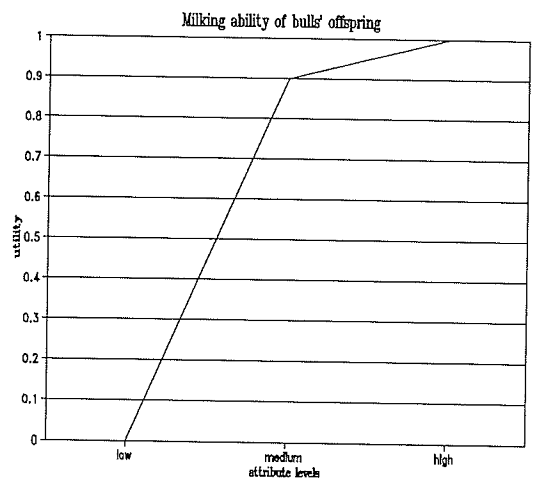


Figure 6.3.Milking ability of bulls' offspring



However, the most important information from these utility graphs resides in the economic interpretation of the slopes. With the minor assumption that changes in attribute levels (improvements of attributes) are continuous, the slopes of the utility functions could be referred to as marginal contribution of improved attributes on producers' preference. The size of the contribution is then determined by slope. For example, an increase in slaughter weight of steer from 1,000 to 1,200 pounds has a greater impact (steeper or a larger slope) on producer preferences than when the slaughter weight is raised from 1,200 to 1,400 pounds. This suggests that although the trend is toward larger animals, producers perceive that the marginal improvement of increasing animal weight above 1,200 pounds would yield a smaller payoff than increasing it from 1,000 to 1,200 pounds. The flatter portion of the utility curve for slaughter weight (figure 6.1) shows a diminishing marginal contribution in relation to the bottom or steeper portion of the curve.

The utility curve for fertility of bull offspring shown in figure 6.2, does not show a diminishing marginal portion. This suggests that marginal contribution to producer preferences increases as fertility of bulls is improved. For example, improving fertility from 90 percent to 95 percent has a larger impact on producers' preference than increasing it from 85 to 90 percent.

These results provide important insight for animal breeders. In addition to being able to identify animal attributes with high payoffs, breeders can look at the improvement of each attribute at the margin. That is, they are able, based on the marginal payoffs of each attribute level, to decide how far they should go in the improvement of a particular attribute. For example, a breeder can compare the marginal payoffs of improving the slaughter weight of steers from 1,000 to 1,200 pounds and from 1,200 to 1,400 pounds and decide to select animals with slaughter weight of 1,200 pounds. Improving the slaughter weight above the 1,200 pounds may bring little payoff compared to the payoff that could be obtained in improving other attributes.

Consequently, breeders can maximize their profits by equalizing the marginal contribution of attributes to producer preferences. Selection for attribute levels should be based upon the contribution of each level to the breeding profit. Attribute levels with high marginal contributions should be selected first, once marginal contribution starts falling, breeders should start selecting for other attributes until all the attribute levels yield equal marginal contribution to producer preferences. The equalized marginal contribution would maximize breeding profit.

The ability of breeders to make selection decisions on level of attributes is a significant advantage of the consumer-driven over the product-driven models (see chapter II for discussion of the product-driven models). In product-driven models, breeders have estimates of economic values of attributes not attribute levels. What this enables them to do is to identify attributes with high payoffs. However, payoffs of attribute levels (different improvements) are not available to them. Hence producers using product-driven models to identify potential attributes do not have economic information on level of attribute to enable them to decide how far they should go in selecting a particular attribute.

Common attributes

In designing the study, three attributes were cross listed in both bull and steer equations. Figure 6.4, figure 6.5 and figure 6.6 depict the relationship between these attributes and producer preferences. While increasing carcass yield of both bulls and steers has a positive impact on producer preferences, producers are more responsive to an improvement of a carcass yield of steers from 59 percent to 61 percent than they are to the improvement of carcass yield of bull offspring in the same range. Similarly, increasing weaning weight from 550 to 650 pounds impacts producers more than if it is observed on steers than if it is observed in the characteristics of bulls.

Figure 6.4. Feed efficiency

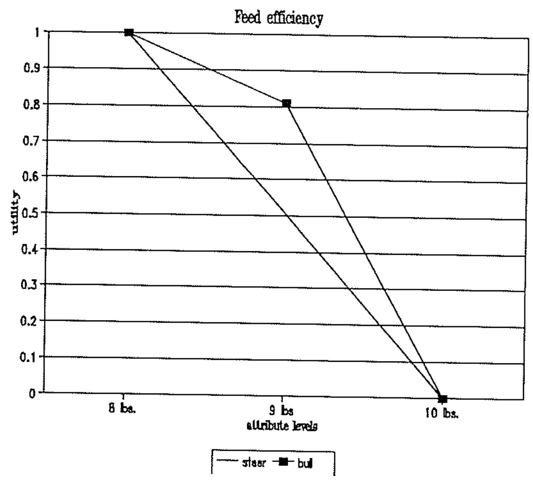


Figure 6.5 Carcass yield

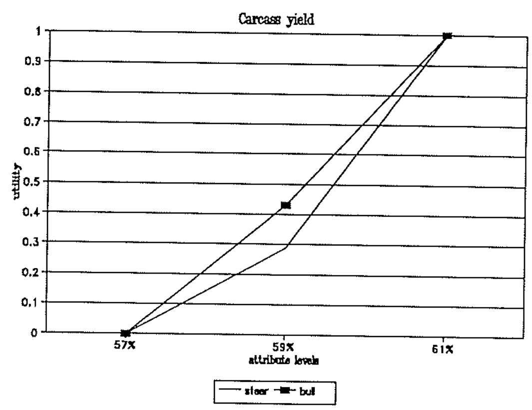
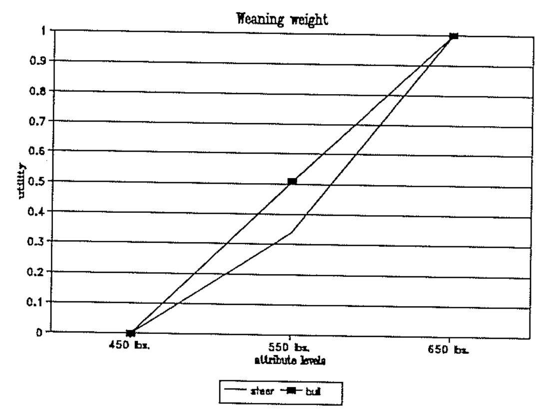


Figure 6.6.Weaning weight



These results suggest larger improvements of product attributes have a bigger impact on producer preferences if they are observed on steers than on offspring of bulls. This preference bias toward improvement product attributes of steers is expected when one considers the function bulls and steers play in the production of beef. Bulls are seen as inputs which are used in the production of calves. It is expected that bulls' attributes would be passed on to their offspring. However because many animal traits are not 100 percent heritable, there is a risk that a given trait may not be observed in bulls' offspring. For example, the heritability of weaning weight is 30 percent and for finishing ability it is 50 percent.

