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Title of Thesis: Quality Factors Affecting the Value of Beef in Kenya: An Assessment of Relevant Attributes and Alternate Methodologies

Degree: Doctor of Philosophy

Year this Degree Granted: 1997

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August 7, 1997

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Quality Factors Affecting the Value of Beef in Kenya: An Assessment of Relevant Attributes and Alternate Methodologies

by

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy

in

Agricultural Economics

Department of Rural Economy

Edmonton, Alberta

Fall 1997

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **"Quality Factors Affecting the Value of Beef in Kenya: An Assessment of Relevant Attributes and Alternate Methodologies"** submitted by **Joseph Thuo Karugia** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** in **Agricultural Economics.**

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Dedication

To my parents

Abstract

In order to identify and estimate the implicit values of quality attributes of Kenyan beef, revealed preference data on carcass prices and attributes and experimental choice data on butchers' contingent behaviour are collected and analysed. Three different methodological approaches are applied to derive estimates of implicit values; (i) a hedonic price model based on revealed preference data, (ii) a discrete choice model of butchers market choices, and (iii) a model of butchers' stated preferences. The three approaches are assessed and compared. Collinearity is evident in the revealed preference data and is avoided by experimental design in the stated preference data. However, the results from the three models are generally consistent. The results show that carcass damage and the quality attributes of carcass conformation, fatness, and weight are important in determining the value of a beef carcass at the wholesale level. Improvements in the handling of animals to reduce animal stress and visible damage on the carcass would increase carcass value. Carcass conformation is the most important of the carcass attributes. There seem to be optimal levels of carcass fatness and weight above which carcass prices are discounted. The results indicate that efforts by farmers, livestock traders and animal breeders to improve these quality attributes could increase the value of carcasses. These attributes could also be used for the establishment of a carcass grading or classification scheme that is economically meaningful. Comparison of the three approaches to characteristic valuation demonstrate their relative weaknesses and strengths. It is suggested that a model that combines the revealed and stated preference data sets may provide an opportunity to exploit the strengths and avoid the weaknesses of each data set

Acknowledgements

I am greatly indebted to the many individuals and institutions that supported me throughout the course of this study. Sincere gratitude is expressed to Dr Michele Veeman, my supervising professor, for her academic guidance and support during my graduate program. Michele, your insight, dedication, and patience made this undertaking a very rewarding experience.

My special gratitude is extended to my supervisory committee members, Dr Wiktor Adamowicz, Dr Mick Price, and Dr Terry Veeman for their valuable advice, suggestions, and comments. Vic provided invaluable technical advice on discrete choice analysis, Mick exposed me to the world of meat science, while Terry ensured that the developmental implications of the study never took a back seat. Dr Merle Faminow of the University of Manitoba made insightful comments that greatly improved the thesis. I am grateful for these insights. My thanks go to Dr E. Kang'ethe of the University of Nairobi for providing much needed lessons on carcass evaluation. Thanks also to Charles Njiri and Veronica Wairimu for their assistance in collecting the data for the study.

Special thanks go to the graduate students, support staff, and academic staff of the Department of Rural Economy. Your friendly companionship and willingness to help made my stay in the department a truly enjoyable one.

A vote of thanks goes to the Kenya-Canada General Training Program for the financial support that enabled me undertake and complete the graduate program. Thanks to the University of Nairobi, my employer, for granting me study leave.

Finally, my inexpressible thanks to my wife, Lucy, and my children, Eddy and Ronny for their unrelenting love, encouragement, and understanding throughout my graduate program. Your support and patience, made the difficult times bearable. Our families in Kenya provided inspirations and encouragement that we found invaluable and made our stay in Canada seem shorter. Thanks everybody.

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Chapter I

Introduction and Problem Statement

1.1 Background

Equitable and efficient agricultural markets are vital for rural development. In many policy papers the Government of Kenya has recognized the importance of remunerative prices to agricultural producers and adequate supply of quality products to consumers (see for example, Kenya, 1980; 1981; 1986; and 1988). To ensure the maximum welfare of all producers and all consumers, marketing costs should not be unnecessarily high. In this regard, judicious investment in physical and institutional infrastructure that has public good attributes can aid the performance of a marketing system. Such improvements in the marketing system can be expected to contribute to both economic and agricultural development. Eicher and Baker (1990) note that in developing countries, effective marketing systems cannot be expected to evolve automatically and that at some stage, efforts by public agencies to stimulate the development of effective internal markets may become crucial to development.

During the past decade, the livestock-meat sector in Kenya has undergone substantial liberalization with the markets being subjected to the forces of supply and demand much more than formerly. It is hoped that liberalization will foster a more efficient allocation of resources thereby increasing both producer and consumer welfare. To achieve net social benefits the market must be efficient.

A major policy change to take place in the last decade is the policy of price decontrol for red meat which was effected in February 1987. The announcement of this policy was met with mixed reactions from many interest groups, including legislators, trade unions, and producer groups. Some groups felt that deregulation would improve the welfare of both producers and consumers while some contended that butchers would exploit consumers (Karugia, 1990). The government's position was that price deregulation would ensure adequate returns to producers and that this would attract investment in beef production. Many studies of the Kenyan livestock-meat sector had identified price regulation as an important obstacle to improved performance of the sector (for example, Kivunja, 1976; Tewoldeberhan, 1976; Chemonics International Consulting Division, 1977).

The expressed fears of consumer exploitation indicated that some people did not expect the market to perform efficiently, i.e., they feared that the possibility of market failure existed. Karugia (1990) investigated the structure of the beef retailing system in Nairobi and concluded that the market was not competitive mainly due to a lack of market information and high entry barriers. The conclusions of this study supported the claim that butchers could earn monopoly profits. It was concluded that competition could be enhanced by improving the level of market information available to participants in the beef market. It was recommended that while the government is expected to play a lesser role in setting beef prices, it should be actively involved in improving the integration of markets to improve the ability of markets to respond to changes in demand and supply conditions.

One prerequisite for effective operation of a marketing system and for rational decision-making by participants is access to adequate and reliable information (Sorenson, 1964). In Kenya, the Ministry of Agriculture has made progress in improving the range and accuracy of market information. However, relatively little information has traditionally been available in the livestock-meat sector. Karugia (1990) attributed the low level of information in the beef market to be due in part to a lack of grades and standards. An effective market information program would be assisted by the use of grades and standards or a classification scheme.

In the case of beef at the wholesale level, it is generally believed that butchers are interested in saleable yield, age, fatness, carcass conformation, and appearance as represented by marbling, colour of muscle and fat, and texture and firmness of muscle and fat (Gregory, 1994; Price, 1995). The specific carcass attributes emphasized will vary from market to market depending on market practices and consumer preferences.

Grading of beef in Kenya was done only by the publicly owned Kenya Meat Commission which supplied most of beef in urban areas. The practice appears to have been gradually abandoned as deregulation allowed privately owned marketing firms to become more important in the beef market. In contrast, beef grades and standards apply in many countries including Australia, Canada, European Union, Zimbabwe, and the United Sates. In cases where grading problems have been experienced, they seem to have been associated with the use of inappropriate product characteristics, a lack of buyer education on the information content of grades, and a tendency to institutionally rank grades or some combination of all three (see for example Considine et al., 1986; Cox et al., 1990; Stanley et al., 1991). There is considerable ongoing debate, especially in meat science, on the merits of grading verses classification of beef carcasses (Everitt and Evans, 1970; Ryan, 1970; Price, 1982, 1995). Considine et al. present an agricultural economics view point on this debate. Grading, in its simplest form, is the separation of a commodity into lots, each lot having relatively high degree of uniformity in certain characteristics associated with market preferences and value (McCoy, 1979). Classification, on the other hand, is the description of a carcass on the basis of important traits. The traits are "scored" objectively or subjectively and the scores represent ranges of values rather than precise numbers (Price, 1995). In this thesis the term grading will be used as a generic term for evaluative systems and includes grading and classification schemes. As discussed in Section 1.2, the purpose of this study is limited to the determination of the important carcass attributes and their valuation. The decision on the type of evaluative scheme to use in grading carcasses requires input from both animal scientists and agricultural economists.

1.2 Problem Statement

As observed by Tomek and Robinson (1992), two important issues arise when establishing a grading system. One is to determine the attributes of the product that should be used as a basis for defining grades. Given information on the attributes, a second issue concerns how such information should be used and reported. These issues can only be addressed sequentially since the answer to the second depends on the answer to the first. The task in this study is to attempt to provide an answer to the first question. The second question requires combined inputs from economists and meat scientists.

For grades to be economically meaningful, the attributes used to define grades must be related to the demands for the product. Using an indifference analysis approach, Freebairn (1967) has demonstrated that if grading is to increase buyer satisfaction, it is necessary to establish that proposed grade specifications reflect those quality characteristics of the commodity which are important to a significant number of buyers. Only those units of a commodity which buyers value differently and can distinguish as having different uses or levels of usefulness, i.e., utility, should be classified in different grades. There is, therefore, a need to build grade standards on factors and terminology that will make grades meaningful to as many users of the product as possible. Helmberger et al. (1981) suggest that ideally, the same grade terminology should be used at all levels of the marketing channel from consumers to producers. Standards should be built on factors that can be accurately and uniformly measured and interpreted.

The above arguments suggest that determining the quality characteristics that are important to most beef buyers and their valuation of these attributes are important. The relevant level of demand for the determination of beef characteristic values can be at the primary demand stage of consumer-level demand. Alternatively, the relevant level may be the derived demand of the initial or subsequent buyer. This study focuses on the wholesale derived demand for beef. To achieve the objectives of the current study, three interrelated approaches to characteristic valuation are employed. The first approach uses the hedonic price framework to determine the carcass attributes that influence price and estimate the values to butchers of these attributes. This approach uses observed market data. In the second approach, observed choice behaviour of butchers is analysed using the discrete choice framework. The third approach, also formulated in a discrete choice framework, uses hypothetical market data generated through a stated preference survey to analyse butcher contingent behaviour.

1.3 Organization of the Study[1]

The rest of this thesis is organized as follows. In Section 1.4 a brief review of literature on the economics of grades and standards is presented. Chapter II presents the hedonic price analysis of beef carcass attributes. An overview of the hedonic price analysis is presented in Section 2.2. Section 2.3 presents the theoretical basis of the hedonic price model. The data used for the analysis are discussed in Section 2.4 and the results of the analysis are presented in Section 2.5. Section 2.6 concludes the chapter. In Chapter III the discrete choice analysis of revealed butcher behaviour in their choice of carcasses is presented. Section 3.1 introduces the problem to be analysed and Section 3.2 presents a brief overview of the discrete choice analysis methodology as it is applied in economic and marketing analysis. In Section 3.3, the theoretical foundations of the Multinomial Logit (MNL) model and its algebraic derivation are presented. A discussion of the data used for the discrete choice analysis is provided in Section 3.4. Results of the MNL analysis of revealed butcher behaviour are presented and discussed in Section 3.5. Section 3.6 concludes Chapter III.

Chapter IV is a presentation of the discrete choice analysis of butcher contingent behaviour based on their stated preferences. The problem analysed is presented in Section 4.1. Section 4.2 provides an overview of the stated preference methodology. The experimental data collection procedure used and the empirical models considered are

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[1] This thesis is prepared according to the paper format where individual studies are presented in separate papers.

discussed in Section 4.3. Results of the MNL analysis of butcher contingent behaviour are presented and discussed in Section 4.4. Section 4.5 concludes Chapter IV.

In Chapter V, a general discussion and conclusions obtaining from the three analyses are presented.

1.4 The Economics of Grades and Standards

The purpose of this section is to give an overview of the analytical and conceptual procedures for evaluating the benefits and costs of grading but not to attempt an exhaustive review of the economics of grading and standardization. The procedures also help to evaluate the impacts of grading on market participants.

The are five potential contributions of a grading system to a marketing system, as outlined below:

(a) it can increase the information set available to market participants;

(b) it can cause a reduction in operational costs by facilitating buying and selling by description;

(c) it can enhance competition by changing market structure;

(d) it can increase consumer welfare by matching product characteristics to consumer preferences,

(e) it can increase producer welfare by causing outward shifts to demands (Freebairn, 1967, Helmberger et al., 1981).

Helmberger et al. (1981) observe that a grading system would help maximize economic gains from marketing if, among other things, a basis and need for grading exist. These conditions will be met if there are (a) distinct or potentially separable demand functions, based on real rather than illusory differences in the product, and (b) if in the absence of grades consumers, marketing firms or both cannot accurately distinguish significantly large differences in basic quality attributes or differences in combinations of these attributes. The list of conditions suggested by Helmberger et al. (1981) appears to be incomplete as it fails to consider the gains achievable if grading by a public agency is less costly than when individual market participants attempt to discover the information on their own. It is worth noting that the task of determining the existence of the conditions listed above is not trivial.

In the case of beef at the point of consumption, it is generally believed that consumers are interested in juiciness, flavour, and tenderness, as well as the price they must pay. Beef that has different levels of these attributes is produced and available to consumers. Separable demand functions based on these attributes might exist. However, consumers may have difficulty distinguishing different levels of these attributes from visual inspection. In this respect, beef could be classified as an "experience" good following Nelson's (1970) classification. At the wholesale level, butchers are generally thought to be interested in salable yield, age of the animal, carcass fatness, carcass conformation, and appearance as represented by the degree of marbling, colour of muscle and fat, and texture and firmness of muscle and fat (Gregory, 1994; Price, 1995). The specific carcass attributes emphasized may vary from market to market depending on market practices and consumer preferences.

It is difficult to implement an empirical study to investigate all the effects of introducing a grading scheme and the author is not aware of any such studies. Most of the post-World War II work on grades and standards involves applied research relating to improving pricing efficiency (Helmberger et al., 1981) . These authors provide a good survey of this literature. An important observation from their survey is that studies that have examined the economic effects of United States Department of Agriculture (USDA) grades for beef documented that grades based on uniform standards reduced market concentration, reduced product differentiation in fresh meat sales, and increased price competition at various points in the marketing channel.

Few theoretical works have been published on the economics of grades and standards. Consequently, only a few representative assessments will be reviewed here. According to Cox et al. (1990), retail-level consumers benefit from an effective agricultural grading system that reduces search and transaction costs, saving consumers both time and money. In addition to providing consumer information, grading facilitates marketing and pricing efficiency between producers and various segments of the processing and distribution system.

Cox et al. (1990) concur with Freebairn (1967) who lists three inducements to grading a commodity as: (a) to increase producers' returns; (b) to increase buyers' satisfaction, and (c) to increase marketing efficiency. He regards the decision to grade a commodity as a market innovation which may affect all members of the market including, producers, buyers and merchants. Moreover, grading will affect market conduct and performance since it entails a change in market structure. By considering grading as a market innovation, Freebairn (1967) constructs a framework that is able to trace the dynamics of buyer, producer, and market adjustment to the grading innovation.

Freebairn (1967) uses indifference analysis to show that introducing a grading scheme may allow buyers to move to higher indifference curves for a given budget. He concluded that grading may either increase the utility of buyers or leave it unchanged. He notes that for commodities used as inputs, grading may increase buyer satisfaction indirectly by increasing the physical operating efficiency of the processing or input using household or firm.

If grading increases consumer satisfaction, it may lead to a shift to the right of the demand schedule for the graded commodity. If this occurs, buyers are prepared to offer an aggregate price for a given aggregate quantity of the graded commodity which exceeds the price they are prepared to pay for the ungraded commodity. Further, demand may shift as additional buyers are attracted to the market by the increased value of the commodity to potential buyers. In terms of producer returns, the effects of grading as suggested by Freebairn's framework are variable and difficult to assess. However, since the aggregate demand schedule for the graded commodity will in general lie to the right of the demand schedule for the ungraded commodity some, if not all, producers can be expected to receive a higher level of returns in all adjustment periods following the grading innovation.

Freebairn (1967) also points out that grading may lower the cost of providing various marketing services, e.g. market reporting, storage, transport, and financing by: (a) making possible buying and selling by description, (b) the provision of a common language for buyers, sellers, and market reporters; (c) by eliminating the time and expense of arguments over quality; and (d) by allowing the pooling and intermingling of products for transport and storage. If this is the case, *ceteris paribus* and with competition in the provision of marketing services, grading will lead to a decrease in marketing margins. Freebairn (1967) uses a utility based concept of net social cost to show that improved market knowledge attributable to grading can improve the allocation of resources. In terms of increasing market efficiency he concludes that in general, standardized grades will result in increased emphasis being placed on price competition. In a two-sector world, this effect would generally favour buyers and reduce the opportunities for producers to earn monopoly profits. In a three-sector world consisting of primary producers, marketers, and consumers, benefits to consumers will depend on the extent to which marketing margins are reduced and the degree of competition at the intermediate level of the marketing chain. If grading is effected at the consumer level, benefits similar to those accruing to the intermediaries should be expected.