In contrast, steers are the final animal product of the production to consumption process. Valuable attributes on steers are more certain and are given premiums or discounts whenever steers are sold. Hence payoffs from valuable attributes of steers are more predictable than payoffs from valuable attributes of bulls.

The utility function for carcass yield, figure 6.5, had surprising results. It was expected to show a smaller slope, or a diminishing marginal portion, when carcass yield is increased from 59 to 61 percent. Carcass yield is estimated on live animals at the moment of sales. Since producers do not have an effective way of measuring the exact carcass yield of a live animal, they may target the higher attainable carcass yield hoping to meet 59 percent which is enough to give them the premium attached to produced cattle with an A1 grade. This risk management strategy could well explain why they still value an increase in carcass yield from 59 to 61 percent even though there is no additional premium above 59 percent. Moreover, cattle producing an A2 grade or with a carcass yield of 58 percent are discounted relative to cattle yielding an A1 grade.

Relative importance of attributes

So far we have dealt with individual attributes and have made comparisons among levels of the same attributes and/or compared levels across attributes. How each attribute compares to the others in terms of importance to producers is discussed in the following paragraphs.

Table 6.4 contains the relative importance of attributes of both bulls and steers. It is computed by taking the difference between the highest and the lowest partworth value of an attribute over the sum of the ranges for all attributes. For example, to compute relative importance of calving ease, one subtracts -0.777 from 0.777 [or 0.777-(-0.777)] to get 1.56 which is divided by the total range of all the attribute to get 34 percent.

Table 6.4 Relative Importance of Animal Attributes (%)

Animal attributes	Bulls	Steers
Calving ease	34	-
Fertility	6	-
Milking ability	17	-
Weaning weight	26	17
Feed efficiency	10	16
Carcass yield	7	11
Muscling	-	13
Slaughter weight	-	21
Temperament	-	22
Total	100	100

Relative importance allows an attribute-to-attribute comparison. It indicates which attributes producers value the most[40]. For the attribute of bulls, calving ease is the most important attribute followed by weaning weight, milking ability of bulls' offspring, feed efficiency, carcass yield and lastly, fertility of bulls[41]. The downstream attributes primarily affecting returns from feeding cattle are relatively less important when ranking bulls, relative to more direct commercial cattle production attributes such as calving ease, milking ability and weaning weight.

This discrepancy in the relative importance of attributes suggests that price information does not flow with the same accuracy from the different producer groups to breeders. Downstream preferences for fed cattle attributes in the breeding herd may be overwhelmed by more immediate preferences for attributes that directly affect cow-calf production, the next stage of the hierarchical process.

Fertility of bull offspring being the least important attribute comes as a surprising result because producers from focus group meetings rated the attribute as being the most important. Although they were asked to rank attributes not level of attributes, it is of major concern that fertility of bull was found to be the least important of all the bulls' attributes included in this study. One possible explanation is that the range of the attribute, 80 to 95 percent fertility rate, was not important to producers. This is possible if most producers did not consider improvement of bull fertility from 80 to 95 percent

[40]The attribute levels to attribute levels comparison discussed earlier gives indication on the attribute levels the most preferred to producers.

[41]Relative importance is computed with coefficients from table 6.3.

to be significant. However, these levels were chosen in conjunction with the normal ranges of fertility shown in the literature[42]

The relative importance of steer attributes is more dispersed than is the case for bulls. This indicates a certain homogeneity in preferences for the attributes of steers studied in this research. Except for temperament, all the attributes of steers in this study are related to weight/growth. Temperament is the most important factor accounting for more than 22 percent of producer preferences. Slaughter weight, the second most important attribute accounted for 21 percent of the preferences. When slaughter weight is combined with weaning weight, feed efficiency and muscling those four attribute accounted for 67 percent of the preference. Surprisingly carcass yield is the least preferred relative to the other attributes, accounting for 11 percent of producers' preference.

In comparison, several striking differences are apparent when contrasting the relative importance of steers and bulls for the same attributes. Weaning weight for bulls accounted for 26 percent of the producers' preference, the second most important attribute. In contrast, weaning weight as an attribute for steers accounted for only 17 percent of the producers' preference, third in the rank of importance. Moreover, feed efficiency and carcass yield were relatively more important for steers than for bulls, 16 and 11 percent of producers' preference respectively for steers and 10 and 7 percent respectively for bulls.

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[42] Manitoba Agriculture *Beef'85 A Manitoba Homestudy course.*

These differences in the relative importance of the cross listed attribute were expected. Feed efficiency and carcass yield are direct commercial cattle product attributes. Steers with those attributes have high values to feedlot operators. In contrast, weaning weight is a production attribute, it has a higher value when observed on bulls than steers.

Threshold variables and their coefficients

Threshold coefficients are summarized in the first part of Table 6.2.1. They provide the ratings of the alternatives. Improvements on attributes increase utility which when it exceeds a threshold level of satisfaction triggers producers to increase their ratings.

Segmentation of the Industry

Although information on average partworth of animal attributes is useful it falls short in providing preferences of specific producer groups. *A priori*[43] segmentation of producers based upon the relative importance of their activity was done to allow estimation of their preferences. Appendices C, D, and E, contain the number of respondents and frequency distributions for producers involved in the different beef production activities. Producers whose herd had more fed cattle than breeding female and calves combined were considered feeders, whereas producers whose number of commercial cows calving annually is higher than the number of purebred cows and fed cattle combined were considered cow-calf operators.[44] These producer profiles, cow-

[43] A priori segmentation was chosen over a postori segmentation because

[44] Different segmentation approaches were tried but this one give the most satisfying results. The limitation of segmenting producers by the importance in number of type of animal in their herd is that integrated operation was not considered.

calf operators, feeders and breeders, were interacted with animal attributes to capture the impact of producers' background on preference for animal attributes.