In summary, Freebairn's (1967) analysis shows that such a grading innovation will be desirable from the buyers' point of view since no buyers are made worse off and the utility of others is increased. With respect to producers, grading innovations may increase the returns of some producers but reduce the returns of others. Considered in aggregate, society's utility should be increased by an appropriate grading innovation via a more efficient allocation of resources which grading facilitates by increasing the level of market knowledge.

A second study by Freebairn (1973) evaluates the potential effects of a uniform meat grading scheme in terms of a change in the state of information. According to this study, a system of uniform grades applied to a heterogeneous commodity set may alter the information state under which market transactions take place. Two assumptions underlie Freebairn's analysis. First, some, but not necessarily all, buyers distinguish between different units of the commodity. Secondly, market participants have less than perfect knowledge about the characteristics and the prices of different units of the commodity. Such imperfect knowledge is perpetuated in part by frequent shifts in the underlying supply and demand functions. Using a framework for evaluating the economic services of information, the effects of a grading scheme are assessed in terms of the effects on (i) the efficiency of market participants' decision making, (ii) the extent and level of information communication, and (iii) the resources spent on enquiry into information about the commodity set.

Freebairn (1973) identifies three factors to which the potential effects on a market participant's behaviour of the information provided by a grading scheme may be traced. First, in the absence of perfect knowledge the decision maker is not always able to choose the *ex post* optimum subset(s) of the commodity set to trade and the amount of each to trade. Second, under conditions of uncertainty, it may be rational for market participants to expend resources on information search. Third, imperfect information may induce decision makers to undertake various forms of risk averting behaviour.

Ex post decision losses arise from actual decisions being different from those decisions which would have been optimum if the decision maker had had perfect knowledge. Such sub-optimal decisions involve some utility loss to market participants.

More information on the prices and characteristics of a heterogeneous commodity would reduce these *ex post* losses.

Freebairn appeals to studies by Stigler (1961; 1962) and McCall (1970) and observes that a potential rationale exists for resource expenditure on information search under conditions of imperfect knowledge. The expected gain from a marginal increase in resource expenditure on information search will be greater the greater the dispersion of the decision maker's probability distribution function for the price and/or characteristics of the commodity being traded. It may be argued that the information provided by a uniform grading scheme would reduce the dispersion of the decision maker's prior probability distribution for the grade price differential and for the characteristics of the units he/she buys or sells. Consequently, less resources would be allocated to information search. This saving would be treated as a benefit of a uniform grading scheme.

A third aspect of the potential effects of a grading system on individual market participant's behaviour is related to risk averting behaviour under conditions of uncertainty. In the typical case where firms have concave utility functions, the output which maximizes expected utility is less than the perfect knowledge output level. Further, the more dispersed the firm's perceived probability distribution function for the unknown terms of the decision problem, the smaller will be the output level which maximizes expected utility. Changes in the information state, therefore, would be expected to shift the aggregate supply function for different grades of the commodity set. Even if a grading system does not change producers' estimate of the average market price, the greater level of market knowledge facilitated by a grading scheme should shift the supply curve outwards.

The informational usefulness of a grading system can be extended to public policy. The information generated by a grading scheme might be used to facilitate the effectiveness of public policy making with respect to the production, consumption and trade of the commodity.

A uniform grading scheme may reduce the aggregate cost incurred in acquiring information and communicating it to market participants. To some extent a grading scheme would replace information search activities by individuals. This would occur only if market participants find the information provided by the grading scheme to be a satisfactory substitute for that being obtained by their current information search activities. According to Freebairn (1973), potential information cost savings would flow from two broad directions. First, a uniform grading scheme may give rise to cost economies in collection and transmission of information. Second, a uniform grading scheme based on fixed classification standards may reduce the errors of information transfer and simplify analysis of data. The simplifying aspects of such a procedure may be compared to situations with a multitude of trade names and to informal evaluation procedures based on local and perhaps more pliable classification criteria.

In terms of aggregate market performance, a uniform grading scheme has the following potential effects. First, a grading scheme may help eliminate some biases in the market information on which participants base their decisions. Second, a grading scheme may enable decision makers to increase their ability to predict grade price differentials so that *ex post* forecast variance of these predictions is reduced.

Freebairn's (1973) analysis does not adequately address the possibility that a system of uniform grades may alter the underlying supply and demand functions for the different grades of the commodity set. Introduction of a grading scheme may tend to shift outwards the market demand and supply curves. In the case of a supply curve shift, consumer surplus would be increased and the effect on producers' quasi-rent would depend on the demand elasticity and on the nature of the supply curve shift.

According to Stigler's (1961) cost-benefit approach to the acquisition of information, when consumers cannot visually distinguish among different grades of a good prior to purchase, the cost of search activity may be quite high. Innovations that lower the cost of search will tend to increase the amount of search activity and, presumably, result in the consumer purchasing a higher quality good. Search costs can be reduced by use of grades which provide additional information prior to search. Information prior to purchase may be especially crucial in the marketing of beef because (a) buyers of beef may not all agree on a definition of quality and (b) buyers may have difficulty distinguishing among beef grades from visual inspection.

Bowbrick (1982) urges a more cautionary approach to attempts to develop models of grades that would be applicable to all markets. He argues that many models are based on unrealistic assumptions which limit their applicability to addressing real world problems. This inspires him to assemble a set of theoretical and conceptual approaches which he argues are capable of being developed to solve the problems of the real world as they relate to buyer purchasing. Bowbrick refers to approaches that cover a wide range of issues including those that view grading as a communications problem, effects of a change in grade specifications, market segmentation, and design of optimal grading schemes.

Bowbrick (1982) regards as satisfactory analyses that view grading as a means of reducing search costs for buyers. His approach here is similar to that of Freebairn (1973). He, however, discounts gains to consumers that would accrue from buying on description for many commodities. He argues that for many commodities, consumers are interested in much more than the information contained in grades. On the aspect of changes in grading specifications, he agrees with Freebairn (1967) that such changes will affect the supply and demand functions for the product. He is, however, of the view that it is futile to try to use *ex ante* data to predict the effects of introducing a grading system throughout the market.

According to Bowbrick (1982) market segmentation is a possible benefit of grading which can increase effective demand for a commodity and also enable producers to earn monopoly profits He laments, however, that attempts to identify market segments have been hampered by the use of techniques that are too refined for the data. Attempts to develop optimal grading schemes are beset with many obstacles. Bowbrick attributes this state of affairs to inconsistencies between the assumptions of the theoretical models of grading and the conditions of real world markets. Many of these problems arise from the assumptions made about the number and nature of attributes. For instance, attributes may be categorical rather than continuous, technological substitutes, and/or economic substitutes. Many theoretical models assume single continuous attributes and do not consider attribute substitutability.

Bowbrick's (1982) analysis raises important issues that deserve consideration in deciding whether to grade or not to grade a commodity. There are indeed commodities for which introduction of uniform grades would not serve a useful economic purpose. As he noted, it is safer to consider commodities on a case by case basis when making policy decisions. His observation that a grading scheme should be formulated to achieve a specific purpose, though desirable, may not be a practical option. Any grading scheme will likely have numerous effects, intended and unintended, on the market. Models that consider overall economic effects are infinitely better suited to guide decisions on grading. Unfortunately, to date research in this area has been limited.

Zusman (1967) has addressed the issue of the establishment of grade boundaries. He defined the individual quality valuation curve (IQVF) as the marginal rate of substitution between the commodity with equal characteristics and a numeraire defined as a composite good representing all other commodities. The upper envelope to the IQVF's defines the market quality valuation curve (MQVF). Under a competitive market structure, the grade boundaries would be placed at the points of intersection of the IQVF's on the MQVF. Zusman (1967) suggests that the MQVF can be estimated through hedonic price analysis.

Considine et al. (1986) have examined the effects of changes in the specifications of the beef grading system in existence in Canada in 1972. These authors found considerable adjustment costs to producers. Their analysis showed that industry revenue declined immediately following the introduction of new specifications and that adjustment took ten years. The changes had been effected in response to changes in consumer preferences. Following adjustment, industry revenues increased substantially as production conformed better with market requirements. The analysis by Considine et al. (1986) demonstrates the perils of constructing beef grades that convey ordinal rankings. They conclude that a grading scheme will be more useful in enhancing market performance and increased pricing efficiency if it is established so as to convey information to buyers about the characteristics of the product. Considine et al. (1986) argue that this may best be achieved by a carcass classification scheme. Numbers of meat scientists agree with this view (see for example, Everitt and Evans, 1970; Ryan, 1970; Price, 1982, 1995). At the same time, a classification scheme would remove the need for dramatic adjustments as buyer preferences change. Buyers would express their preferences for beef with different amounts of the characteristics by purchasing more of that product. Changes in relative prices would provide the signal to adjust production and adjustments would be gradual.

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CHAPTER II

The Hedonic Approach and Butchers' Valuation of Beef Attributes

2.1 Introduction

The value of beef, as with most products, is influenced by the interaction of many factors. Knowledge of the value of specific quality attributes is valuable information for the establishment of a grading system that is economically meaningful. This knowledge could also be useful to producers and livestock traders in making their economic management decisions and allocating limited resources. Animal breeders need a detailed knowledge of the values of quality characteristics so that they can prioritize their breeding programs to select for characteristics that meet market requirements. There is currently a lack of information regarding which quality attributes are important and the values of these quality characteristics to beef buyers in Kenya.

The purpose of this paper is to derive estimates of the marginal implicit values (implicit prices) of the most important attributes of beef carcasses in Kenya. The approach used involves the specification and estimation of hedonic price functions of the quantities of the various carcass attributes. The hedonic technique has been widely used by economists and marketing analysts to estimate the values to buyers of product characteristics.

There are many identifiable characteristics that are embodied in a beef carcass. The characteristics that are most widely recognized, both in meat science literature and by butchers in Kenya, are considered in this study. The characteristics are hypothesized to be the attributes affecting the price of carcasses at the wholesale level in Kenya. The analysis is undertaken taking into account the intrinsic correlations that exist among the quality attributes. Such correlations may cause potential multicollinearity problems.

2.2 Overview of the Hedonic Price Analysis

The basic theoretical premise for hedonic price analysis was formulated by Rosen in a model of pure competition for differentiated products in 1974. Several empirical applications, however, predate the development of the theory. Waugh (1928) and Fettig (1963) are early applications in agricultural economics.

The fundamental concept of hedonic price analysis is the notion that a good is a "tied bundle" of characteristics and the observation that it is the consumption of these characteristics, and not of the goods *per se*, that contributes to utility and hence the structure of final demand (Lancaster, 1966). Ladd and Martin (1976) explain that in much the same way, it is the characteristics of inputs which determine their value in production and the structure of factor demands. Moreover, the package of characteristics embodied in a good, be it for final or intermediate consumption, will influence production costs and hence, the supply decisions of profit maximizing firms.

It is the traditional task of hedonic analysis to "uncover" the implicit market valuations of characteristics from observable market data. Brown and Rosen (1982), Mendelsohn (1985), and Epple (1987) pointed out the problem of identification of structural supply and demand functions for characteristics. However, few studies have estimated the structural parameters of the demand and supply for characteristics. Most have assumed that the demand for characteristics is relatively stable and so focus on a single equation or single stage of estimation of the inferred value of product characteristics. Such studies include: Wilson, (1984); Veeman, (1987); Coelli, et al. (1991); Stanley et al., (1991); Jones et al., (1992); Harper and Greene, (1993); Williams et al., (1993); Ahmadi-Esfahani and Stanmore, (1994a, 1994b); Lenz, (1994); and Oczkowski, (1994).

Bowman and Ethridge (1992), represent the first attempt to estimate both the value of characteristics and the underlying characteristic market structure for an agricultural product (cotton). In the first stage they obtain a vector of implicit marginal values by differentiating price, $P(Z)$, with respect to its arguments, (Z_i, $i = 1...n$), and evaluating the derivatives at the levels of characteristics purchased or sold. In the second stage, demand and supply functions for attributes are specified. Bowman and Ethridge (1992) specify characteristic demand equations which express each implicit market price as a function of demand shift variables and characteristics inherent in cotton. Similarly the characteristic supply equation expresses the marginal supply price of a characteristic as a function of commodity characteristic levels and a set of shift variables which influence the supply of attribute i.

The current study does not consider the estimation of characteristic supply and demand parameters. The data are collected over a short time span, during which it appears reasonable to assume that the demand for characteristics is relatively constant. Thus the observed price variation can be attributed to variations in the supply of characteristics, rather than to shifts in the demand for characteristics (Veeman, 1987).

2.3 Theoretical Basis for Hedonic Price Model for Beef

The theoretical basis for the hedonic price model recast in terms of input demand is well explained in Ladd and Martin (1976). Wilson (1984) and Veeman (1987) have used the adaptation by Ladd and Martin (1976) of the characteristics demand approach to study the malting barley prices in the USA and world wheat prices respectively. In this approach the demand for an intermediate product is derived from the demand for the final product. One can view the activities of butchers as comparable to profit maximizing, competitive multiproduct firms purchasing heterogeneous inputs. Butchers produce beef cuts from carcasses. The nature and value of the cuts is directly related to the characteristics, attributes or traits of the carcass and the cuts themselves. The selling costs of the cuts are also expected to be directly related to the traits of the carcass. Therefore, the butchers' production function of retailing service can be seen to depend upon carcass characteristics. More formally, the production function can be depicted as (Veeman, 1987):

$$q_y = f(z_{1y}, \ldots z_{ny}) \qquad \textbf{(2.1)}$$

where:

q_y = the quantity of output y ($y = 1, \ldots Y$), and

z_{jy} = the quantity of input characteristic j, ($j = 1, \ldots n$).

The firm's profit function is:

$$\pi = \sum_{y=1}^{Y} p_y f(z_{1y}, \ldots z_{ny}) - \sum_{y=1}^{Y} \sum_{i=1}^{m} p_{xi} x_{iy} \qquad \textbf{(2.2)}$$

where:

x_{iy} = the quantity of market input i (i = 1, ...m) used in the production of output y;

p_y = the given price of output y; and

p_{xi} = the given price of input x_i.

Considering a single output, y, and noting that z_{jy}, the total quantity of each characteristic used in the production of y, is a function of the input quantities, x_{iy}, and the quantity of characteristic j contained in unit quantities of input, the first order conditions for profit maximization with respect to the use of market input i can be stated as:

$$\frac{\partial \pi}{\partial x_i} = p_y \sum_{j=1}^{n} \left(\frac{\partial f}{\partial z_{jy}}\right) \left(\frac{\partial z_{jy}}{\partial x_{iy}}\right) - p_{xi} = 0, \quad i = 1, \ldots m \tag{2.3}$$

Solving for p_{xi} gives:

$$p_{xi} = p_y \sum_{j=1}^{n} \left(\frac{\partial f}{\partial z_{jy}}\right) \left(\frac{\partial z_{jy}}{\partial x_{iy}}\right) \tag{2.4}$$

where:

$\partial z_{jy}/\partial x_{iy}$ = the marginal yield of characteristic j from the i^{th} input in production of y; and

$\partial f/\partial z_{jy}$ = the marginal physical productivity of one unit of characteristic j in the production of y.

The term $p_y(\partial f/\partial z_{jy})$ is the marginal value product of a unit of the j^{th} characteristic used in producing y. That is, it is the marginal implicit value of a unit of characteristic j or the hedonic price of a unit of that characteristic. Specifying $p_y(\partial f/\partial z_{iy}) = \beta_i$ and $\partial z_{jy}/\partial x_{iy} = z_{ij}$ simplifies equation (2.4) to yield the hedonic price function as:

$$p_{xi} = \sum_{j=1}^{n} \beta_j z_{ij} \qquad \textbf{(2.5)}$$

By appending an error term to equation (2.5), regression analysis can be used to obtain estimates of β_j and to test hypotheses relating to β_j and the model (Veeman, 1987).

2.4 The Data and the Empirical Model

As noted by Everitt and Evans (1970), the number and variety of classification and grading schemes for beef and veal carcasses in use throughout the world illustrate the complexity and lack of agreement on appropriate characteristics. Different grading schemes use different attributes or attach different weights to attributes. The objective of this study is to determine and calculate the relative marginal values of the characteristics that are considered to be important in the Kenyan beef market. To achieve this objective, it was necessary to consider an extended list of characteristics. The characteristics of potential importance were identified through a review of literature complemented with interviews with Kenyan butchers. Accordingly, data on the following characteristics of individual carcasses were collected: age of animal; dressed (carcass) weight; carcass length; breed; gender; fatness; conformation; amount of kidney fat; amount of channel fat; colour of fat; degree of visible damage; and colour of lean meat.

The age of the animal was determined by counting the number of permanent incisor teeth. The carcass side was weighed with the kidney and channel fat present and this constituted the weight variable. Carcass length was measured from the tip of the pubic (or 'H' bone) to the anterior edge of the vertebrae associated with the first rib (Yeates, 1965). Three broad breed types were distinguished; these were local dual-purpose breeds (meat and milk) that mostly consisted of the Small East African Zebu, and the Boran (Large East African Zebu); improved beef animals consisting of exotic beef breeds and their crosses with local breeds; and improved dairy animals consisting of exotic dairy breeds and crossbreeds of these and local dual-purpose breeds. The breed of the animal was determined by observing such physical characteristics as colour of hair, presence or absence of hump, and shape. The animals were categorized into three gender classes consisting of bulls, cow/heifers, and steers. Carcass conformation has meant different things at different times and to different people. For this study this factor was taken to mean "meatiness," reflecting thickness of flesh and a blocky shape. This definition does not distinguish between muscle thickness and fat thickness. Four conformation levels were defined with level 1 being the poorest and level 4 being the best conformation. Subcutaneous fat thickness was chosen to represent carcass fatness. In meat science, bovine subcutaneous fat thickness is not considered a good predictor of total fat. It represents less than 35% of the fat in a beef carcass and its proportion changes as the animal develops. However, a simple repeatable predictor of beef carcass fatness continues to elude meat scientists (Price, 1995). Fatness, amount of kidney fat, and channel fat were subjectively evaluated into four levels using standard pictures of carcasses whose attributes had previously been determined in collaboration with a meat scientist. For the attributes of conformation, fatness, kidney fat, and channel fat, four levels were defined and labelled

1, 2, 3, and 4. Conformation 1 represented the poorest level while 4 represented the best conformation. For the attributes of fatness, kidney fat, and channel fat, 1 represented a lean carcass with no fat while 4 represented fattest level. Colour of fat and lean were evaluated against coloured reference standards. The attributes and the variables used to represent them in the analysis are listed in Table 2-1.

Seasonality may influence prices for foods such as meat and particular holiday periods may affect purchasing decisions and therefore prices. The data collection period spanned from December 1995 (a period just before Christmas Holidays) to January 1996 (a period just after Christmas Holidays). A dummy variable was defined to take a value of one if a sale was transacted after January 1, 1996 and zero otherwise. A *t*-test of the coefficient of this dummy variable provides a test of the hypothesis that carcass prices did not differ between the pre-Christmas and post-Christmas periods.

Data were collected at slaughterhouses serving Nairobi and its environs. This region was chosen because it represents a major and quickly expanding meat consumption area. Abattoirs serving Nairobi and its environs handle more than 30 per cent of all the animals slaughtered in Kenya (Karugia, 1990). All slaughterhouses in Nairobi and its environs were visited and data were collected from the Co-operative, Thiani, Kangari, and Mumu abattoirs at Dagoretti. Others were Kirima Slaughterhouse at Dandora and Co-operative and Kiserian slaughterhouses at Kiserian. Other slaughterhouses were visited but no data collected from them because of the small daily slaughter, these slaughterhouses were the Kenya Meat Commission at Athi River, Kayole Slaughterhouse, Hurligam Butchers, and two slaughterhouses at Ong'ata Rongai.

Table 2-1 List of Carcass Attributes Used in the Hedonic Price Analysis

Attribute	Description of Variable Used
Breed	D_{local} = 1 if Local dual-purpose breed; =0 otherwise D_{beef} = 1 if Improved beef; =0 otherwise D_{dairy} = 1 if Improved dairy; =0 otherwise
Gender	D_{bull} = 1 if Bull; =0 otherwise D_{cow} = 1 if Cow/heifer; =0 otherwise D_{steer} = 1 if Steer; =0 otherwise
Age	D_{young} = 1 if Young stock ($\leq$3 pairs of incisors); =0 otherwise D_{mature} = 1 if Mature stock ($\rangle$3 pairs of incisors); =0 otherwise
Weight	Side weight in kilograms
Length	Length in centimetres
Conformation	DC_i =1 if Level i (i=1, 2, 3, 4); =0 otherwise
Fatness	DF_i =1 if Level i (i=1, 2, 3, 4), =0 otherwise
Kidney fat	KF_i =1 if Level i (i=1, 2, 3, 4); =0 otherwise
Channel fat	CF_i =1 if Level i (i=1, 2, 3, 4); =0 otherwise
Colour of fat	D_{white} =1 if Colour is white; =0 otherwise D_{yellow} =1 if Colour is yellow; =0 otherwise D_{gel} =1 if Colour is gelatinous yellow; =0 otherwise
Colour of lean	D_{cherry} =1 if Colour is cherry red; =0 otherwise D_{red} =1 if Colour is red; =0 otherwise D_{deep} =1 if Colour is deep red; =0 otherwise
Damage	D_{none} =1 if no damage; =0 otherwise $D_{moderate}$ =1 if damage is moderate; =0 otherwise $D_{extensive}$ =1 if damage is extensive; =0 otherwise

The author and two enumerators were trained by a meat scientist on how to evaluate carcasses for the characteristics listed above. The price per kilogram of each observed carcass was also recorded. Carcasses were randomly selected on each market day using a systematic sampling technique. Animals to be evaluated were systematically chosen as the cattle entered the stunning pen. The systematic sampling rule was to pick the k^{th} animal with k varying depending on the rate at which the animals entered the stunning pen. A sample of 346 carcasses was achieved. Some descriptive statistics for the sample are presented in Appendix A. It is evident from Appendix A that variation in some attributes, such as amount of kidney fat, amount of channel fat, and to a lesser extent conformation, and fatness, is limited.

As indicated in Section 2.2 above, hedonic price analysis involves obtaining a vector of implicit marginal values by differentiating price $P(Z)$ with respect to its arguments, Z_i, and evaluating the derivative at the level of the characteristics purchased or sold (Rosen, 1974). The empirical model used in this study was specified as follows:

$$P = \beta_0 + \sum_1^n \beta_i Z_i + \varepsilon_i \qquad \textbf{(2.6)}$$

where P is price/kg of carcass, Z_i, ($i = 1,\ldots,n$), denotes the n relevant characteristics, β_j, (j=0,...,n), are coefficients to be estimated, and ε_i is the error term.

As noted above, seasonality may influence carcass price. This observation was frequently made by butchers as well. A dummy variable, Period2, is included in the model to account for such possible influence. From Table 2-1 it is observed that only weight and length enter the model as continuous variables. The rest of the variables enter the model as categorical variables. For continuous variables, the partial derivative exists and can be evaluated to yield the marginal implicit prices. For discrete variables the partial derivatives are not defined. Instead the discrete variables are interpreted as causing a displacement of the production frontier. The theoretical interpretation of dummy variables in a hedonic function is provided by Edmonds (1984). In this case coefficient estimates for the dummy variables measure the impact of the presence of the attributes represented by the variables.

The model of equation (2.6) is estimated by ordinary least squares (OLS) method assuming that the error term satisfies all the classical assumptions of this estimator. Heteroskedasticity is a problem often associated with cross-sectional data. The hedonic price model was tested for this using the diagnostic tests in Shazam (White, 1993) including the Breush-Pagan/Godfrey, Harvey, and Glejser tests, and found to be heteroskedastic. White's (1980) heteroskedasticity-consistent covariance matrix estimator was used to estimate the variance-covariance matrix of the model estimates. Although it is not strictly a violation of the OLS assumptions, collinearity may be a problem in this kind of data. A common observation in animal science literature is that correlations may exist between some of the quality attributes listed in Table 2-1 above. Correlation coefficients for the carcass attributes are presented in Appendix B From the correlation matrix it is observed that correlation coefficients of 0.5 and higher exist between weight and length, weight and conformation, channel fat and kidney fat, conformation and kidney fat, weight and kidney fat, and weight and channel fat. These correlations indicate the existence of a potential collinearity problem. Further analysis was carried out by means of auxiliary regressions to assess the extent of the collinearity problem. The R^2 values of these auxiliary regressions are reported in Appendix C. The combination of correlation analysis and auxiliary regressions clearly indicates that potentially harmful collinearity involving weight, length, kidney fat, channel fat, and to a lesser extent conformation, may exist in the data. This potential collinearity problem is taken into account when applying the OLS technique to the data by a careful selection of variables as noted below. The OLS procedure of Shazam (White, 1993) was used to run the linear regressions.

2.5 Results and Discussion

2.5.1 Results

As indicated in Section 2.4 above, collinearity in the data used in this study was a concern. Consequently, a search for a satisfactory model was undertaken taking into account the natural relationships between the variables and the econometric properties of the models specified. All the initial specifications considered consistently yielded significant estimates of the coefficients for weight, conformation, fatness, colour of lean, and level of carcass damage. These variables are retained in the final model. Some variables including, breed, length, kidney fat, channel fat, and colour of fat did not yield significant coefficient estimates. As well, carcass length, kidney fat, and channel fat appeared to be the important sources of collinearity. These variables are omitted from the final model and are not considered further in this part of the study. The estimation results for the final model are presented in Table 2-2.

The estimated model has a good fit for cross-sectional data. The coefficient of multiple determination, R^2, indicates that the variables included in the model explain about

Table 2-2 Coefficient Estimates of the Hedonic Price Model of Carcass Attributes

Variable	Coefficient estimate	Standard error	*t*-statistic
Constant	62.397	4.453	14.010***
D_{steer}	0.671	0.648	1.036
D_{young}	-1.253	1.031	-1.507
Weight	0.688	0.095	7.265***
Weight Squared	-0.003	0.0004	-6.746***
DC_2	2.639	0.743	3.550***
DC_3	9.092	1.050	8.663***
DC_4	16.145	1.779	9.074***
DF_2	3.256	0.639	5.099***
DF_3	4.258	1.173	3.631***
DF_4	2.645	1.225	2.159**
D_{red}	-0.319	0.626	-0.510
D_{deep}	-0.813	1.398	-0.582
$D_{extensive}$	-2.129	0.835	-2.550***
Period2	-2.280	0.753	-3.027***
R^2	0.668		
Adjusted-R^2	0.654		
F-statistic	47.482***		
N	346		

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

67% of the variation in carcass price. The F-statistic test of the joint significance of the included variables is significant at the 1 per cent level.

Table 2-2 shows that the coefficients of conformation dummy variables are all positive and significant. This result conforms with *a priori* expectations. Relative to carcasses of conformation level 1, carcasses with better conformation scores have higher values. A joint *F-test* of the equality of the conformation dummy coefficients was rejected at the 1% level. All fatness coefficients are positive and significant. They exhibit the same pattern as conformation coefficients. The corresponding values, however, are lower. Generally, the higher the fat level, the higher the coefficient estimate although the relationship is not linear. Fatness level 4 has a lower coefficient estimate compared to the lower fatness level 3. A joint *F-test* of the equality of the fatness dummy coefficients could not be rejected at the 5% level It is concluded that there were only two differentiable fatness levels in the range of data considered in the analysis. The coefficient for extensive damage is negative and significant at the 1% level. Thus damaged carcasses had their prices discounted, as expected.

The coefficient estimate for the sample of observations in the period after the Christmas holidays is negative and significant at the 1% level. The coefficient implies that carcass prices were lower after the Christmas festivities. This would be expected as meat consumption tends to increase during the celebrations and the increased demand may force prices to rise. A word of caution is necessary in the interpretation of the coefficient on period 2 dummy variable. This is because the coefficient may confound slaughterhouse effect with the seasonality effect. This observation is relevant because the sequencing of data collection was such that the post-Christmas period coincided with the end of data collection at Dagoretti, the location of four of the six major slaughterhouses serving Nairobi at the time the survey was conducted. In other words, possible differences in pricing may exist between slaughterhouses that are spatially separated.

Both the linear and quadratic coefficients for carcass weight are significant and of opposite signs, indicating a nonlinear relationship between price and weight. Above a certain weight, heavier carcasses are discounted, according to this result. Although positive, the coefficient on steers is not significant implying that bull and cow carcasses are not discounted relative to steers. This finding is not consistent with our expectations. The coefficient estimate on the variable representing carcasses from young animals is negative, contrary to expectations. The estimate is not, however, significantly different from zero.

2.5.2 Valuation of Beef Carcasses

Since the functional form of the specified hedonic model is linear in all variables except weight, the estimated coefficients represent the marginal implicit prices of the characteristics that are continuously measured. On the other hand, the coefficients of the categorical variables represent the average impact (change in price) of the characteristic when present in the carcass, relative to a base case. The average price of the reference carcass in this case is represented by the constant term in the model of equation (2.6). The constant term can be interpreted as the sum of the products of the characteristics that are non-varying from carcass to carcass and their prices (Edmonds, 1984).

Considering the magnitudes of the estimated implicit prices presented in Table 2-2, it can be inferred from the hedonic analysis that conformation is the most important attribute. Higher conformation scores add more to the value of the carcass than the preceding levels of beef animals to Nairobi meat wholesalers. Fatter carcasses are valued more than lean carcasses. However, fatness levels 2, 3, and 4 add statistically equivalent values to the price of the carcass. Visible damage on carcasses causes the price to decline by Sh. 2.13/kg. Weight has a nonlinear influence on carcass value. Its influence on carcass value is positive at side weights lower than 229.48 kg. For carcass side weights higher than this value, weight is discounted. The attributes of breed, gender, age, carcass length, kidney and channel fat, and colour of fat do not affect the price of a carcass, according to the results of this study. The influences of these insignificant variables may have been captured by the other variables as evidence from animal science literature suggests that some butchers may use different carcass attributes as alternate measures of the same basic quality dimension.

The results of this study imply that farmers could increase the value of their animals by bringing to market heavy animals with a high conformation score and good finishing. Extension work would be required to educate farmers on how these characteristics can be evaluated in live animals. The deep red colour of carcasses, which causes some price discounting, is associated with poor pre-slaughter handling of animals (Price, 1982; FAO, 1991). Wholesale beef traders could increase the value of their carcasses by improving the handling of animals prior to slaughter as damage also causes a substantial price discount. Extension efforts to improve handling and reduce carcass damage should be considered by the Livestock Marketing Division of the Ministry of Agriculture and managers of livestock markets.

The results indicate that a grading or classification scheme based on conformation, finishing and size of the animal could achieve the objective of sorting beef carcasses into economically distinguishable classes. Appropriate discounting for damage would need to be factored into a grading or classification scheme.

2.6 Conclusions

A hedonic price model with a good fit is estimated using the least squares method on data on carcass prices and characteristics . The coefficient estimates of the linear model represent the "implicit prices" of the corresponding carcass attributes. The results indicate that conformation, fatness, weight, and damage are important in determining the price that butchers are willing to pay for beef carcasses. There is also evidence that there may be seasonal effects on beef carcass prices although this result is not conclusively demonstrated. The estimated values of the quality attributes appear reasonable and the hedonic price model does not appear to be harmed by collinearity after some naturally collinear attributes are omitted. Carcass length supplies similar information about carcass size as is supplied by weight. The amount of channel fat and kidney fat are related measures of carcass fatness, as is subcutaneous fat.

The estimates of the implicit prices of the important attributes remained stable in various specifications of the model. Variables such as breed, gender, and colour of fat, although generally thought by animal scientists to be important, do not appear to be so in the Kenyan market. These variables do not appear to influence the price that the butchers are willing to pay for a carcass.

The results of this study demonstrate the existence of separate categories of carcasses that can be distinguished on the basis of conformation, fatness, and weight. It is, therefore, possible to define classes of carcasses on the basis of these attributes. Butchers are willing to pay premiums on high conformation score and good finishing. Over-fat carcasses are valued less than carcasses of intermediate fatness. This study provides evidence that these few carcass attributes are sufficient to define carcass classes that are economically meaningful.

2.7 References

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CHAPTER III

Discrete Choice Analysis of Butchers' Revealed Preferences

3.1 Introduction

The purpose of this chapter is to analyse butchers' observed choice behaviour to determine what carcass attributes they take into account when buying beef and what values they attach to them. The approach followed is formulated in a discrete choice framework. That is, buyers choices to purchase or not to purchase specific carcasses are modelled in this approach. The basic premise and economic theory of the discrete choice analysis is similar to that of the hedonic price analysis of Chapter II. That is, the approach pursued here is based on the premise that buyers' demand can be visualized as the demand for characteristics of the product (Lancaster, 1966; Rosen, 1974) and hence the product characteristics rather than the product *per se* are the arguments in individual's utility functions. However, since the approach relates to buyers' decisions to purchase specific carcasses, in addition to the beef quality attributes listed in Table 2-1, characteristics of buyers and butcheries that may influence their purchase choices are also included in the analysis. This approach represents an alternative approach to characteristic valuation based on data relating the observed choices of individual buyers and a sample of observed carcasses that were not chosen by those particular buyers.