Table 6.2 comprises estimated coefficients of the interaction variables. The coefficients are obtained by differentiating ratings with respect to the interaction variables, π_i. The (coefficients) represent incremental value of preference for animal attribute due to producer profiles. Since the coefficients are deviations from the average partworth they could be positive or negative depending on producer groups. For instance, a 'typical' producer would value a weaning weight attribute of 650 pounds at 0.597; a breeders' increment to that value would be 0.095, a cow-calf operator would add 0.0546 and a feeder would discount -0.0589 from the average partworth values. In the end, breeders' partworth for a weaning weight of 650 pounds is 0.692, cow-calf operators' partworth is 0.652, and feeders' partworth is 0.538. Simply put, it means that cow-calf producers place the highest value on bulls with a weaning weight of 650 pounds than breeders and feeders[45]. Similar adjustments were made for average partworth of steer attributes. The incremental contributions of breeders, cow-calf operators and feeders to a steer with a slaughter weight of 1,400 pounds is -0.035, 0.043, and 0.045 respectively.

Table 6.5 contains partworth values of each segment of the industry. The partworth values for each segment are computed by adding partworths of a 'typical' producer to the incremental partworth value due to producer profiles. Only coefficients

[45]Adding the interaction effect to the main effect coefficients we obtain +1.12 for cow-calf operators, +0.66 for breeders, and +0.528 for feeders.

that were statistically different from zero were included in the partworth values of producer groups. A non-statistically significant coefficient of the interaction variables would mean that group's preference for that particular attribute was not different from the preference of a typical producer.

Breeder preferences

Results of the study indicate that breeders have high preferences for reproduction traits compared to product traits. For example, breeders have the highest preference for fertility, milking ability, and weaning weight and the lowest preferences for carcass yield of steers, conformation, slaughter weight, temperament and calving ease. This preference for reproduction traits implies that breeders are more concerned with attributes affecting cow-calf production, the next stage of the hierarchical beef production process than they are with factors affecting feeders, who are further downstream in the production process.

Low preferences of purebred breeders for calving ease although counter intuitive is not a surprising result. There is a trade off between easy calving and birth weight of calves. Purebred breeders seem to have the highest preference for heavy calves (a large partworth for weaning weight, see Table 6.5) than any other producers, which makes their lowest preferences for easy calving reasonable.

Table 6.5 **Partworth values of animal attributes to different segments of the beef industry.**

Characteristics of bulls	Industry by segments		
	Breeders	Cow-calf	Feeders
Calving ease	0.770	0.814	0.809
Weaning weight 650 lbs	0.692	0.652	0.538
Feed efficiency 10 lbs.	-0.268	-0.268	-0.315
Carcass yield 61%	0.152	0.152	0.152
Fertility 95%	0.134	0.134	0.092
Milking ability high	0.309	0.273	0.222

Steer attributes	Breeders	Cow-calf	Feeders
Carcass yield 61 lbs.	0.151	0.188	0.188
Muscling heavy	0.126	0.157	0.157
Weaning weight 650 lbs.	0.334	0.322	0.286
Slaughter weight 1,400 lbs.	0.200	0.278	0.280
Feed efficiency 10 lbs.	-0.242	-0.242	-0.242
Temperament easy	0.260	0.323	0.274

Preferences of Cow-calf Producers

Results from Table 6.5 indicate that cow-calf operators have the highest preference for calving ease and temperament than any other producer group. Note these two attributes are primarily cow-calf attributes. However, preferences of cow-calf operators tend to be close to breeder' preferences on reproduction traits and to feeders on product traits. Cow-calf operators share with breeders similar preferences for fertility and feed efficiency traits. Again with breeders, cow-calf operators have higher preferences for weaning weight and milking ability than feeders. On the other hand, preferences of cow-calf producers for product attributes tend to be close to feeders' preferences. They have similar preferences for carcass yield and conformation (muscling). Similar to feeders, cow-calf operators have higher preferences for slaughter weight than breeders.

These results on preferences of cow-calf producers make sense. Caught in between two producer groups, purebred breeders in upstream and feeders in downstream, cow-calf operators are expected to have preferences that are close to breeder and feeder preferences. Many cow-calf operators can also be involved in feeding activities and tend to think of themselves as breeders. This issue was brought to our attention during producer group meetings when some cow-calf operators identified themselves as breeders.

Feeders' Preferences

Feeders have the highest preferences for feed efficiency and slaughter weight relative to other producer groups. The results also indicate that feeder preferences are closer to cow-calf operators than they are to breeders. For example, feeders and cow-calf operators have higher preferences for slaughter weight, carcass yield, and conformation than breeders. Moreover, breeders have the lowest preference for slaughter weight and feeders have the highest preference for slaughter weight relative to any producer groups.

The above results suggest that different producer groups have different preferences for animal attributes. Feeders were found to place higher value on animal attributes which are product related such as feed efficiency, carcass yield, conformation, and slaughter weight, while placing lesser importance on non-product related attributes. Cow-calf operators, on the other hand, more highly value attributes that are reproduction related: easy calving, weaning weight, fertility of bulls, and milking ability.

Breeders who in general have preferences close to cow-calf operators tend to value attributes such as fertility of bulls, weaning weight, and milking ability.

The implications of these findings are very important. The beef industry is a very heterogenous industry in terms not only of products but also of preferences. Price signals which were supposed to carry information on preferences of the parties involved in the production system through premiums and discounts may not be perfectly effective. Out of the twelve animal attributes included in this study, only two attributes, carcass yield and feed efficiency, have their preferences not influenced by producer profiles. In other words, for only two attributes do all producer groups give identical values. The other 10 attributes are valued differently by different categories of producers.

Other Techniques to estimate partworths

The Ordinary Least Squares technique was used to estimate partworths of animal attributes. Results of the estimation are included in Table 6.6. A Comparison of estimates and standard deviations of both the OLS and ordered probit routine are summarized in Table 6.7. The results show that OLS standard deviation estimates to be inflated and higher than standard deviation estimates from ordered probit. This was expected since the dependent variables of the model, ratings of producers, was not continuous. Aldrich and Nelson (1984) argued that when dependent variables are not continuous OLS estimates will not be the smallest possible sampling variance. Hence, coefficients are unbiased but not efficient. Consequently, only estimates from the ordered probit model will be referred to in this study.