3.2 Overview of Discrete Choice Analysis

A discrete regression model is one in which the dependent variable assumes discrete values. Discrete choice models that relate choices of economic agents to appropriate choice sets have been used in environmental, transportation, and marketing economics to impute market values to goods and services that must be purchased (and hence must be evaluated) as components of tied bundles of attributes and other relevant factors. The basic problem confronted by discrete choice analysis is the modelling of choice from a set of mutually exclusive and collectively exhaustive alternatives. A decision maker is modelled as selecting the alternative with the highest utility among those available at the time a choice is made. An operational model consists of a parameterized utility function in terms of observable independent variables and unknown parameters, and the values of these parameters are estimated from a sample of observed choices made by decision makers when confronted with a choice situation (Ben-Akiva and Lerman, 1985).

In discrete choice analysis, the attractiveness of an alternative is evaluated in terms of a vector of attribute values and other relevant variables. The attribute values are measured on a scale of attractiveness that can be ordinal or cardinal. Alternatives are heterogeneous and decision makers may have different choice sets, evaluate different attributes, and assign different values for the same attribute of the same alternative (Ben-Akiva and Lerman, 1985). As with the hedonic approach, in these cases it is more appropriate to work directly with a general characterization of each alternative by its attributes rather than just quantities associated with it, as in conventional demand analysis. Some recent applications of the discrete choice analysis include Cropper, et al., 1993; Hensher and Brandley, 1993; Adamowicz, et al., 1994, 1997; Deighton, et al. 1994; Swait, et al., 1994; Jayne, et al., 1996; and Kling and Thomson, 1996.

3.3 The Theoretical Basis and Derivation of the Multinomial Logit Model

Probabilistic discrete choice models are frequently based on random utility theory. Random utility models are derived from assumptions about individual's evaluations of choice objects. In these models an individual's utility measures are represented by systematic and random components. The systematic component is a function of observable attributes of products or brands of a product and individuals, while the random component captures variations in choice due to within- and between-individual variance, omitted variables, measurement errors and imperfect information (Ben-Akiva and Lerman, 1985). The random component is assumed to be independently and identically distributed according to a particular probability distribution. Different assumptions about the forms of this probability distribution give rise to different choice models. Two of the frequently assumed probability distributions are the independently and identically (IID) Gumbel distribution, which yields a multinomial logit (MNL) choice model, and the IID normal distribution, which results in a multinomial probit model.

The preferred model for this study is the non-nested MNL which has been found to be useful in many applications. Batsell and Louviere (1991) note, however, that the MNL model has sometimes been incorrectly applied in situations that have contravened the property of the independence of irrelevant alternatives (IIA) that is a basic assumption of the model. They observe that the MNL model might be more generally appropriate if specified to account for individual-specific differences. This view holds that violations of IIA arise because of heterogeneity in tastes and preferences, which can be accounted for by appropriate specification of utility functions to include individual difference terms which interact with design variables (attributes). The model specified in this study incorporates individual-specific attributes.

The following is an abbreviated derivation of the multinomial logit model which follows Maddala (1983) and Ben-Akiva and Lerman (1985). As noted above, the overall utility associated with choice can be expressed as:

$$U_{in} = V_{in} + \varepsilon_{in} \tag{3.1}$$

where U_{in} is person *n's* utility of choosing alternative *i*, V_{in} is the systematic component of utility, and ε_{in} is a random component. Alternative *i* is chosen over alternative *j* if $U_{in} > U_{jn}$. The probability of individual *n* choosing alternative *i* is:

$$P_n(i) = Pr(V_{in} + \varepsilon_{in} \geq V_{jn} + \varepsilon_{jn}, \quad \forall_j \in C_n) \tag{3.2}$$

where C_n is the choice set for individual *n*, and V_{in} is the individual's conditional indirect utility function. It is assumed that V_{in} has a linear form:

$$V_{in} = \beta' x_{in} \tag{3.3}$$

where x_{in} is a vector of attributes of alternative *i*. Assuming that the error terms are Gumbel distributed with scale parameter μ, the probability of individual *n* choosing alternative *i* is:

$$P_n(i) = \frac{\exp^{\mu\beta' x_{in}}}{\sum_{j \in C_n} \exp^{\mu\beta' x_{in}}} \tag{3.4}$$

The scale parameter μ cannot be estimated independently and it is typically normalized to 1 (Ben-Akiva and Lerman, 1985).

In order to capture buyer differences, the MNL model is modified by including individual- specific attributes in the design matrix x. Since MNL models are difference-in-utility models, any variables that do not vary across alternatives fall out of the probability. To allow for individual specific effects, the model is modified by interacting the attribute variables with the individual-specific variables. The maximum likelihood method is used to estimate the model of equation (3.4). The econometrics program, LIMDEP Version 7.0, of Greene (1995) is used for this purpose.

3.4 Data

The data for this study were collected by observing butchers making their beef purchases at slaughterhouses serving Nairobi and its environs in December 1995 and January 1996. This allowed for consistency between the data used in the three studies presented in this thesis as the samples were obtained from the same population of butchers. Carcasses were evaluated for the characteristics listed in Table 2-1 and their prices recorded. Visual assessment of carcasses, the most frequently used form of grading beef, was used. The author and two enumerators were trained by a meat scientist on how to evaluate carcass attributes.

The following is a description of the observation and data recording procedure that was followed during the survey. Carcasses to be evaluated were randomly selected (see Section 2.4 above) as the cattle entered the stunning pen and the breed of these animals was recorded by observing such physical characteristics as colour of hair, presence or absence of hump, and shape. Three broad breed types were distinguished; these were local dual-purpose breeds (meat and milk), improved beef animals, and improved dairy animals. Stunning was followed by sticking (severing of the major arteries of the neck) and as the animal bled on the floor, its gender (bull, cow/heifer, or steer) was determined. Dentition was also determined by counting the number of permanent incisor teeth present. Identification labels were placed on the carcasses as soon as skinning started. The carcasses were then followed through the skinning and dressing stages and the attributes of fatness, conformation, length, amount of kidney and channel fat and level of damage were assessed and recorded. Weighing was done before the carcasses were loaded on to transport trucks. The price per kilogram of each observed carcass was also elicited from the buyer or seller, in the majority of the cases both buyer and seller were queried as to the price. When evaluating carcasses, standard pictures of carcasses which had been assessed for the various characteristics by the meat scientist, were used to improve consistency. In a process of random selection, wholesale purchasers who bought some of the selected carcasses on a particular day were asked to provide information regarding their buyer/butchery characteristics such as location of butchery, selling practices, experience, volume of sales, and the degree to which they deal with one or a few traders (as a measure of vertical integration). Also recorded were the time of day that the sale was transacted, the day of the week, the date, and the slaughterhouse name and location. The survey instrument used for the data gathering is presented in Appendix D. Data were obtained for 126 butchers and 346 carcasses. Some descriptive statistics for the sample of carcasses are presented in Appendix A. It is evident from Appendix A that variation in some attributes, such as amount of kidney fat, amount of channel fat, and to a lesser extent conformation, and fatness, is limited.

The information relating to butchers and butcheries was matched with the carcasses that they had chosen. In addition 5 carcasses were randomly selected from those that were available to the butcher but were not chosen. These were matched with the butcher to complete the choice set for this experiment and the associated analysis of data. This is a practical procedure to establish an appropriate delineation of the choice set facing a decision maker. The procedure was suggested by McFadden (1978) who showed that estimating a model using random draws from the full choice set facing a decision maker can give unbiased estimates of the model with the full set of alternatives. The procedure has been employed by Parsons and Kealy (1992) in a study of lake recreation to delimit individuals' choice sets from an available large number of lakes. Peters (1993) also used the procedure in her study of sportfishing in Southern Alberta.

3.5 Results and Discussion

3.5.1 Estimation Results

Data for a relatively large listing of carcass attributes and buyer/butchery characteristics were collected and considered in this study, since one primary purpose was to determine which are the most important of several carcass attributes and buyer/butchery characteristics in influencing butchers' choice behaviour.

The initial analysis of the broad data set eliminated several carcass attributes and buyer/butchery attributes as being inconsequential in influencing butcher choice. Among the carcass attributes that emerged as significant are conformation, fatness, price, and weight. Buyer/butchery attributes that appeared to have a significant influence on carcass choice were time of day of the sale, the education of the butcher, location of the butchery, and the degree of vertical integration by butchers.

In the initial step of the final analysis, only carcass attributes were considered. Subsequently both carcass attributes and buyer/butchery characteristics are assessed. Table 3-1 presents the coefficient estimates for a version of the model in which only carcass attributes were assumed to determine choice. Although, the subsequent analysis of an expanded model is preferred, the results of Table 3-1 are useful in giving estimates under the assumption that butchers are a homogenous group. The model also showed greater robustness compared to the expanded model when various collinear attributes were omitted. The collinearity problem in the data seemed to be exacerbated by the inclusion of buyer/butchery characteristics in the expanded model.

From the summary statistics of the basic model in Table 3-1 it is seen that the variables included are jointly significant in explaining butchers' choice behaviour. The Chi-squared statistic of the likelihood ratio test of joint significance of all the included variables is higher than 21.67, the critical Chi-squared value at 1% level and 9 degrees of freedom.

The coefficient estimates presented in Table 3-1 show that carcass price, weight, conformation, and fatness are important in determining choice. Both the linear and quadratic price coefficients are significant, suggesting a nonlinear relationship between

Table 3-1 Discrete Choice Model: Coefficient Estimates of the Multinomial Logit Model of Butchers' Choices With Only Carcass Attributes Included

Variable	Coefficient estimate	Standard error	Asymptotic t-statistic
Price/100	21.810	12.081	1.805*
Price/100 Squared	-14.011	6.729	-2.082**
Weight/100	-1.453	0.714	-2.035**
DC_2	0.944	0.312	3.025***
DC_3	1.748	0.579	3.017***
DC_4	3.605	0.964	3.741***
DF_2	0.800	0.273	2.927***
DF_3	0.839	0.565	1.485
DF_4	-0.011	0.725	-0.016

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

Summary Statistics

Number of Observations	=126
Log likelihood function	=-214.179
Log likelihood: constants only	=-225.106
Log likelihood: No coefficients	=-225.762
$-2[(L(0) - L(\beta)]$	= 23.166
Rho squared	= 0.05
Rho-bar squared	= 0.01

price and the utility of a carcass. Taken together, the two price coefficients imply that at prices higher than Sh. 77.83[2], price has a negative effect on utility. At prices lower than this figure, the effect of price on buyer utility is positive, perhaps because it may act as a signal for improvements in other attributes not considered in the model, and that are unknown to the buyer. The type of feeding and the origin of the animal are examples of such variables. The conformation dummy variables are all positive and significant at the 1% level. Improvements in carcass conformation have a positive effect on buyer utility. The magnitudes of the coefficients dummy variables also indicate that the higher the conformation score, the higher the incremental utility. A Wald test of the hypothesis of equality of the three conformation coefficients rejected the hypothesis at the 1% level. Fatness level 2 is positive and significant. The coefficients for the dummy variables for fatness level 3 and 4 are statistically equal to zero. It appears that fatness level 2 adds more to utility than levels 3 and 4. Evidently, buyers have no preference for over-fat carcasses (fatness levels 3 and 4) over lean carcasses (fatness level 1).

The effect of weight on the utility derived from a carcass appears to be negative, contrary to expectations. The coefficient estimate for weight is negative and statistically different from zero. This result is in contrast to the findings of the hedonic price analysis reported in Chapter II and the stated preference analysis of Chapter IV which found weight to have a quadratic relationship with utility. However, according to the results of the basic model of discrete choice, butchers discount heavier carcasses. It is possible that

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[2] The figure is obtained by solving for price in the following equation: β-price $+(2*\beta$-price$^2)*$price$=0$.

heavier carcasses are more difficult to handle than lighter ones. Perhaps the limited cold storage capacity that some butchers have for carcasses compel them to buy only what they can dispose of in a day or two. Some caution should be exercised in interpreting the results of this model. As discussed in Chapter II, a problem of collinearity may affect the standard errors and signs of some of the coefficient estimates when these data are used. Evidence from the hedonic analysis suggests that carcass weight has a significant influence on price and having the two together as explanatory variables in the discrete choice model may cause a collinearity problem. Collinearity in data is likely to have more serious effects in non-linear than linear models as the former demand a lot more from the data than the latter (Davidson and MacKinnon, 1993).

One of the main criticisms of the multinomial logit model is that it fails to account for heterogeneity in subject behaviour (Louviere, 1992). A remedy that is often suggested for this is to modify the basic model to take account of individual-specific characteristics. Accordingly, the model reported in Table 3-1 is modified to include buyer/butchery characteristics in the specification. The buyer/butchery characteristics considered are education, experience, ownership, location of the butchery, volume of sales, class of butchery, and the degree of vertical integration. Many butchers and wholesalers felt that carcass price varied depending on the time a sale was transacted. Also, a hypothesis that butcher choices were influenced by seasonality as represented by pre-Christmas and post-Christmas periods was advanced. Consequently, variables representing time and season were also considered. The variables used to represent buyer/butchery characteristics are presented and described in Table 3-2. Most of the data on the buyer/butchery attributes

Table 3-2 List of Buyer/Butchery Characteristics Used in the Modified MNL Model

Characteristic	Description of Variable Used
Gender	D_{male} =1 if butcher is male; =0 otherwise D_{female} = 1 if butcher is female; =0 otherwise
Level of education	D_{low} = 1 if primary school education or lower; =0 otherwise D_{educnH} = 1 if secondary school education or higher; =0 otherwise
Butchery ownership	D_{owner} = 1 if buyer is owner of butchery; =0 otherwise $D_{notowner}$ = 1 if buyer is not owner of butchery; =0 otherwise
Location of butchery	$D_{location1}$ = 1 if butchery is located in a low income area; =0 otherwise $D_{location2}$ = 1 if butchery is located in a high income area; =0 otherwise
Experience of butcher	D_{exp1} = 1 if butcher has <24 months of experience; =0 otherwise D_{exp2} = 1 if butcher has ≥ 2 years of experience; =0 otherwise
Volume of sales	Volume (Number of carcasses sold per week)
Selling practice	D_{Hclass} = 1 if ≥50% of beef is sold as special cuts; =0 otherwise D_{Lclass} = 1 if <50% of beef is sold as special cuts; =0 otherwise
Degree of integration	D_{lowI} = 1 if buys from one wholesaler <50% of the time; =0 otherwise D_{highI} = 1 if buys from one seller ≥50 of the time; =0 otherwise
Time	D_{early} = 1 if sale transacted before 11:00 a.m.; =0 otherwise D_{late} = 1 if sale transacted after 11:00 a.m.; =0 otherwise
Season	$D_{pre\text{-}Xmas}$ = 1 if sale transacted before Jan 1, 1996; =0 otherwise $D_{post\text{-}Xmas}$ = 1 if sale transacted after Jan 1, 1996; =0 otherwise

were collected as categorical variables. Some categories did not have sufficient observations for a meaningful analysis. Such categories were merged and this increased the degrees of freedom for a more efficient estimation. On the basis of years of education, butchers were classified as having a low education level if they had no more than primary school education and a high level of education if they had received secondary school (or more) education. Butcheries were categorized as either located in high income areas or low income areas. Precise data to facilitate a distinction of low and high income locations of Nairobi were not available. A proxy measure was, therefore, adopted . Using newspaper sources and direct questioning of butchers, average rent rates for houses in particular locations were computed. Locations were classified as high income if they had rent rates above the average for all the locations. Butchers were also classified into two experience categories. Butchers were considered to be experienced if they had been in the beef retail trade for more than two years and inexperienced if they had been in this business for less than two years. On the basis of their selling practices, butchers were classified to be either "high class" or "low class." Butchers who sold most of their beef in special cuts such as sirloin or rump steak were classified as high class. Low class butchers consisted of those who sold beef as meat-on-bone. Butchers who dealt with one wholesaler more than 50 percent of the time were classified as being "highly vertically integrated" and those who tended to deal with different wholesalers were considered to have a "low degree of vertical integration".