Table 6.6 Estimates of the interaction model using an OLS technique

Variables	Bulls df = 2915	Steers df = 2915
Constant	4.5736*** (0.0389)	5.3193*** (0.3839)
Calving ease	1.4353*** (0.0311)	
Fertility 90%	-0.0273 (0.0510)	
Fertility 95%	0.197*** (0.0697)	
Milking ability **medium**	0.373*** (0.0510)	
Milking ability **high**	0.544*** (0.0704)	
Weaning weight **550 lbs.**	0.048 (0.0532)	-0.0546 (0.0526)
Weaning weight **650 lbs.**	1.077*** (0.0767)	0.487*** (0.0717)
Feed efficiency **9 lbs.**	0.175*** (0.0519)	0.0324 (0.0514)
Feed efficiency **10 lbs.**	-0.482*** (0.0695)	-0.441*** (0.0691)
Carcass yield **59%**	-0.010 (0.0511)	-0.070* (0.0511)
Carcass yield **61%**	0.229*** (0.0697)	0.330*** (0.0697)
Muscling **medium**		0.131*** (0.0511)
Muscling **heavy**		0.314*** (0.0703)
Slaughter weight **1200 lbs.**		0.311*** (0.0511)
Slaughter weight **1400 lbs**		0.407*** (0.0697)
Temperament **easy**		0.616*** (0.0544)

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 6.7 **Comparison between ordered probit and OLS estimates of the interaction model using coefficients of bull attributes.**

Characteristics of bulls	Ordered probit		Ordinary Least Squares	
	Coefficient	Standard deviation	Coefficient	Standard deviation
Weaning weight: 650 lbs.	0.597	0.0424	1.077	0.0767
Feed efficiency: 10 lbs.	-0.268	0.0381	-0.482	0.0695
Carcass yield: 61%	0.152	0.0380	0.229	0.0697

Segmentation model

Partworths of producer groups were estimated using a different model. This model, referred hereafter as segmented model (SM), unlike the interaction model (IM), estimates partworths by running a regression (probit routine) for each producer group. Producer groups were segmented using the technique as in the first model. Estimates of the SM are included in Table 6.8.

Table 6.9 reports the partworths of producer groups from the IM and SM models. The relative importance of animal attributes to producer groups computed using coefficients from the SM model are identical to the relative importance of attributes from the IM model. Breeders and cow-calf operators had high values for attributes of bulls and bulls offspring such as weaning weight, fertility and milking ability in both models; whereas, feeders valued feed efficiency more.

The similarity in results of the relative importance of animal attributes using two different models, ordered probit and OLS techniques, is a good indication of the robustness of the estimates. Both models yield unbiased estimates, although those from OLS are not efficient.

The superiority of the IM over the SM model is that in addition to providing comparable results on segments' preferences, the IM model provides aggregate or average preference function for the whole industry. This additional information on preference of the industry is valuable, especially when producers are moving in and out of segments frequently making a preference mapping based on their principal activity very difficult.

Table 6.8 Estimates of segmented model using an ordered probit technique: Characteristics of bulls

Variables		Breeders	Cow-calf	Feeders
Calving ease		0.698*** (0.0525)	0.742*** (0.0557)	0.790*** (0.0679)
Weaning weight:	550 lbs	0.031 (0.0669)	0.001 (0.0655)	-0.0130 (0.0803)
	650 lbs	0.718*** (0.0779)	0.604*** (0.0736)	0.499*** (0.0918)
Feed efficiency	9 lbs	0.0649 (0.0638)	0.1058* (0.0657)	0.0909 (0.0808)
	10 lbs	-0.247*** (0.0653)	-0.312*** (0.0668)	-0.323*** (0.0822)
Carcass yield	59 %	-0.054 (0.0637)	0.007 (0.0641)	-0.001 (0.0783)
	61 %	0.123* (0.0646)	0.161** (0.0668)	0.115 (0.8191)
Fertility	90 %	0.0003 (0.0650)	-0.0160 (0.0651)	-0.0256 (0.0810)
	95 %	0.126** (0.0627)	0.1994*** (0.0658)	0.1308* (0.0798)
Milking ability	medium	0.220*** (0.0649)	0.2783*** (0.0697)	0.2546** (0.0840)
	high	0.346*** (0.0612)	0.2566*** (0.0630)	0.2059*** (0.0793)
Log-likelihood		-1096.470	-1100.810	-711.1062
Restricted (slopes=0)		-1296.937	-1261.852	-810.731
Chis-Squared (11)		332.948	322.085	199.249
Significance level		0.000	0.000	0.000
Degrees of freedom		557.000	557.00	359.000

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 6.9. **Comparing partworth values from Interaction and segmented models.**

Characteristics of bulls	Interaction model			Segmented model		
	Breeders	Cow-calf operators	Feeders	Breeders	Cow-calf operators	Feeders
Weaning weight: 650 lbs.	0.692	0.562	0.538	0.718	0.604	0.499
Feed efficiency: 10 lbs.	-0.268	-0.268	-0.315	-0.247	-0.312	-0.323
Carcass yield: 61%	0.152	0.152	0.152	0.123	0.161	0.155
Fertility 95%	0.134	0.134	0.092	0.126	0.199	0.131
Milking ability: high	0.309	0.273	0.222	0.346	0.257	0.206

CHAPTER VII

SUMMARY AND CONCLUSIONS

In order for cattle breeders to maximize profits they must select animals with traits that are desirable to producers and final consumers. Unlike feeding or raising animals which can take a year or two, selection activities take 10 to 30 years and an incredible amount of resources in order to yield commercial results. Because resources are committed for a long period of time, it is necessary for breeders to consider, before hand, the economic values or partworth values of their commercial results and attributes selected for breeding.

Most of the techniques used to estimate economic weight of animal attributes are production driven. A profit function (different types of profit functions are used) is differentiated with respect to animal attribute to give economic weights. These economic weights are then used to decide which attributes are to be included in the selection goals. The limitations of the production approach are severe:

1. Economic weights or values are volatile because they are derived from profits which tend to vary from year to year.

2. Derived economic weights are estimates for attributes not levels of attributes. For example, an economic value for a weaning weight attribute does not tell a breeder the premium or discount attached to increasing the weaning weight from one level to the next. Rather it suggests to breeders this particular attribute would yield higher or lower economic value than other attributes.

3. Finally, the production approach does not give breeders an indication on the economic values of animal attributes at different production levels. In

other words, breeders do not know the value of an animal attribute to different producer groups.

The objective of this study was to develop a consumer-driven approach model to estimate the value of animal attributes to cattle producers. Since different producer groups have different preferences, the developed model was used to assess the value that each segment of the industry places on specific animal attributes. These values were then used to identify attributes to be included in breeding objectives. The estimated values from a consumer-driven approach and the economic weights from a production-approach have the same purpose, to provide guidance to breeders so they select traits based on their value rather than heritability or other non-economic grounds. The economic weights and partworth values are both proxies of the market values of traits. Their only difference resides in the approach used to derive them, economic weights are derived from profit functions and partworth values are derived from preference functions.

The model known as conjoint analysis uses the stated preferences of producers to determine economic or partworth values of animal attributes. Producers of beef cattle from Manitoba were surveyed and asked to rate a set of hypothetical bulls and steers which were described to them. Each animal was represented by a 'card' which contained a list of attribute levels describing the animal. The ratings were decomposed using a probit routine.

Two types of coefficients were estimated from the probit routine. The first type of coefficient, which were obtained by deriving producer ratings with respect to animal attributes, were referred to as average partworth values of attribute levels. They represented average preferences of a typical producer surveyed for the animal attributes. The second type of coefficients derived from producer ratings with respect to the interaction variables (a combination of level of attributes and producer profiles) represented incremental partworths associated with producer profiles. Combining the average partworths and incremental partworths due to producers profiles yielded preferences for specific attributes at different levels of the production system.

Because levels of attributes were used in the estimation process, the partworths represented values that producers attached to attribute levels. Hence, it was possible to gauge producers' responses as attribute levels were changed. This information on preferences with respect to variation of attribute levels could be useful to breeders when they want to find out how far they should go in improving one attribute.

Conclusions

This study has three major conclusions. First, stated preferences (ratings) of producers for animals can be used to estimate partworth values or economic weights of the animal attributes. These values, which represent proxies of the market values of each animal trait, were used to determine the relative importance of animal attributes to producers. The following summarizes major components of the first conclusion:

a) Reproduction and production traits, calving ease, milking ability and weaning weight of bull offspring were found to be more important to producers than product traits carcass yield and feed efficiency.

b) Attributes of steers temperament, slaughter weight, weaning weight and feed efficiency were very important to producers. In contrast, carcass yield and muscling were less important.

Second, producer groups (breeders, cow-calf operators, and feeders) attached different values to animal attributes. Cow-calf operators rated calving ease and temperament as most important, while purebred breeders placed the highest value on weaning weight and milking ability. Feeders, on the other hand, have the highest values for slaughter weight and feed efficiency.

Finally, the third main conclusion of this study is that partworth values of attribute levels can be regarded as incremental values to producer preferences when animal attributes are improved. This information could be used by breeders to decide how far they should go on improving the performance level of traits.

Limitations of the Study

The limitations of this study are two fold. The first group of limitations are those that are inherent to conjoint analysis. The results of this study hold only on the range of attributes and levels specified in this study. Using the results to predict partworths of other attributes not included in the design of this study is not valid. Moreover, the number of attributes and their levels to include in the survey has to be limited to allow survey participants to provide reliable data. This implies that not all the attributes of a product can be studied at once. Finally, preferences are an ordinal measure, results of this study are limited to indicating that one attribute is more preferred than other.

The second set of limitations were related to this particular design. Producers were involved, through focus group meetings, in the choice of attributes to include in the study. The levels of attributes were determined without their contribution. Since attribute levels were the actual variables that drive utility in the analysis, a poor choice of attribute levels could affect the relative importance of an attribute. This may have happened for the attribute about fertility of bulls. This attribute was chosen as being the most important attribute by producers from the focus group meetings. However, because the range of attribute levels were 85 to 95 percent, probably not enough from producers' view, the coefficient for each level was relatively small. A wider range, if genetically attainable may have yielded different results.

Topics for Further Research

This study attempted to estimate values that producers place on animal characteristics. A logical extension of this study would be to identify preferences of final consumers of the beef industry. Since producers are expected to deliver products that meet final consumers needs, studying the final consumers' preference for beef attributes such as marbling, types of cuts and so on could make the beef industry more effective in providing products with high value to consumers.

The conjoint analysis technique could also be used to identify preferences in other livestock sectors such as the dairy industry. Milk producers are in a similar situation as their beef producers counterpart. To maximize their profits, milk producers would have to use cows with good milk producing characteristics and milk with qualities required by consumers. Estimations of the values that dairy producers place on different cow traits and the value that consumers attach to different attributes of milk (e.g., protein, fat) could be done using conjoint analysis.

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APPENDIX A. Questionnaire distributed in group meetings

Dear Reader:

Attached is a survey which is important to you and to us.

The Faculty of Agriculture and Food Sciences is conducting a study on the value of characteristics of animals used by commercial beef producers.

We would be most grateful if you could spend a few minutes to fill out the questionnaire.

The information we are collecting could help breeders better identify those characteristics that are important to you.

Thank you for your help.

Section A. Bull's Characteristics

In answering this question consider the importance of the attributes of bulls in terms of how they would affect your operation. For each attribute place a check in one of the blanks on the scale 1 to 5 where (1) is very important, (5) is not important, and (2), (3) and (4) rank importance between the two extremes.

	Very important (1)	(2)	(3)	(4)	Not important (5)
Calving ease	______	______	______	______	______
Birth weight	______	______	______	______	______
Weaning weight	______	______	______	______	______
Post-weaning average daily gain	______	______	______	______	______
Slaughter weight	______	______	______	______	______
Carcass grade	______	______	______	______	______
Carcass yield	______	______	______	______	______
Temperament	______	______	______	______	______
Milking ability	______	______	______	______	______
Fertility of cows	______	______	______	______	______
Fertility of bulls	______	______	______	______	______
Hardiness	______	______	______	______	______
Conformation	______	______	______	______	______
Colour	______	______	______	______	______
Maintenance efficiency of cows	______	______	______	______	______
Size of cows at maturity	______	______	______	______	______
Feed efficiency of feedlot cattle	______	______	______	______	______
Breed	______	______	______	______	______

☞

Section B. Steer's Characteristics

In answering this question consider the importance of the attributes of steers in terms of how they would affect your operation. For each attribute place a check in one of the blanks on the scale 1 to 5 where (1) is very important, (5) is not important, and (2), (3) and (4) rank importance between the two extremes.

	Very important (1)	(2)	(3)	(4)	Not important (5)
Weaning weight	______	______	______	______	______
Post-weaning average daily gain	______	______	______	______	______
Slaughter weight	______	______	______	______	______
Carcass grade	______	______	______	______	______
Carcass yield	______	______	______	______	______
Temperament	______	______	______	______	______
Hardiness	______	______	______	______	______
Conformation	______	______	______	______	______
Colour	______	______	______	______	______
Size of steer at maturity	______	______	______	______	______
Feed efficiency of feedlot cattle	______	______	______	______	______
Breed	______	______	______	______	______

APPENDIX B. Survey instrument

Section A.

Evaluating Bulls Offspring Characteristics

- In this section of the questionnaire we would like you to evaluate bulls with respect to the performance of their offspring. In answering this section, please consider the importance of the bulls in terms of how their offspring would affect your operation.

- Eighteen bulls (represented here by tables) are described in the following pages. Please assume that all these bulls were raised in the same environment and any important characteristics not listed in the tables are the same for all the bulls.