The results of the modified MNL model are presented in Table 3-3. The model of Table 3-1 is nested in the modified model of Table 3-3. A likelihood ratio test was done

Table 3-3 Discrete Choice Model: Coefficient Estimates of the MNL Model of Butchers' Choices with Buyer/Butchery Characteristics Included

Variable	Coefficient estimate	Standard error	Asymptotic *t-statistic*
Price/100	26.248	14.182	1.851*
Price/100 squared	-20.912	8.005	-2.612***
DC_2	0.677	0.399	1.698*
DC_3	0.152	0.935	0.162
DC_4	1.929	1.263	1.527
DF_2	0.802	0.279	2.868***
DF_3	1.133	0.594	1.908*
DF_4	0.326	0.781	0.417
Weight/100	-1.424	0.758	-1.877*
$DC_2{*}D_{location2}$	0.904	0.526	1.717*
$(DC_3+DC_4){*}D_{location2}$	2.903	0.939	3.090***
Price squared*D_{late}	1.570	1.473	1.065
Price squared*D_{educnH}	3.521	1.535	2.293**
Price squared*D_{veryI}	2.272	1.413	1.608

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

Summary Statistics

Number of Observations =126
Log likelihood function =-200.338
Log likelihood: constants only =-225.106
Log likelihood: no coefficients =-225.762
$-2[L(\mathbf{0}) - L(\beta)]$ = 54.166
Rho squared = 0.11
Rho-bar squared = 0.05

to test whether the modified model is an improvement on the basic model. The Chi-squared value for the likelihood ratio test is 27.68. The critical Chi-squared value with 5 degrees of freedom for a 0.01 level of significance is 15.09. Thus, the hypothesis that the modified model is not an improvement on the basic model is rejected. This observation is further supported by the resulting increases in both rho squared and rho-bar squared which indicate that the included buyer/butchery characteristics improve the explanatory power of the model. In the modified model, price has a significant influence on choice. At prices lower than Sh. 62.76/kg (see footnote 2 above), price has a positive effect on the utility derived from a choice alternative. It is possible that when price is low, an increase in price may act as a signal to buyers of improvements in otherwise unobservable attributes of an alternative that may be known to the seller. The type of feeding and region of the origin of animals are examples of such possible factors. At prices higher than Sh. 62.76/kg, the effect of price is negative. The results indicate that the carcass attributes of conformation and fatness are significant influences on butchers' choice behaviour.[3] Considered alone, conformation and fatness do not have as prominent an influence when buyer choice is modelled to include specific buyer/butchery characteristics. All three conformation dummy variable coefficients have the expected positive sign. Conformation coefficients for levels 3 and 4 are not statistically significant. The conformation attribute, however, forms significant interaction terms with the high income location variable. These interaction terms are positive, indicating that butchers in high income locations attach positive

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[3] With the inclusion of interaction terms, the 'total' relative impact of a particular level of a categorical attribute is a function of the interacting buyer/butchery characteristics.

premiums to carcasses with conformation scores better than level 1. The interaction term of conformation level 4 and high income location was omitted from the modified model because it represented only a few observations and this led to convergence problems in estimating the model. Instead, the few observations for this variable (8 in total), were grouped together with those for the conformation level 3-high income location interaction term.

All carcass fatness dummy variables have the expected positive sign. The estimated coefficients on fatness levels 2 and 3 are significantly different from zero at the 10% level or better. Fatness level 4 is not significant at the 10% level. In other words, according to the results of this study, fatness level 4 does not increase the utility of an alternative above the level of utility of fatness level 1. The fatness attribute does not form significant interaction terms with any of the buyer/butchery characteristics considered in this study. The coefficient on weight is significant at the 10% level and is negative, contrary to expectations. As explained above, this result must be interpreted with caution due to the collinearity inherent in the data used in this analysis.

Many butchers and wholesalers expressed the opinion that carcass prices were lower later in the day than earlier on. They believed that butchers coming late to the market did so strategically so that they could find sellers who were desperate to sell to avoid overnight storage costs and loss of weight by carcasses. To model the effect of time on choice, a dummy variable representing sales transacted after eleven o'clock was defined and interacted with price. It was hypothesized that if buyers believed that prices were lower later in the day, those coming to the market late would be less price responsive than those who came to the market earlier in the day. The coefficient on this dummy variable was expected to be positive. The estimated coefficient for the interaction term between price and time of day is positive, but it is not significantly different from zero at the 10% level. The hypothesis that the demand by buyers who come late to the market is less price elastic than for those who come to the market earlier in the day is rejected.

Price forms a significant interaction term with the high education variable. The positive coefficient on this interaction term implies that butchers with a high level of education are less price sensitive relative to those with less education. This may reflect a higher opportunity cost of time to these butchers, who may prefer to spend less time haggling for lower prices in favour of paying more attention to other carcass attributes. The positive price coefficient on the integration-price interaction term similarly implies that the demand for carcasses by those butchers who tend to deal with a single buyer is less price elastic than for those who buy from many sellers. However, this coefficient is not significant at the 10% level. A positive coefficient would be expected if the tendency to deal with one seller is due to some formal or informal contract. There was evidence that such contracting was taking place but the results of this analysis do not support the hypothesis that this practice had any influence on butchers' price responsiveness.

3.5.2 Valuation of Carcass Attributes

The indirect utility function, Equation (3.3), is linear and, therefore, a ratio of any two coefficients appearing in it provides information about the trade-off, or marginal rate of substitution, between the corresponding variables. The ratio of an attribute coefficient and the price coefficient represents the marginal implicit price of that attribute (Lareau and Rae, 1988). For the categorical variables, the ratio of the attribute coefficient and the price coefficient represents the implied change in price of the carcass relative to a base case. This interpretation follows that of Kennedy (1992) for dummy variables in linear models, and Louviere (1994), who notes that logit parameters represent effects of contrasts in levels of qualitative attributes. Similar interpretations of dummy variables in the context of attribute valuation can be found in the hedonic studies of Edmonds, 1984; Coelli, et al., 1991; Williams et al., 1993; and Oczkowski, 1994. Table 3-4 presents the estimated implicit prices of the quality attributes based on the basic model. The estimated implicit prices from the preferred modified model are presented in Tables 3-5 and 3-6.

Table 3-4 Estimated Implicit Prices of Carcass Attributes (Homogeneity of Butchers Assumed)

Attribute	Value (Sh./unit)	Standard error	*t*-statistic
Weight	-0.243	0.169	-1.433
DC_2	15.781	6.306	2.503**
DC_3	29.218	10.610	2.754***
DC_4	60.246	22.910	2.630***
DF_2	13.365	5.392	2.479**
DF_3	14.021	9.546	1.469
DF_4	-0.189	12.136	-0.016

*** significant at 1% level
** significant at 5% level
* significant at 10% level

Table 3-5 Estimated Implicit Prices of Carcass Attributes for Butchers in Low Income Locations

Attribute	Value (Sh./unit)	Standard error	*t*-statistic
Weight	-0.093	0.058	-1.612
DC_2	4.445	2.611	1.703*
DC_3	0.996	6.082	0.164
DC_4	12.664	8.413	1.505
DF_2	5.263	2.001	2.630***
DF_3	7.434	4.148	1.792*
DF_4	2.139	5.066	0.422

*** significant at 1% level
** significant at 5% level
* significant at 10% level

Table 3-6 Estimated Implicit Prices of Carcass Attributes for Butchers in High Income Locations[a]

Attribute	Value (Sh./unit)	Standard error	*t*-statistic
DC_2	10.377	3.704	2.802***
DC_3	20.052	6.245	3.211***

[a] Only conformation had implicit prices different from those of the low income butchers.

*** significant at 1% level

The results of Table 3-4 show the relative valuations of carcasses when butchers are assumed to be a homogenous group. Weight has a negative marginal implicit value, although the estimate is not statistically different from zero at the 10% level.[4] Higher conformation levels have higher values relative to the ones below. The magnitudes of these figures appear reasonable, given the observed price ranges. Fatness levels 2 and 3 have positive values relative to level 1. Fatness level 4 does not add to the value of the carcass; All else equal, over-fat carcasses appear to have the same value as lean carcasses.

Tables 3-5 and 3-6 should be considered together. They represent the valuations of carcass attributes by butchers located in low and high income areas of Nairobi respectively. Table 3-5 shows that conformation level 2 and fatness levels 2 and 3 have premiums over the respective base levels. The premiums are significantly different from zero for the butchers in low income areas. Animals with conformation ratings higher than level 2 may not be in these butchers' choice sets as these carcasses also tend to command higher prices. Indeed, considering that the implicit price of conformation level 2 is only marginally significant, conformation may not be important to butchers in the low income

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[4] The asymptotic variances of the implicit prices were indirectly estimated by using a truncated Taylor series expansion as follows:

$$V[f(\hat{\beta})] = \left(\frac{\partial f(\hat{\beta})}{\partial \hat{\beta}}\right)' V(\hat{\beta}) \left(\frac{\partial f(\hat{\beta})}{\partial \hat{\beta}}\right)$$

where, $\hat{\beta}$ is a vector of the estimated coefficients and $\partial f/\partial \hat{\beta}$ is a vector whose i^{th} element is the partial of $f(\hat{\beta})$ with respect to the i^{th} element of $\hat{\beta}$. See Kennedy (1992) and Johnson (1972) for details of this method. The Wald command in LIMDEP (Greene, 1995) was used to compute the standard errors.

locations. Results of models run separately for the group operating in low income locations and high income locations suggest that fatness and price are the only attributes driving the choice decisions of these butchers. In other words, other factors that were not considered in this analysis may be influencing the behaviour of butchers in low income locations. Further research is suggested to identify the factors driving these butchers' choice behaviour.

The high income location variable formed significant interactions with the conformation dummy variables. Thus only conformation appeared to be valued differently by the butchers in these areas. The estimated valuations are higher for this group of butchers than for their low income counterparts.

3.6 Conclusions

Actual market data representing butchers' carcass choices are collected and analysed using a Multinomial Logit model of discrete choices. The data collected show a degree of collinearity that seems to affect model estimation. Nevertheless, a basic model that assumes that butchers' choices are influenced only by carcass attributes yields reasonable results after some collinear variables are omitted from the model. The results show that buyer choice may be influenced by a few important carcass attributes. The attributes identified by this model are conformation, fatness and weight. The prices that butchers must pay for the carcasses also significantly influence their choice behaviour. Butchers do not appear to be influenced by attributes such as breed, gender, age, and carcass length when making their carcass choices. It should be noted that the influence of these attributes may be already reflected in the fatness and conformation scores as well as the asking price of the sellers. The inclusion of buyer/butchery characteristics improves the model as expected. The coefficient estimates of the resulting model suggest that for some sections of the market, some levels of conformation and fatness do not add significantly to butchers' utilities. The reasons for this observation may be different for the attributes of conformation and fatness. Butchers in the low income areas may not consider carcasses of high conformation scores to be in their choice set. Thus availability or non-availability of these carcasses may have no influence on their utility. For the Kenyan butchers, carcasses of fatness level four may be considered to have too much trimmable waste so that their prices are appropriately discounted.

As cautioned above, collinearity may have degraded some of the coefficient estimates. Parameters appeared unstable when different specifications involving different variables were considered. The best remedy for this problem is acquisition of better data. Further research may be necessary to obtain such data and to gain insight as to the extent to which the collinearity problem harms the results of this study. This led to application of a further research approach to the problem, involving an experiment to assess butchers' preferences based on stated choice, rather than actual market data. This is explained in the following chapter of this thesis.

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Chapter IV

Discrete Choice Analysis of Butchers' Stated Preferences

4.1 Introduction

In certain circumstances, the stated preference approach may be more appealing to marketing economists than revealed preference approaches, such as presented in Chapter II and Chapter III. The main attraction of the revealed preference approaches is that they use actual market data to estimate the marginal valuation of quality characteristics. They are, therefore, based on observed behaviour. However, as Louviere (1992) noted, real markets frequently exhibit limited ranges of variation in important behavioural or managerial variables. As well, new products or services may contain features or enhancements not yet available in real choice data. Some new products or services pioneer new categories and offer new benefits not previously available in past market data. Frequently, explanatory variables based on real market data exhibit collinearity, may be measured imprecisely (or even incorrectly), or may violate a variety of statistical properties limiting the analysis based on them.

The data issues outlined above seem particularly relevant to the Kenyan beef market. As noted by Karugia (1990), the price control policy that applied prior to February 1987 tended to encourage the fairly uniform production and sale of low quality beef. This situation was encouraged by the fact that the price control policy was applied at the retail level and not at the wholesale level. Thus, despite paying different prices at the wholesale level, butchers had to sell beef at the specified retail price regardless of quality. Thus butchers had an incentive to sell low quality beef, as this had a wider retail margin. Over time, the quality of beef produced and sold in Kenya deteriorated. Casual observation of current beef retailing practices seems to suggest that this situation has not changed much. This observation is not surprising given that a lack of market information has been a pervasive feature of the Kenyan beef market (Karugia, 1990). Observed market data would, therefore, not be expected to exhibit wide variations in the attributes considered here. This observation is borne out by evidence gathered in the studies presented in the preceding two chapters of this thesis. Evidence of potential existence of collinearity is indicated in Appendixes B and C of this thesis. Thus, despite the obvious and immediate appeal of external validity exhibited by observational choice data, there are compelling reasons why we might want to collect experimental choice data.

4.2 Overview of the Experimental Analysis of Choice

Experimental analysis of multiple choice behaviour was motivated by developments in choice modelling, discrete multivariate analysis, and conjoint analysis (Batsell and Louviere, 1991). These procedures have mostly been applied in analysing consumer behaviour. Their application at modelling producer behaviour has been a natural extension, especially in the context of conjoint analysis (see for example, Jennings, 1993). Experimental choice models have been and are being applied to practical problems in marketing (Guadagni and Little, 1983; Louviere and Woodworth, 1983; Kamakura and Russell, 1989; Jayne et al., 1996), transportation planning (Morikawa, 1989; Ben-Akiva and Morikawa, 1990; Hensher and Brandley, 1993; Ben-Akiva et al., 1994; and Swait et al., 1994), and environmental and recreation studies (Louviere, et al., 1993; Adamowicz, et al., 1994, 1997).

Experimental choice analysis differs from econometric probabilistic discrete choice analysis only in that the choice data analysed are experimental and not observational. However, the econometric theory underlying choice models is blind to the source of choice data, so choice experiments represent a natural extension of econometric and statistical theory.

4.3 Data and the Empirical Model

The experimental choice analysis pursued in this study involved four main tasks: (i) design of a formal experiment that satisfied necessary and sufficient conditions for the estimation of a probabilistic discrete choice model; (ii) estimation of model parameters from the data collected in the choice experiment; (iii) tests of model specification based on the choice experiment; and (iv) use of the estimated parameters to determine the relative importance and implicit values of the various quality characteristics.

Choice experiments often rely on combinatorial experimental designs to construct choice stimuli. The choice experiment in this study was designed by using an orthogonal, fractional factorial array to design alternatives and choice sets simultaneously. In experimental design, the size of choice sets (the number of alternatives in choice sets) is influenced by the nature of the research problem, experimental design technology and limits to human cognition It is widely agreed that choice experiments should mimic the actual choice situations faced by individuals as closely as possible. To date it has proved difficult to design practical choice experiments involving more than four to six choice alternatives that can be administered in field settings unless the number of attributes associated with each alternative is small (Batsell and Louviere, 1991). In this study choice sets of three alternatives were constructed. The third alternative was non-varying between choice sets.

The size of choice experiments is a function of the number of attributes to be varied in association with each choice alternative. The larger the number of attributes, the larger the number of choice sets. To reduce the number of choice sets presented to each respondent, it was necessary to block the experiment so that different individuals could respond to different choice sets. Batsell and Louviere (1991) observe that the different blocks can be concatenated to estimate aggregate models. One way to ensure that the blocks are approximately statistically equivalent is defining an extra variable and including it in the experimental design as a factor (Adamowicz, et al., 1994).

In constructing the choice experiment for this study the researcher was confronted with a number of issues and tasks. These included (i) identifying the set of determinant characteristics; (ii) selecting the levels which each characteristic was to take; and (iii) deciding how to present product stimuli to respondents. Several approaches to characteristic identification are suggested in the available literature. Cattin and Wittink (1982) list the approaches used in commercial applications of conjoint analysis as: (a) eliciting the 'expert judgement' of knowledgeable industry participants; (b) group interviews of buyers; (c) direct questioning of individual subjects; (d) use of Kelly's repertory grid, a technique that elicits the unique dimensions along which individuals classify their world; and (e) protocols. Other methods include reviewing relevant technical and trade literature, and direct observation of subjects' behaviour. Currim et al. (1981) note that in some cases the set of experimental characteristics is limited to those which product managers are able and willing to manipulate. For this study, a combination of methods was used to identify the relevant characteristics. A preliminary review of literature on beef marketing and meat science was undertaken to identify the attributes that are likely to be most important to beef retailers in Kenya. This was followed by direct questioning and interviews with butchers before the actual survey commenced. Butchers were also observed making carcass choices at slaughterhouses. The four attributes that were identified by this process as being the most important to butchers were price per kilogram, carcass conformation, carcass fatness, and carcass weight.

Carcass conformation has meant different things at different times and to different people. For this study this factor was taken to mean "meatiness," reflecting thickness of flesh and a blocky shape. This definition does not distinguish between muscle thickness and fat thickness. Subcutaneous fat thickness was chosen to represent carcass fatness. In meat science, bovine subcutaneous fat thickness is not considered a good predictor of total fat. It represents less than 35% of the fat in a beef carcass and its proportion changes as the animal develops. However, a simple repeatable predictor of beef carcass fatness continues to elude meat scientists (Price, 1995). Weight was used as a proxy for carcass size. In practice, all three attributes are correlated to some degree. A fat carcass is likely to have good conformation and weigh more.