- Please rate each of the bulls on a preference scale 0 to 10 where (0) is for bulls whose offspring are least desirable to have in your operation and (10) is for bulls whose offspring are most desirable to have in your operation. Indicate how you rate each bull by writing your rating (0 to 10) on the line at the bottom of each table (see example below).

Preference Scale

0	1	2	3	4	5	6	7	8	9	10

Least desirable

Most desirable

EXAMPLE

Bull Example

Calving Ease of offspring
Few Assisted

Weaning Weight of offspring
650 lbs.

Feed Efficiency of offspring
8 lbs. of dry matter/lbs. gain

Carcass Yield of offspring
61%

Fertility of female offspring
95%

Milking ability of offspring
High

Make Your Rating Here → **Rating:**__________

Bull 7

Calving ease of offspring
Many assisted

Weaning weight of offspring
650 lbs.

Feed efficiency of offspring
10 lbs. of dry matter/lb. gain

Carcass yield of offspring
57%

Fertility of female offspring
95%

Milking ability of offspring
Low

Rating: ______

Bull 8

Calving ease of offspring
Many assisted

Weaning weight of offspring
450 lbs.

Feed efficiency of offspring
8 lbs. of dry matter/lb. gain

Carcass yield of offspring
61%

Fertility of female offspring
85%

Milking ability of offspring
High

Rating: ______

Bull 9

Calving ease of offspring
Few assisted

Weaning weight of offspring
550 lbs.

Feed efficiency of offspring
9 lbs. of dry matter/lb. gain

Carcass yield of offspring
59%

Fertility of female offspring
90%

Milking ability of offspring
Medium

Rating: ______

Please assume that all these bulls were raised in the same environment and any important characteristics not listed in the tables are the same for all the bulls.

Bull 4

Calving ease of offspring
Many assisted

Weaning weight of offspring
550 lbs.

Feed efficiency of offspring
8 lbs. of dry matter/lb. gain

Carcass yield of offspring
59%

Fertility of female offspring
95%

Milking ability of offspring
Low

Rating: ______

Bull 5

Calving ease of offspring
Few assisted

Weaning weight of offspring
550 lbs.

Feed efficiency of offspring
9 lbs. of dry matter/lb. gain

Carcass yield of offspring
57%

Fertility of female offspring
85%

Milking ability of offspring
High

Rating: ______

Bull 6

Calving ease of offspring
Many assisted

Weaning weight of offspring
450 lbs.

Feed efficiency of offspring
10 lbs. of dry matter/lb. gain

Carcass yield of offspring
61%

Fertility of female offspring
90%

Milking ability of offspring
Medium

Rating: ______

Bull 16

Calving ease of offspring
Many assisted

Weaning weight of offspring
550 lbs.

Feed efficiency of offspring
9 lbs. of dry matter/lb. gain

Carcass yield of offspring
61%

Fertility of female offspring
95%

Milking ability of offspring
High

Rating: ______

Bull 17

Calving ease of offspring
Many assisted

Weaning weight of offspring
650 lbs.

Feed efficiency of offspring
10 lbs. of dry matter/lb. gain

Carcass yield of offspring
59%

Fertility of female offspring
85%

Milking ability of offspring
Medium

Rating: ______

Bull 18

Calving ease of offspring
Few assisted

Weaning weight of offspring
450 lbs.

Feed efficiency of offspring
8 lbs. of dry matter/lb. gain

Carcass yield of offspring
57%

Fertility of female offspring
90%

Milking ability of offspring
Low

Rating: ______

Preference Scale

0	1	2	3	4	5	6	7	8	9	10

Least desirable **Most desirable**

Bull 10

Calving ease of offspring
Few assisted

Weaning weight of offspring
650 lbs.

Feed efficiency of offspring
8 lbs. of dry matter/lb. gain

Carcass yield of offspring
61%

Fertility of female offspring
95%

Milking ability of offspring
Medium

Rating: ______

Bull 11

Calving ease of offspring
Many assisted

Weaning weight of offspring
450 lbs.

Feed efficiency of offspring
9 lbs. of dry matter/lb. gain

Carcass yield of offspring
59%

Fertility of female offspring
85%

Milking ability of offspring
Low

Rating: ______

Bull 12

Calving ease of offspring
Many assisted

Weaning weight of offspring
550 lbs.

Feed efficiency of offspring
10 lbs. of dry matter/lb. gain

Carcass yield of offspring
57%

Fertility of female offspring
90%

Milking ability of offspring
High

Rating: ______

☞

Bull 13

Calving ease of offspring
Few assisted

Weaning weight of offspring
450 lbs.

Feed efficiency of offspring
10 lbs. of dry matter/lb. gain

Carcass yield of offspring
59%

Fertility of female offspring
95%

Milking ability of offspring
High

Rating: ______

Bull 14

Calving ease of offspring
Many assisted

Weaning weight of offspring
550 lbs.

Feed efficiency of offspring
8 lbs. of dry matter/lb. gain

Carcass yield of offspring
57%

Fertility of female offspring
85%

Milking ability of offspring
Medium

Rating: ______

Bull 15

Calving ease of offspring
Many assisted

Weaning weight of offspring
650 lbs.

Feed efficiency of offspring
9 lbs. of dry matter/lb. gain

Carcass yield of offspring
61%

Fertility of female offspring
90%

Milking ability of offspring
Low

Rating: ______

Bull 1

Calving ease of offspring
Many assisted

Weaning weight of offspring
450 lbs.

Feed efficiency of offspring
9 lbs. of dry matter/lb. gain

Carcass yield of offspring
57%

Fertility of female offspring
95%

Milking ability of offspring
Medium

Rating: ______

Bull 2

Calving ease of offspring
Few assisted

Weaning weight of offspring
550 lbs.

Feed efficiency of offspring
10 lbs. of dry matter/lb. gain

Carcass yield of offspring
61%

Fertility of female offspring
85%

Milking ability of offspring
Low

Rating: ______

Bull 3

Calving ease of offspring
Many assisted

Weaning weight of offspring
650 lbs.

Feed efficiency of offspring
8 lbs. of dry matter/lb. gain

Carcass yield of offspring
59%

Fertility of female offspring
90%

Milking ability of offspring
High

Rating: ______

In answering this section what rating did you give to the <u>least</u> desirable bull? ___ and what rating did you give to the <u>most</u> desirable bull?___

☞

Section B.
Information on Your Operation

This section of the questionnaire is related to your operation. Please answer the questions to the best of your knowledge.

1. **Please check the box (es) which best describe your operation**

1.1 Purebred For how long have you been involved in the purebred business? ____ years.

Number of breeding bulls		**Number of females calving annually (Jan-Dec)**		**Annual (Jan - Dec) purebred receipts ($)**	
0 - 5	☐	0 - 10	☐	under 2,500	☐
6 - 10	☐	11 - 20	☐	2,500 - 4,999	☐
11 - 15	☐	21 - 30	☐	5,000 - 9,999	☐
16 - 20	☐	31 - 50	☐	10,000 - 24,999	☐
21 - 25	☐	51 - 70	☐	25,000 - 49,999	☐
26 - 30	☐	71 - 140	☐	50,000 - 99,999	☐
31 - 35	☐	141 - 200	☐	100,000 - 249,999	☐
36 and over	☐	201 and over	☐	250,000 and over	☐

1.2 Cow-calf or Commercial ☐ For how long have you been involved in the cow-calf business? ___years.

Number of cows calving annually (Jan-Dec)		**Annual (Jan - Dec) cow-calf receipts ($)**	
0 - 30	☐	under 2,500	☐
31 - 80	☐	2,500 - 4,999	☐
81 - 120	☐	5,000 - 9,999	☐
121 - 140	☐	10,000 - 14,999	☐
141 - 150	☐	15,000 - 19,999	☐
151 - 160	☐	20,000 - 24,999	☐
171 - 180	☐	25,000 - 29,999	☐
181 - 270	☐	30,000 - 49,999	☐
271 - 530	☐	50,000 - 99,999	☐
531 - 1,127	☐	100,000 - 249,999	☐
1,128 and over	☐	250,000 and over	☐

☞

1.3 Fed Cattle ☐

1.3.1 Concentrated feeding ☐ Backgrounding ☐

For how long have you been involved in fed cattle activities? _____ years.

One time capacity		Number fed cattle sold per year		Annual (Jan - Dec) fed cattle cash receipt ($)	
0 - 49	☐	0 - 49	☐	under 50,000	☐
50 - 100	☐	50 - 100	☐	50,000 - 99,000	☐
101 - 200	☐	101 - 250	☐	100,000 - 249,999	☐
201 - 450	☐	251 - 500	☐	250,000 - 499,999	☐
451 - 600	☐	501 - 1,000	☐	500,000 - 999,999	☐
601 - 750	☐	1,001 - 1,500	☐	1,000,000 - 1,499,999	☐
751 - 1,000	☐	1,501 - 3,000	☐	1,500,000 - 2,999,999	☐
1,001 - 1,500	☐	3,001 - 3,500	☐	3,000,000 - 3,499,999	☐
1,501 and over	☐	3,501 and over	☐	3,500,000 and over	☐

1.4 **Other Agricultural Production**

Forage crops_____ All other crops_____ All other animal production_____

(grain, oil seed, etc.) (dairy, poultry, swine, etc.)

2. **Please check the box which best describes your total farm receipts ($)**

Total annual (Jan-Dec) farm receipts ($)	
under 50,000	☐
50,000 - 74,999	☐
75,000 - 99,999	☐
100,000 - 149,999	☐
150,000 - 249,999	☐
250,000 - 499,999	☐
500,000 - 999,999	☐
1,000,000 - 1,499,999	☐
1,500,000 - 2,999,999	☐
3,000,000 - 3,499,999	☐
3,500,000 - 4,999,999	☐
5,000,000 and over	☐

☞

3. **Please check the box which corresponds to the largest source of your receipts**

Fed cattle ☐ Cow-calf ☐ Purebred ☐ Non cattle operation ☐

Explain:____

____

4. **Please check the appropriate answer to the following questions**

4.1 In your farm activities, are you primarily a cattle operator ?

☐ Yes ☐ No

4.2 Are you involved in off-farm employment or a nonfarm business?

☐ Yes ☐ No

4.3 Are you a member of any cattle performance recording program (e.g, R.O.P, breed associations, home computer programs, or home records)?

☐ Yes ☐ No

4.4 List cattle performance recording program(s) to which you belong:

____

____

____

____

4.5 Do you use data from any cattle performance recording program (e.g, R.O.P. breed associations, home computer programs, or home records) to make purchasing decisions?

☐ Yes ☐ No ☞

4.6 **Please check the appropriate box (es) to indicate how often you use information from cattle performance recording programs. Extra lines are provided if you wish to add other cattle performance recording programs to complete the list.**

Sources	Very often	Often	Not often	Not used	Not familiar with Programs
Record of Performance (ROP)	[ ]	[ ]	[ ]	[ ]	[ ]
Bull Test Station Data	[ ]	[ ]	[ ]	[ ]	[ ]
Expected Progeny Difference (EPD)	[ ]	[ ]	[ ]	[ ]	[ ]
Home Computer Programs	[ ]	[ ]	[ ]	[ ]	[ ]
Home Records	[ ]	[ ]	[ ]	[ ]	[ ]
________________	[ ]	[ ]	[ ]	[ ]	[ ]
________________	[ ]	[ ]	[ ]	[ ]	[ ]

4.7 **Of the cattle performance recording program (s) that you may get information from, please check the appropriate box (es) to indicate your level of confidence.**

Sources	Very Confident	Confident	Not Confident	Not Applicable
Record of Performance (ROP)	[ ]	[ ]	[ ]	[ ]
Bull Test Station Data	[ ]	[ ]	[ ]	[ ]
Expected Progeny Difference (EPD)	[ ]	[ ]	[ ]	[ ]
Home Computer Programs	[ ]	[ ]	[ ]	[ ]
Home Records	[ ]	[ ]	[ ]	[ ]
________________	[ ]	[ ]	[ ]	[ ]
________________	[ ]	[ ]	[ ]	[ ]

4.8 **Please provide any comments that you wish about the cattle performance recording programs or information sources you have used**

____

____

____

5 **Please check <u>one</u> box to indicate which one of the following bull offspring characteristics is more important in your operation**

Calving ease [ ]   slaughter weight [ ]

Section C
Evaluating Steers

- In this section of the questionnaire, we would like you to evaluate steers with respect to their characteristics. In answering this section consider the importance of the steers in terms of how they would affect your operation.

- Eighteen different steers (represented here by tables) are described in the following pages. Please assume that all these steers were raised in the same environment and any important characteristics not listed in the tables are the same for all the steers.

- Please rate each one of the steers on a preference scale 0 to 10 where (0) is for steers which are least desirable to have in your operation and (10) is for steers which are most desirable to have in your operation. Indicate how you rate each steer by writing your rating (0 to 10) on the line at the bottom of each table (see example below).