In deciding on the levels that each characteristic was to take, a degree of pragmatism was involved. Green and Srinivasan (1978, 1990) observe that the researcher must balance between 'familiarity with' and 'believability of' the stimuli by the respondents. This improves the *prima facie* validity of judgement based responses. Four levels were defined for each of the four characteristics identified above. The actual levels for conformation and fatness of each inspected carcass were determined in collaboration with a meat scientist who was present for the early stages of the field work. The price and weight levels were defined so as to encompass the range of the prevailing wholesale prices and carcass weights.

With four attributes at four levels, an orthogonal main effects plan yielded 32 choice sets. Blocking yielded four statistically equivalent blocks. Therefore, the final experimental design consisted of four blocks of eight choice sets with each choice set consisting of three alternatives. The third alternative was a constant reference that ensures that the parameter estimates have a common origin and scale unit (Adamowicz, et. al 1994; Batsell and Louviere, 1991).

The decision as to the method of stimuli presentation was guided by considering how butchers currently choose carcasses at the wholesale level. As noted by Ryan (1970), throughout time butchers and their customers have used their sense of sight to grade meat. Accordingly, the use of visual judgements where respondents were presented with pictures of the various stimuli was a logical way to proceed. Pictures of beef carcasses whose attribute levels had been determined were presented to respondents for their judgement. The four price levels that were included in the experimental design were Sh. 70, 90, 105, and 120 per kilogram of dressed weight. For the attributes of conformation and fatness, the four levels were labelled 1, 2, 3, and 4. Conformation 1 represented the poorest level while 4 represented the best conformation. For the attribute of fatness, 1 represented a lean carcass with no fat while 4 represented the thickest and most uniform subcutaneous fat cover. The four weight levels included in the experimental design were 80, 140, 220, and 300 kilograms. Each respondent was presented with eight choice sets, each of which consisted of three carcasses of different quality attributes. For each choice set, the respondent was required to indicate the proportion of each choice alternative that they would purchase on a typical buying occasion. Figure 1 shows a typical choice set. The personal interview method used in the survey allowed the interviewers to explain the purpose of the survey and present the survey questions to the respondents accurately and completely. This method ensured that respondents understood the task well and thereby minimized inaccuracies in the data collected.

Set # 1			
Product attributes	*Choice A*	*Choice B*	*Choice C*
Price (Sh./Kg)	120	90	70
Conformation	3	2	1
Fatness	1	4	1
Weight (Kg)	300	80	80

Indicate the proportion of each alternative that you would purchase on a typical buying occasion.

A__________ B__________ C__________

Figure 4-1 An Example of a Stated Preference Question

Data were collected in the metropolitan area of Nairobi in the months of January and February 1996. This region was chosen because it represents a major rapidly expanding region of meat consumption. Abattoirs serving Nairobi and its environs handle more than 30 per cent of all the animals slaughtered in Kenya (Karugia, 1990). A list consisting of all the butcheries that had been licensed to operate within the City of Nairobi in 1995 was constructed from records obtained from the City Inspectorate Department. This list served as the sampling frame. It contained a total of 562 butcheries. From the sampling frame a random sample of 150 butcheries was selected In each butchery, the person responsible for purchasing beef was interviewed. Complete and useful surveys were completed with 108 butchers who represented 72 percent of the sample. The remaining 42 surveys (or 28 percent of the total) consisted of 9 (6 percent) butcheries that had closed down in the previous year, 15 (10 percent) butchers who declined to be interviewed or did not wish to complete the whole survey, and 18 (12 percent) butchers who were unavailable even after repeat visits. The response rate was high for this type of survey.

As indicated above, respondents were presented with eight choice sets each of which consisted of three carcasses of different quality attributes. The respondents were asked to indicate the proportion of each alternative carcass that they would purchase on a typical buying occasion. The gender of respondents was recorded and respondents were also asked to provide information about their individual characteristics, including their level of education, selling practices, location, experience, and volume of sales. A survey questionnaire was used for the data gathering exercise. The author and two trained enumerators administered the survey. The survey instrument is presented in Appendix E.

As noted above, experimental choice models are amenable to analysis by applying the theory of random utility processes and the econometric theory that applied to discrete choice observations. Accordingly, the multinomial logit model (MNL) was used in this analysis; further discussion and derivation of the model is given in Chapter III.

The MNL model that is empirically tested in this analysis is:

$$P_n(i) = \frac{\exp^{\mu\beta' x_{in}}}{\sum_{j\in C_n} \exp^{\mu\beta' x_{in}}} \tag{5.1}$$

Since the scale parameter μ cannot be estimated independently, it is typically normalized to unity (Maddala, 1983; Ben-Akiva and Lerman, 1985). Following common practice, the indirect utility function was assumed to be linear. $P_n(i)$ is the probability that individual n will choose alternative i, x_{in} is the vector of carcass attributes of conformation, fatness, weight and price; and β_i, (i=1,...,n), are parameters to be estimated. In the modified MNL model the design matrix $\boldsymbol{x}$ is modified to include interaction terms between the four carcass attributes and the buyer/butchery characteristics. The variables used in the model to represent carcass attributes were presented in Table 2-2 of Chapter II. Variables used to represent the buyer/butchery characteristics are presented and described in Table 3-2.

4.4 Results and Discussion

Using the data collected in the survey, various combinations of explanatory variables and data transformations were used to fit different specifications of the discrete choice model. Although carcass conformation and fatness represent underlying continuous variables they are best represented as categorical variables because the difference between any two successive levels is not constant. On the other hand, price and weight are continuous and are, therefore, represented as such. Most of the data on the buyer/butchery characteristics were collected as categorical variables. Some categories did not have sufficient observations for a meaningful analysis. Such categories were merged and this increased the degrees of freedom for a more efficient estimation.

On the basis of years of education, butchers were classified as having a low education level if they had no more than primary school education and a high level of education if they had received secondary school (or more) education. Butcheries were categorized as either located in high income areas or low income areas. Precise data to facilitate a distinction of low and high income locations of Nairobi were not available. A proxy measure was, therefore, adopted . Using newspaper sources and direct questioning of butchers, average rent rates for houses in particular locations were computed. Locations were classified as high income if they had rent rates above the average for all the locations. Butchers were also classified into two experience categories. Butchers were considered to be experienced if they had been in the beef retail trade for more than two years and inexperienced if they had been in this business for less than two years. On the basis of their selling practices, butchers were classified to be either "high class" or "low class." Butchers who sold most of their beef in special cuts such as sirloin or rump steak were classified as high class. Low class butchers consisted of those who sold beef as meat-on-bone. Butchers who dealt with one wholesaler more than 50 percent of the time were classified as being "highly integrated" and those who tended to deal with different wholesalers were considered to have a "low degree of integration".

The choice variables of price, conformation, fatness, and weight were included in all the model specifications that were considered. These models differed only in the specification, i.e. the inclusion or omission, of particular buyer/butchery-specific characteristics. A notable feature of all the models specified was that alternative-specific constants were omitted. The omission of alternative-specific constants is consistent with the idea of an 'abstract product' espoused by Quandt and Baumol (1966). The significance of the abstract carcass approach is that no attention needs to be paid to the specific physical entities of carcass A, B or C. Thus, in the orthogonal fractional factorial experimental design outlined above, each alternative was assumed to be completely characterized by its characteristics.

Model I is a discrete choice model involving the three choices in each choice set and no buyer/butchery characteristics. The results are presented in Table 4-1. In this model, the price coefficient was found to be insignificant and estimates of implicit values of attributes did not appear plausible. Several specifications that included buyer/butchery characteristics showed that the price parameter estimate was unstable. Examination of the data showed that alternative C was chosen in only 27 (3.2 percent) of the 837 observations. This implies that there was insufficient information about the third alternative for meaningful parameter estimation. Consequently, the third alternative and the 27 sample observations that involved its choice were deleted from the data and binary choice models

Table 4-1 Estimation Results for Model I (Three Choices)

Variable	Coefficient estimate	Standard error	t-statistic
Price/100	-0.1041	0.2653	-0.392
Conformation level 2	0.9170	0.1467	6.250***
Conformation level 3	1.3988	0.1443	9.697***
Conformation level 4	1.4864	0.1478	10.057***
Fatness level 2	1.1250	0.1455	7.734***
Fatness level 3	1.1322	0.1429	7.926***
Fatness level 4	0.6269	0.1421	4.412***
Weight/100	0.2494	0.0629	3.965***

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

Summary statistics

Number of observations = 837
Log likelihood function =-641.0454
Log likelihood: Constants only =-680.7044
Log likelihood: No coefficients =-919.5385
$-2[L(\mathbf{0})-L(\beta)]$ =556.986
Rho squared =0.3029
Rho-bar squared =0.2942

were estimated. It is necessary to reinterpret the choice experiment to reflect that respondents are being forced to choose between two alternatives rather than three.

With the data reinterpreted in this manner, several model specifications involving the different buyer and butchery-specific variables were assessed. Rejection of a particular model was based on the congruence of the model estimates with *a priori* expectations and statistical significance tests. In some cases, especially those in which a large number of buyer and butchery characteristics were included, estimation was not feasible due to singular Hessians. Results for three model specifications are presented here.

Initial estimation results identified four buyer/butchery characteristics to have significant influences on the butcher behaviour. The location of the butchery, the experience of the butcher, selling practices, and the degree of "integration" were found to affect choice significantly. Butcher education, gender, butchery ownership, and volume of sales did not show significant influences on butcher choice behaviour. Models II, III, and IV differed only in how these buyer/butchery characteristics entered the models. In Model II the buyer/butchery characteristics were not included. Butcher choice behaviour was assumed to be influenced only by price and the quality attributes of conformation, fatness, and weight. Model II estimation results are presented in Table 4-2. Model III includes the buyer/butchery characteristics of location, experience, selling practices, and "integration" interacting with all the carcass attributes. The estimation results are presented in Table 4-3. Model IV was specified so as to exclude most of the interaction terms that were not significant in Model III. The coefficient estimates for Model IV are presented in Table 4-4.

Table 4-2 Estimation Results for Model II

Variable	Coefficient estimate	standard error	*t*-statistic
Price/100	8.2363	3.5908	2.294**
Price/100 Squared	-4.6878	1.8953	-2.473**
Conformation level 2	0.5295	0.1519	3.485***
Conformation level 3	1.0900	0.1553	7.020***
Conformation level 4	1.1075	0.1548	7.153***
Fatness level 2	0.7196	0.1502	4.791***
Fatness level 3	0.6943	0.1528	4.543***
Fatness level 4	0.2150	0.1513	1.421
Weight/100	1.0768	0.3826	2.815***
Weight/100 squared	-0.2510	0.0985	-2.550**

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

Summary statistics

Number of observations = 810
Log likelihood function =-497.5116
Log likelihood: Constants only =-561.4270
Log likelihood: No coefficients =-561.4492
$-2[L(\mathbf{0})-L(\beta)]$ =127.8752
Rho squared =0.114
Rho-bar squared =0.096

Table 4-3 Estimation Results for Model III

Variable	Coefficient estimate	standard error	*t*-statistic
Price/100	4.7046	3.8019	1.237
Price/100 Squared	-4.4008	1.9705	-2.233**
Conformation level 2	0.9879	0.4154	2.378**
Conformation level 3	1.2863	0.4108	3.131***
Conformation level 4	1.8083	0.4203	4.303**
Fatness level 2	1.2673	0.4123	3.074***
Fatness level 3	0.6692	0.4009	1 669*
Fatness level 4	0.6445	0.4208	1.532
Weight/100	1.1425	0.4367	2.616***
Weight/100 Squared	-0.2342	0.1044	-2.244**
Price*Location2	1.4281	0.6664	2.143**
Conformation2*Location2	-0.2300	0.3517	-0.654
Conformation3*Location2	-0.1171	0.3620	-0.323
Conformation4*Location2	-0.6998	0.3555	-1.969**
Fatness2*Location2	0.2709	0.3541	0.765
Fatness3*Location2	-0.3540	0.3496	-1.013
Fatness4*Location2	0.2082	0.3529	0.590
Weight**Location2	-0.0492	0.1505	-0.327
Price*Experience2	1.9474	0.7409	2.628***
Conformation2*Experience2	-0.2268	0.3874	-0.585
Conformation3*Experience2	0.0078	0.3773	0.021
Conformation4*Experience2	0.2466	0.3804	0.648
Fatness2*Experience2	-0.4304	0.3852	-1.117
Fatness3*Experience2	0.4214	0.3722	1.132

Table 4-3 continued

Variables	Coefficient estimate	standard error	*t*-statistic
Fatness4*Experience2	-0.0938	0.3884	-0.241
Weight*Experience2	-0.0904	0.1597	-0.566
Price*Class2	1.0527	0.8348	1.261
Conformation2*Class2	-0.0985	0.4366	-0.226
Conformation3*Class2	-0.6104	0.4390	-1.390
Conformation4*Class2	-0.2617	0.4315	-0.607
Fatness2*Class2	-1.0559	0.4081	-2.587***
Fatness3*Class2	-0.3561	0.4340	-0.820
Fatness4*Class2	-0.7156	0.4360	-1.641*
Weight*Class2	0.1075	0.1835	0.586
Price*Integration1	1.1762	0.6195	1.899*
Conformation2*Integration1	-0.2343	0.3341	-0.701
Conformation3*Integration1	0.0396	0.3353	0.118
Conformation4*Integration1	-0.8474	0.3431	-2.470***
Fatness2*Integration1	-0.1029	0.3203	-0.321
Fatness3*Integration1	-0.0024	0.3354	-0.007
Fatness4*Integration1	-0.4201	0.3364	-1.249
Weight*Integration1	-0.0624	0.1375	-0.454

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

Summary statistics
Number of observations = 810
Log likelihood function =-469.7386
Log likelihood: Constants only =-561.4270
Log likelihood: No coefficients =-561.4492
$-2[L(0)-L(\beta)$ =183.4212
Rho squared =0.1633
Rho-bar squared =0.0885

Table 4-4 Estimation Results for the Most Preferred Model IV

Variable	Coefficient estimate	standard error	t-statistic
Price/100	6.1278	3.7192	1.648*
Price/100 Squared	-5.0236	1.9337	-2.598***
Conformation level 2	0.5914	0.2296	2.576**
Conformation level 3	1.0256	0.2321	4.420***
Conformation level 4	1.4662	0.2397	6.116***
Fatness level 2	0.9393	0.1784	5.266***
Fatness level 3	0.8082	0.1764	4.581***
Fatness level 4	0.3118	0.1748	1.783*
Weight/100	1.1000	0.3929	2.800***
Weight/100 Squared	-0.2533	0.1012	-2.504**
Price*Location2	1.7203	0.5981	2.876***
Price*Experience2	1.9277	0.7062	2.730***
Fatness2*Class2	-0.8578	0.3616	-2.373**
Fatness3*Class2	-0.4096	0.3944	-1.039
Fatness4*Class2	-0.4073	0.3924	-1.038
Price*Integration1	0.9311	0.5976	1.558
Conformation2*Integration1	-0.1173	0.3174	-0.369
Conformation3*Integration1	0.1789	0.3166	0.565
Conformation4*Integration1	-0.6378	0.3225	-1.977**

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

Summary statistics

Number of observations	= 810
Log likelihood function	=-481.9590
Log likelihood: Constants only	=-561.4270
Log likelihood: No coefficients	=-561.4492
$-2[L(\mathbf{0})-L(\beta)$	=158.9804
Rho squared	=0.1416
Rho-bar squared	=0.1077

The results in Table 4-2 show that Model II has a reasonable fit for cross-sectional data. The McFadden's R^2 is 0.114 and McFadden's adjusted R^2 is 0.096. All four attributes are significant. At the average of the four price levels (Sh. 96.25) the price coefficient is negative as was expected. The quality attributes also have the expected positive sign. However, since Batsell and Louviere (1991) have observed that MNL models perform better when specified to account for individual specific attributes, the next step in this study was to specify a MNL model that included buyer/butchery characteristics. Since buyer/butchery characteristics are constant for all choices in an observation, they were included in the model by interacting them with the product attributes.

Model III includes the buyer/butchery characteristics of location, experience, selling practices, and "integration" interacting with all the carcass attributes. The estimation results presented in Table 4-3 show that price, conformation, fatness, and weight are all significant and have the expected signs. However, only 7 of the 32 interaction terms are significant at the 10% level. The McFadden's R^2 for this model is 0.163 and McFadden's adjusted R^2 is 0.089. The inclusion of all the interaction terms did not seem to improve the fit of the model as measured by McFadden's adjusted R^2. It was, therefore, necessary to specify a more parsimonious model.