Preference Scale

0	1	2	3	4	5	6	7	8	9	10

Least desirable **Most desirable**

EXAMPLE

Steer Example

Carcass Yield
57%

Conformation
Light muscling

Weaning Weight
650 lbs.

Slaughter Weight
1,000 lbs.

Feed efficiency
8 lbs. of dry matter/lbs. gain

Temperament
Difficult to handle

Make Your Rating Here → **Rating:**____________

Steer 13	Steer 14	Steer 15
Carcass yield **61%**	Carcass yield **59%**	Carcass yield **57%**
Conformation **Medium muscling**	Conformation **Medium muscling**	Conformation **Medium muscling**
Weaning weight **650 lbs.**	Weaning weight **450 lbs.**	Weaning weight **550 lbs.**
Slaughter weight **1,400 lbs.**	Slaughter weight **1,000 lbs.**	Slaughter weight **1,200 lbs.**
Feed efficiency **8 lbs. of dry matter/lb. gain**	Feed efficiency **9 lbs. of dry matter/lb. gain**	Feed efficiency **10 lbs. of dry matter/lb. gain**
Temperament **Easy to handle**	Temperament **Difficult to handle**	Temperament **Easy to handle**
Rating: ______	**Rating:** ______	**Rating:** ______

Please assume that all these steers were raised in the same environment and any important characteristics not listed in the tables are the same for all the steers.

Steer 10	Steer 11	Steer 12
Carcass yield **59%**	Carcass yield **57%**	Carcass yield **61%**
Conformation **Heavy muscling**	Conformation **Heavy muscling**	Conformation **Heavy muscling**
Weaning weight **550 lbs.**	Weaning weight **650 lbs.**	Weaning weight **450 lbs.**
Slaughter weight **1,000 lbs.**	Slaughter weight **1,200 lbs.**	Slaughter weight **1,400 lbs.**
Feed efficiency **8 lbs. of dry matter/lb. gain**	Feed efficiency **9 lbs. of dry matter/lb. gain**	Feed efficiency **10 lbs. of dry matter/lb. gain**
Temperament **Easy to handle**	Temperament **Easy to handle**	Temperament **Difficult to handle**
Rating: ______	**Rating:** ______	**Rating:** ______

Steer 16

Carcass yield
57%

Conformation
Light muscling

Weaning weight
550 lbs.

Slaughter weight
1,400 lbs.

Feed efficiency
8 lbs. of dry matter/lb. gain

Temperament
Difficult to handle

Rating: ______

Steer 17

Carcass yield
61%

Conformation
Light muscling

Weaning weight
650 lbs.

Slaughter weight
1,000 lbs.

Feed efficiency
9 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

Steer 18

Carcass yield
59%

Conformation
Light muscling

Weaning weight
450 lbs.

Slaughter weight
1,200 lbs.

Feed efficiency
10 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

Preference Scale

0	1	2	3	4	5	6	7	8	9	10

Least desirable **Most desirable**

Steer 4

Carcass yield
59%

Conformation
Medium muscling

Weaning weight
650 lbs.

Slaughter weight
1,200 lbs.

Feed efficiency
8 lbs. of dry matter/lb. gain

Temperament
Difficult to handle

Rating: ______

Steer 5

Carcass yield
57%

Conformation
Medium muscling

Weaning weight
450 lbs.

Slaughter weight
1,400 lbs.

Feed efficiency
9 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

Steer 6

Carcass yield
61%

Conformation
Medium muscling

Weaning weight
550 lbs.

Slaughter weight
1,000 lbs.

Feed efficiency
10 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

☞

Steer 1

Carcass yield
57%

Conformation
Heavy muscling

Weaning weight
550 lbs.

Slaughter weight
1,000 lbs.

Feed efficiency
8 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

Steer 2

Carcass yield
61%

Conformation
Heavy muscling

Weaning weight
550 lbs.

Slaughter weight
1,200 lbs.

Feed efficiency
9 lbs. of dry matter/lb. gain

Temperament
Difficult to handle

Rating: ______

Steer 3

Carcass yield
59%

Conformation
Heavy muscling

Weaning weight
650 lbs.

Slaughter weight
1,400 lbs.

Feed efficiency
10 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

Steer 7

Carcass yield
61%

Conformation
Light muscling

Weaning weight
450 lbs.

Slaughter weight
1,200 lbs.

Feed efficiency
8 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

Steer 8

Carcass yield
59%

Conformation
Light muscling

Weaning weight
550 lbs.

Slaughter weight
1,400 lbs.

Feed efficiency
9 lbs. of dry matter/lb. gain

Temperament
Easy to handle

Rating: ______

Steer 9

Carcass yield
57%

Conformation
Light muscling

Weaning weight
650 lbs.

Slaughter weight
1,000 lbs.

Feed efficiency
10 lbs. of dry matter/lb. gain

Temperament
Difficult to handle

Rating: ______

In answering this section what rating did you give to the least desirable steer? ___ and what rating did you give to the most desirable steer?___

☞

Section D. Personal Information

This is the final section of the questionnaire. We would like to ask some questions about your personal background.

5. **Gender**

   male ☐ female ☐

6. **Please indicate your age range**

   < 20 ☐ 21-35 ☐ 36-54 ☐ 55-70 ☐ >70 ☐

7. **Please indicate the number of years you have been involved in the beef cattle production as an owner and/or an operator.**

Activities	Number of years of Experience as Owner/Operator
Purebred	____years
Cow-calf	____years
Fed cattle	____years

8. **Please check the appropriate boxes indicating your educational background**

8.1 Grade school ☐ High school ☐

High school graduate ☐ Short courses, seminars ☐

8.2 Post High school education ☐ Technical degree ☐

8.3 University programs

Degree ☐ Diploma ☐ did not complete ☐

8.4. Did you major in agriculture at university?

☐ No ☐ Yes

APPENDIX C. **Frequency distribution of respondents involved in breeding activities**

Number of purebred females calving annually	Number of respondents	Percentage of the total sample
Less than 20	32	14.7
Between 20 and 70	46	21.2
Greater than 70	27	12.4
Total	105	48.4

APPENDIX D. Frequency distribution of respondents involved in cow-calf activities

Number of cows calving annually	Number of respondents	Percentage of the total cow-calf operators
Less than 80	97	44.7
Between 80 and 150	45	20.1
Greater than 150	20	9.2
Total	162	74.7

APPENDIX E. **Frequency distribution of respondents involved in cattle feeding activities**

Number of fed cattle sold annually	Number of respondents	Percentage of total feeders
Less than 80	31	14.3
Between 100 and 500	49	22.6
Greater than 500	9	4.5
Total	89	41.1