Model IV was specified so as to exclude most of the interaction terms that were not significant in Model III. To facilitate clear interpretation of the coefficients and further analysis based on them, some interaction terms that were not significant in Model III were included in this model. For instance, the interaction terms between conformation levels 2 and 3 and high integration variable had large standard errors in Model III but they were included in Model IV because the interaction of conformation level 4 and high integration variable produced a significant effect on the probability of choice. The estimated coefficient of the interaction between conformation 4 and integration could then be interpreted with conformation level 1 and low integration as the base.

The coefficient estimates for Model IV show that the omission of interaction variables with large standard errors improved the estimation of the remaining coefficients. Fourteen of the 19 coefficients in this model are significant. McFadden's R^2 for this model is 0.142 and McFadden's adjusted R^2 is 0.108. Of the four models considered here, Model IV had the best fit in terms of McFadden's adjusted R^2. The congruence of the model estimates with *a priori* expectations and the strong statistical significance made this the preferred model on which the attribute valuations, which are presented in Table 4-5, were computed. The coefficient estimates are fairly robust across the four models.

As noted above, the estimated coefficients for the four beef attributes have the expected signs in all four models. Price is significant in all models except Model I. In models II, III, and IV, price has a quadratic relationship with utility. At low levels price a positive influence on the utility of a choice. This result collaborates the observation in Chapter III that, at low levels, price may signal to butchers improvements in unobservable attributes. In all four models, carcasses with better conformation have higher utilities than poorer ones. The magnitudes of the conformation dummy coefficient estimates indicate that the utility of an alternative increases as it improves from conformation level 1 to level 4. A Wald test of the equality of the three conformation coefficients in Model IV rejected this hypothesis at the 1% level. All else equal, utility is highest for carcasses with conformation 4. In all models, carcasses with more fat have higher utilities than lean ones. The fatness dummy variables show the same general pattern as the conformation dummy coefficient estimates. Relative to the lean carcass, fatter carcasses have higher utilities. Except in Model I, the relative values of the three fatness coefficients indicate that a larger increase in utility is produced when the carcass fatness increases from level 1 to 2. In all four models, fatness level 4 produces a lower increase in utility than fatness levels 2 and 3, reflecting buyer disutility associated with over-fat carcasses. In Model I, the largest increase in utility is produced by fatness level 3. A Wald test of the equality of the three fatness coefficients in Model IV rejected this hypothesis at the 1% level. Further testing showed that fatness level 2 is not significantly different from fatness level 3. However, fatness level 2 and 3 have a significantly higher effect on utility than level 4 which does not significantly increase utility relative to level 1. This result suggests the existence of an optimal level of fatness. Weight has a nonlinear influence on the utility derived from a carcass. From the results of Model IV, the influence on utility is positive at carcass weights lower than 434.22 kg. For carcass weights higher than this value, weight is discounted. This result is similar to that from the hedonic price analysis of Chapter II.

An interpretation of the coefficients of the interaction variables is presented for Model IV only. Similar interpretations apply for Model III as the coefficients have the same signs and similar coefficient values in both models. Price produced significant interaction terms with the buyer/butchery-specific variables of the location of the butchery, the experience of the butcher, and the degree of "integration". The coefficient estimates are positive. From these results it can be inferred that butchers who operate in high income locations are less price elastic than their counterparts in low income areas. Their choice behaviour appears to be influenced more by other carcass attributes than by price. This may reflect a degree of price insensitivity and higher quality consciousness of the higher income consumers who are served by these butchers. A similar interpretation may apply to the positive coefficient of the interaction between the experience of the butcher and price. Butchers with more than two years of experience may be concerned with attributes other than price and may prefer to provide better quality beef and charge higher prices to their customers. These coefficient estimates may also reflect a higher opportunity cost to these butchers of the time spent haggling for prices in the wholesale markets. It is interesting to note that butchers who tend to deal with the same wholesaler are less price sensitive than those who prefer to deal with different wholesalers most of the time. This group of butchers may prefer to deal with one wholesaler so as to ensure that they obtain beef of desired quality attributes even if this means paying a higher price. It is also possible that by contracting with one or a few wholesalers to supply them with beef, these butchers may be able to reduce their buying costs, for example by avoiding trips to the wholesale market. Some butchers preferred to have wholesalers deliver beef to their butcheries rather than going physically to buy at slaughterhouses. Evidently butchers who deal with different wholesalers shop around for low priced beef.

The interaction of fatness dummy variables and the "high class" dummy variable produced negative coefficient estimates indicating that high class butchers are less likely to buy fatter carcasses compared to other butchers. The interaction of fat level 2 with the "high class" dummy variable is significant while interactions with levels 2 and 3 are not.

Carcasses with fatness higher than level 2 may not enter the choice sets of high class butchers and their absence or presence has no effect on their utility. To these butchers, fat may represent trimmable waste that needs to be discounted for when they make their purchase decisions. Butchers who prefer to deal with one seller are less likely to buy carcasses of conformation level 4, as indicated by the negative coefficient estimate on the conformation level 4-integration term.

The inclusion of price as one of the factors affecting the probability of choice provides the basis to estimate the value of the various quality attributes. Ben-Akiva and Lerman (1985) and Lareau and Rae (1988) note that for a linear indirect utility function, a ratio of two coefficients appearing in the same utility function provides information about a trade-off, or marginal rate of substitution, between the two corresponding variables.[5] Table 4-5 presents the estimated implicit values of the three quality attributes considered in this study. Implicit prices are presented for five categories of butchers. The base category consists of those butchers who are located in low income locations, have less than two years of experience, do not sell meat in special cuts, and tend to deal with many wholesalers. The other four categories represent stratification of the sample on the basis of high income location, more than two years of experience, high class, and degree of integration. These categories are compared to the base category. Category A consists of butchers in high income locations, Category B consists of butchers with more than two

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[5] More complex specifications of the indirect utility function yield somewhat more complex formulas for the marginal rate of substitution. These formulas are obtainable by applying the total derivative rule of calculus.

Table 4-5 Estimated Implicit Values of Carcass Attributes Based on Model IV

Attribute	Value (Sh./unit)	Standard error	*t*-statistic
(A) Base Category			
Conformation level 2	16.693	7.364	2.267**
Conformation level 3	28.949	8.956	3.229***
Conformation level 4	41.387	10.936	3.785***
Fatness level 2	26.515	7.509	3.531***
Fatness level 3	22.812	6.861	3.325***
Fatness level 4	8.802	5.348	1.646*
Weight	0.046	0.021	2.180**
(B) High Income Location Category			
Conformation level 2	32.452	18.130	1.790*
Conformation level 3	56.279	26.270	2.142**
Conformation level 4	80.459	35.299	2.279**
Fatness level 2	51.546	23.155	2.226**
Fatness level 3	44.349	20.345	2.180**
Fatness level 4	17.112	12.094	1.415
Weight	0.089	0.051	1.751*
(C) More Experienced Category			
Conformation level 2	36.619	19.766	1.853*
Conformation level 3	63.505	27.083	2.345**
Conformation level 4	90.790	34.806	2.608***
Fatness level 2	58.164	23.692	2.455**
Fatness level 3	50.043	20.916	2.393**
Fatness level 4	19.309	13.038	1.481
Weight	0.101	0.055	1.848*

Table 4-5 continued

(D) High Class Category[a]

Attribute	Value (Sh./unit)	Standard error	*t*-statistic
Fatness level 2	2.301	8.900	0.258
Fatness level 3	11.250	10.213	1.101
Fatness level 4	-2.696	9.878	-0.273
(E) High Integration Category			
Conformation level 2	18.155	9.567	1.898*
Conformation level 3	46.123	14.898	3.096***
Conformation level 4	31.721	11.856	2.676***
Fatness level 2	35.968	11.588	3.104***
Fatness level 3	30.946	10.555	2.932***
Fatness level 4	11.941	7.435	1.606
Weight	0.062	0.030	2.049**

[a] For the High Class category, implicit prices for conformation and weight are the same as those of the Base Category.

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

years of experience; Category C consists of high class butchers; and Category D consists of butchers who tend to deal with one wholesaler. The implicit price estimates are calculated from the most preferred model (Table 4-4).[6]

The estimated implicit prices suggest that all else being equal, butchers attach positive values to the attributes of conformation, fatness, and weight. For conformation and fatness, the implicit prices represent the value per kilogram added to the carcass relative to the base level, level 1. In the case of weight the implicit prices are for marginal increases in weight. The estimated implicit prices for conformation are generally of the same magnitude for all butcher groups. Although they are expected to be higher than for the base category, the attribute implicit prices for the high income location and butchers with more than two years of experience appear to be high. Actual market prices of carcasses ranged between Sh. 50/kg and 120/kg. Increases in value of Sh. 90/kg relative to the base level appear to be unlikely. Estimates for other groups appear to fall within a reasonable range. It is observed that in general, each successive conformation level adds more value to the carcass than the preceding level.

In a similar fashion, fatness increases the value of carcasses. On average, butchers are willing to pay a higher price for a fat carcass relative to a lean carcass represented by fat level 1. However, the highest increase in value is for carcasses of fat level 2. Beyond fat level 2, the increase in carcass value decreases. For all butcher groups, fatness level 2 increases the value of the carcass the most followed by fatness level 3 while level 4

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[6] For the method of the computation of the asymptotic standard errors of the implicit prices, see footnote 4 on page 58.

produces the lowest increase in value. In fact, fat level 4 has an implicit value of zero for all butchers' groups except for the base category where it is just marginally significant. A closer examination of the estimated implicit prices reveals that there are substantial differences in the value attached to fatness by different butcher groups. The high class butchers do not attach any value to carcass fatness according to the results of this study. As observed earlier, this group of butchers sell beef in special cuts and may, therefore, consider fat as trimmable waste and hence discount for it if present in a carcass. It is also possible that the high income clientele served by this group of butchers is conscious of the health implications of animal fat in their diet.

All else being equal, larger animals, as measured by carcass weight, are valued more than smaller ones. The implicit value of a marginal increase in weight ranges from 4.6 cents/kg for the high class butchers to 10.1 cents/kg for the more experienced group of butchers. In general, the implicit values of the carcass attributes appear reasonable given the observed price ranges in actual beef wholesale markets (see Appendix A).

All in all, of the three quality attributes considered in this study, conformation appears to be the most valued by butchers. The implicit value for conformation 2 ranged between Sh. 16.69/kg for the base and high class categories and Sh. 36.62/kg for the more experienced butchers. Conformation level 4 had the highest value except in the case of the group of butchers that is highly integrated.

Attempts to stratify the sample of butchers further, for example, by interacting location and experience produced implicit values with large standard errors. This is because the sample of 108 butchers was too small to allow for meaningful estimation of implicit prices for smaller subgroups. As would be expected, implicit value estimates from Model III show the same pattern as those discussed for Model IV.

4.5 Conclusions

This study presents a method of collecting experimental choice data and using such data to estimate the implicit prices of quality attributes in the same spirit as hedonic price analysis which uses actual market data. The results of the study show that the quality attributes of carcass conformation, fatness, and weight are important in determining the value of a carcass at the wholesale level. Conformation appears to be the most important attribute that determines the probability of choice of particular beef carcasses.

The inclusion in the model of buyer/butchery characteristics improves the performance of the model as evidenced by the improvement of the coefficient estimates especially that of the price variable. The location of a butchery, the experience of the butcher, selling practices, and the extent of the tendency to deal with one seller appear to be the most important of the buyer/butchery characteristics considered. Gender, education, ownership, and volume of sales seem to be unimportant characteristics in influencing butcher buying behaviour. While this is somewhat at variance with our expectations, some of these results may be explained if we consider what these variables are measuring. Higher volume butcheries tend to be located in high income locations where beef consumption is higher. Kivunja (1976) found beef to be highly income elastic. Experience may compensate for a low education level hence making education inconsequential in the buying practices of the more experienced butchers.

The information generated in this study shows that a grading system based on the attributes of carcass conformation, fatness, and carcass weight would reflect the different valuations that buyers attach to these attributes. This information can also be used by farm managers to adjust their management systems so as to meet market requirements and obtain premium prices for their product. Farmers can substantially increase the values of their animals by improving conformation through breeding and management. The market does not prefer over-fat carcasses and some market segments prefer lean animals. Of course, a cost benefit analysis would be necessary to determine the net benefits to farmers of raising better conformed animals with desired fat levels. Extension work is necessary to educate farmers and farm managers on how to evaluate these characteristics in live animals. According to these results animal breeders should breed for larger animals with good conformation and intermediate fatness. The market prefers fat carcasses over lean ones, however, there is discounting of over-fat carcasses.

4.6 References

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CHAPTER V

General Discussion and Conclusions

5.1 Introduction

The major purpose of this study is to determine the beef attributes that are important to Kenyan butchers and the values that they attach to them. Several carcass attributes including breed, gender, age, weight, length, conformation, fatness, colour of fat and lean, and damage to carcass are considered. Attributes determined to be important may be used as a basis for defining grades. Another purpose of the study is to assess the general methodological approaches that may be used to value attributes. Three econometric approaches are used to determine and estimate the implicit values of the major quality attributes. In the first approach, a hedonic price model is econometrically estimated. In its basic form, the hedonic price model involves the regression of carcass price against quality variables. The second and third approaches are formulated in a discrete choice framework and multinomial logit models are estimated. One major difference between these last two approaches is the source of data. In the second approach, butchers' behaviour is analysed using data on their observed market choices including their purchases and carcasses that were not chosen. In the third approach, butchers' contingent behaviour is analysed using hypothetical data generated through an experiment to survey their stated preferences. All the data for this study were collected in two surveys of Kenyan butchers that were carried out between November 1995 and February 1996.

The study aims at making a contribution to the empirical knowledge of factors that influence the value of beef in Kenya. It represents the application, to an agricultural marketing problem, of analytical methods usually applied in environmental and transport economics. In this concluding chapter a summary of the major empirical findings of the studies and their implications for the beef industry are presented in Section 5.2. In Section 5.3, some comparative results of the three methodological approaches are presented. A brief discussion of the limitations of this study is presented in the last section of this chapter.

5.2 Summary and Implications

In the hedonic price analysis of Chapter II, attributes that are important in explaining variations in carcass prices are determined and their implicit values estimated. The attributes of conformation, fatness, weight, colour of lean and degree of visible damage were found to be important in determining price. The coefficient estimates for these attributes did not appear to be harmed by the intrinsic collinear relationships between some of the attributes. The magnitudes of the estimated implicit prices appear to be reasonable, and their relative magnitudes conform with *a priori* expectations.

Observed choices by butchers are analysed through a discrete choice model in Chapter III. The multinomial logit model is used to estimate the parameters of butchers' indirect utility function and the coefficients used to calculate butchers' valuations of specific quality attributes. The attributes of conformation, fatness, weight and carcass price were found to have significant influences on butchers' choice behaviour. Other significant influences on butcher behaviour were associated with the buyer/butchery characteristics of location, education, and the degree of integration. The results of this analysis were also influenced by the collinearity between some of the beef carcass attributes. Carcass weight appeared to have a negative effect on utility, in contrast to the results from the other analytical approaches. It seems that the problem of collinearity was less severe in the case of hedonic analysis and more evident in this discrete choice analysis. For example the latter showed some instability of estimates when the model was varied by omitting some variables. In the case of stated preference analysis, collinearity is not a problem, having been avoided by the experimental design.

Chapter IV presents an analysis of butchers' contingent behaviour using a multinomial logit model. The data for this analysis were collected via a stated preference survey. The experimental design minimized many of the data imperfections that are inherent in the revealed preference data. The results of the stated preference analysis showed that the four selected carcass attributes of conformation, fatness, weight, and price are important determinants of butchers' choice behaviour.

The results of the three studies presented in this thesis have important implications for the beef industry in Kenya. All three studies identify conformation and fatness to be important attributes that affect the value of carcasses. Butchers are willing to pay premiums for certain levels of these attributes. Kenyan butchers may not be concerned with many alternative attributes such as age, and breed, that are often thought to influence carcass choice according to the results presented here. It follows then that a grading or classification scheme could be established on the basis of a few attributes, thus greatly simplifying the otherwise difficult task of determining how such attributes should be combined to specify carcass classes or grades. Similarly, animal breeders can focus attention on a few attributes which can increase the productivity and success of their breeding programs. Farmers can also focus their attention on easily identifiable characteristics and have a greater chance of increasing the value of their animals.

Although caution is urged in interpreting the values attached to specific attributes, no serious problems should be expected in using the results of these study for the purposes advocated here. If, as indicated in this study and other animal science research, the linear associations between attributes are intrinsic, predictions of carcass values are not affected by the multicollinearity problem.

Finally, the results of the current analysis have implications for future research in the valuation of beef characteristics. A proposal that has obvious immediate appeal is to recognize the complementary nature of the revealed preference (RP) data and the stated preference (SP) data. The RP data have been found to be ill-conditioned and the effects of some of the beef attributes could not be identified. Combining the RP and SP data sets could reduce the collinearity sufficiently to identify many of these parameters (Louviere, 1994). On the other hand, such a model could benefit from the demand-revealing property of the RP data. The approach of combining RP and SP data has been applied successfully by Adamowicz et al. (1994) in a study in which they estimated the value of stream improvement to people who engage in water-based recreation in Southern Alberta.

5.3 A Comparison of Results of Three Approaches to Characteristic Valuation

The studies presented in Chapters II, III and IV provide an opportunity that is rarely available to economists of comparing and evaluating the performance of actual market data with hypothetical data. Such comparisons have the value of assessing the relative usefulness of hypothetical data, which may be the only available data for non-marketed goods. As indicated in Section 5.2 above, it would be of interest to combine the RP data and the SP data to exploit the complementarities between them to estimate parameters of the butchers' indirect utility function. Such an exercise is, however, possible only if the two data sets are derived from similar underlying preference structure (Adamowicz et al., 1994). The underlying preference structure is similar if, for linear-in-parameters indirect utility functions, the coefficients from the two data sets are equal up to positive constants of proportionality (Louviere and Swait, 1996). In Figure 5-1, the coefficient estimates from the basic revealed preference discrete choice model are plotted against the corresponding estimates of the basic stated preference model. Figure 5-2 is a similar graph for the estimates of the models incorporating buyer/butchery characteristics for the RP analysis and the SP analysis respectively. From these graphs a clear linear relationship between the RP and SP coefficients can be discerned This linear relationship suggests that the two data sets are derived from similar underlying preference structure. A combined model of the RP and SP data may offer considerable scope for improving the estimation of beef carcass attribute values. A research effort in this direction will be undertaken in the near future.

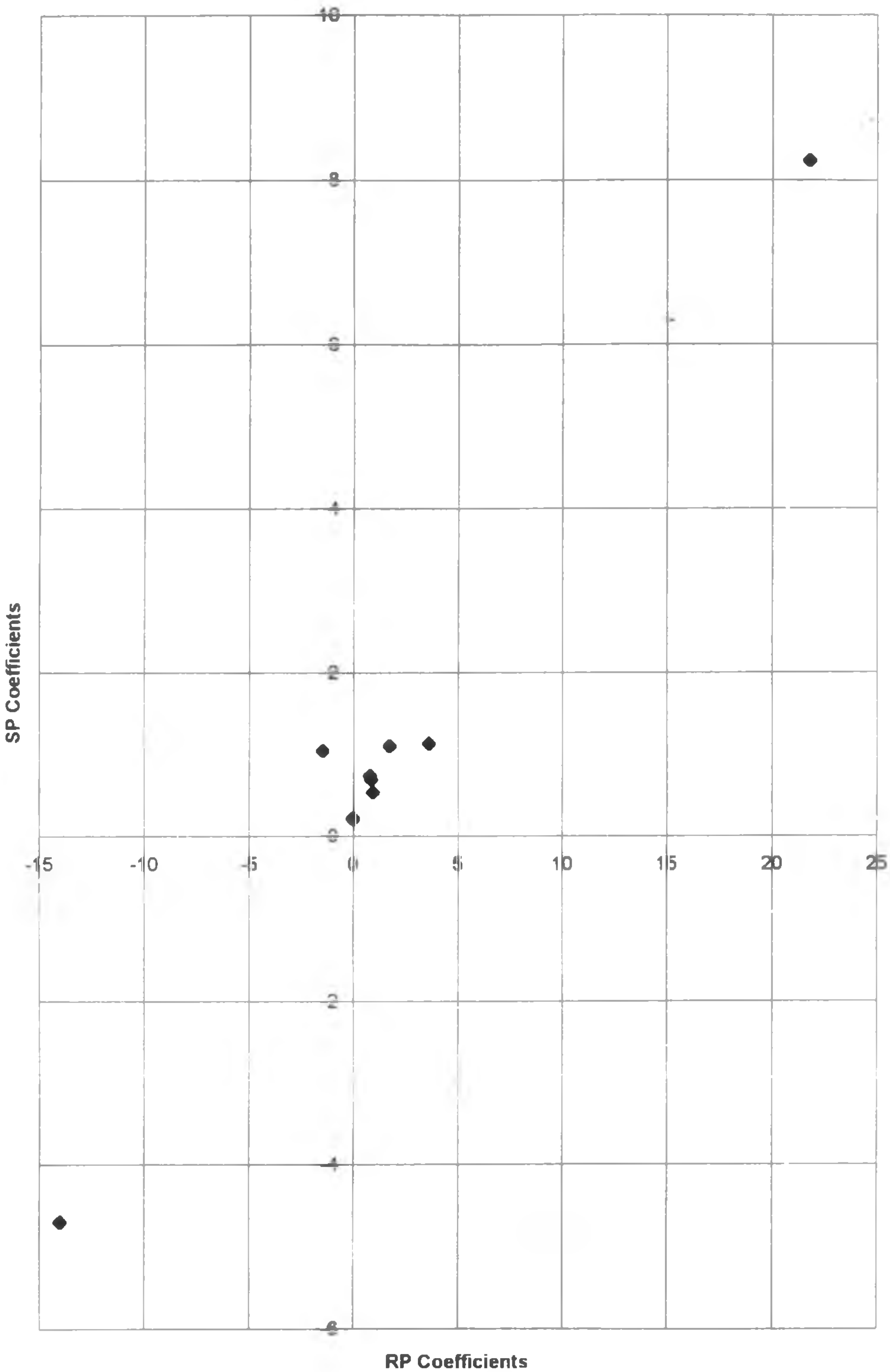

Figure 5-1 Comparison of RP and SP Coefficient Estimates from the Respective Basic Models

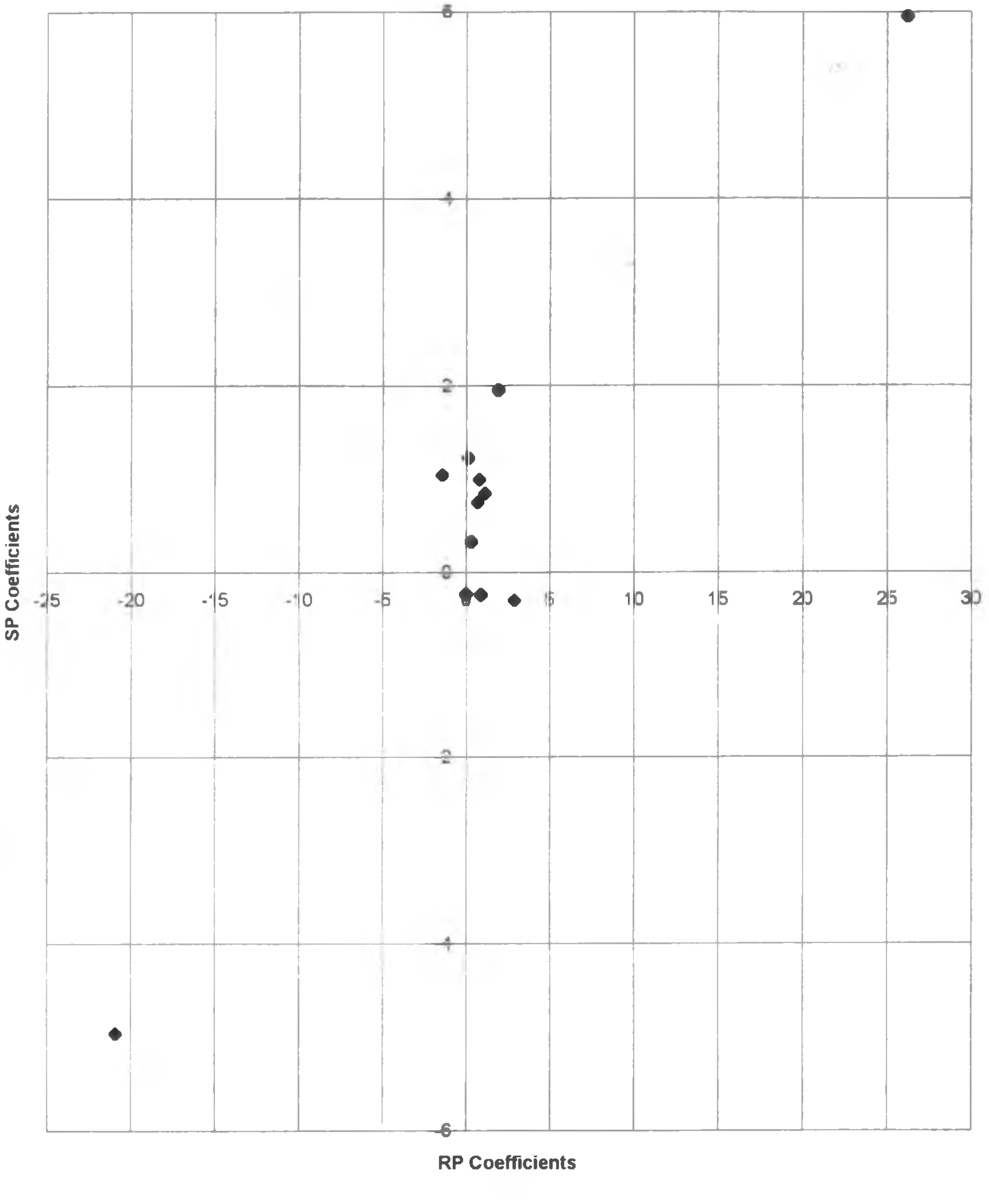

Figure 5-2 Comparison of RP and SP Coefficient Estimates from the Respective Models Incorporating Buyer/Butchery Characteristics

The study also provides the unique opportunity for a comparison of "implicit price" estimates from the hedonic approach and the discrete choice approach. Both approaches are based on the premise that a good is a "tied bundle" of characteristics but the two approaches are founded on somewhat different theoretical underpinnings. Table 5-1 presents a comparison of the implicit prices of the attributes estimated from the hedonic price analysis, the discrete choice analysis of butchers' revealed choices and the discrete choice analysis of butchers' stated preferences.

From Table 5-1, it is observed that all three models yield positive marginal valuations for conformation and fatness. Recognizing that no stratification of the data was done in the hedonic analysis, the magnitudes of the values are comparable to those of the discrete choice analysis of revealed preferences. The only exceptions are conformation level 4 and weight which have zero valuations in the discrete choice model. The general agreement between the estimates of these two models is expected since they were estimated using the same data set. The lower standard errors and conformity with expectations of the coefficient estimates of the hedonic price analysis compared to those of the discrete choice model of revealed preference suggests that the hedonic approach may have merit over the discrete choice approach in the valuation of beef carcass attributes. This finding is contrary to that of Cropper et al. (1993) in their study of housing characteristics using simulated market data. These authors found that the two approaches perform equally well in estimating marginal attribute valuations but the discrete choice approach outperforms the hedonic approach in valuing non-marginal attribute changes.

Table 5-1 A Comparison of the Implicit Price Estimates from the Three Models

Attribute	Hedonic Model	RP[a] Discrete Choice Model	SP[b] Discrete Choice Model
DC_2	4.350 (0.898)***	4.445 (2.611)*	16.693 (7.364)**
DC_3	8.042 (1.598)***	0.996 (6.082)	28.949 (8.956)***
DC_4	9.639 (3.426)***	12.664 (8.413)	41.387 (10.936)***
DF_2	4.584 (0.782)***	5.263 (2.001)***	26.515 (7.509)***
DF_3	5.273 (1.935)***	7.434 (4.148)*	22.812 (6.861)***
DF_4	4.720 (2.214)**	2.139 (5.066)	8.802 (5.348)*
$DC_2 * D_{location2}$	-	10.377 (3.704)***	32.452 (18.130)*
$DC_3 * D_{location2}$	-	-	56.279 (26.270)**
$(DC_{3+}DC_4) * D_{location2}$	-	20.052 (6.245)***	
$DC_4 * D_{location2}$	-	-	80.459 (35.299)**
Weight	0.111 (0.019)***	-0.093 (0.058)	0.046 (0.021)**

[a] Revealed Preference
[b] Stated Preference

Standard errors of estimates are in parentheses.

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

The magnitudes of the implicit price estimates from the stated preference analysis are substantially higher than those of the other two analyses. This is not surprising given the nature of the stated preference survey where respondents focus only on important attributes that are included in the experimental design. Such data allow for a more focussed and efficient isolation of the effects of specific attributes on choice. Furthermore, measurement error is not an issue in the stated preference data. It will be recalled that the data are categorical for conformation and fatness, even though these represent continuous variables. In the case of the stated preference survey, this does not present any problems. However, in the case of actual observational data, border line cases could fall in the lower or higher category, and prices may not be different. In other words some of the variability in the observational data used in both the hedonic and discrete choice model variants may be artificially introduced by the measurement method. Estimates of marginal valuations from such data would be expected to be lower than those from a stated preference survey.

5.4 Limitations of the Current Study

Most of the limitations of this study have been alluded to in previous sections. In this section, these limitations are restated and possible remedies suggested for future research. The most pervasive problem relating to the revealed preference data is associated with the intrinsic correlations between carcass quality attributes. In future research, such a problem can be reduced by abandoning the technique of randomly selecting carcasses and instead selecting a purposeful sample to increase the variation in carcass attributes. Although some variables are necessarily categorical, other variables such as fatness could be objectively measured as continuous variables. Price (1982, 1995) notes that for some carcass attributes, such as colour of fat and lean, there exists ranges of acceptance and non-acceptance. If this is the case in the Kenyan beef market, i.e., if for some attributes a range of indifference or a threshold level exists, then the observed differences in attributes may not be reflected in attribute valuations. It would be interesting to investigate this issue.

Discrete choice analysis of revealed preferences may be adversely affected by the problem of delineating the choice set. In this study, a method suggested by McFadden (1978) of randomly generating choice sets was applied. Five carcasses were randomly drawn from a possible set of hundreds of carcasses and added to the chosen carcasses to form each buyer's choice set. Peters (1993) compared two models, one that used a randomly generated choice set and another that used the entire choice set, and found that while the former model was relatively robust, the estimated coefficients had larger standard errors compared with the estimates from the model that used the whole choice set. In a related study, Parsons and Kealy (1992) found that increasing the number of randomly drawn alternatives in each individual's choice set improved the efficiency of estimation. These two studies also provide evidence that suggests that if the choice sets are drawn from the set of alternatives that individuals are aware of, estimation efficiency is improved. The findings of Peters, (1993) and Parsons and Kealy (1992) support the author's suspicion that improved estimates for the models using discrete choice analysis, based on observational data could be obtained with some investment in time and resources to closely monitor transactions so as to determine butchers' choice sets on the bases of alternatives that they are aware of or those that they consider before making their final purchase decision.

An important assumption underlying the analysis of butchers' revealed preferences in both the hedonic and discrete choice analyses is that all relevant information is available to the market participants. Interpreting implicit prices as the value that the butchers place on the characteristics assumes that butchers have full information on prices and characteristics and are able to use this information effectively (Stanley, 1991). If information about a characteristic is lacking, the characteristic will be unrelated to the butcher's choice. This might explain the observed statistical insignificance, as an influence on butchers' behaviour, of such attributes as the age and breed of animals. Information on these characteristics was not readily available to the butchers. This informational problem does not affect the analysis of stated preferences.

At the theoretical level, this type of informational problem may also have implications for hedonic analysis. Rosen's (1974) theoretical framework assumes that buyers' bid functions are always tangential to sellers' offer functions at the hedonic price gradient. That is, a competitive market structure is assumed. Given the nature of the beef wholesale market in Kenya, such an assumption may not be altogether correct (see Karugia, 1990). The motivation for this study, it will be recalled, is to increase the flow of market information which is a requisite for the existence of a competitive market structure.

Despite these limitations, the studies reported here provide useful information regarding attributes considered to be important by Kenyan butchers and the values that they attach to them. Important policy implications for the Kenyan beef sector are drawn from the results of the analysis presented here. Firstly, beef carcass characteristics that are important to the majority of buyers have been identified and valued. These characteristics could be used as a basis for establishing a grading scheme. This information may also be used by beef traders, animal breeders, and farm managers. Secondly, a comparison of three general methodological approaches to characteristic valuation was done and their strengths and weakness in valuing beef characteristics discussed.

5.5 References

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Appendix A Descriptive Statistics for the Sample Carcasses

Attribute	Number	Percent	Mean	Standard Deviation	Range
Price (Sh./kg)			99.18	9.53	50-120
Breed					
Local dual-purpose	234	67.63			
Improved beef	62	17.92			
Improved dairy	50	14.45			
Gender					
Bull	92	26.59			
Cow/Heifer	112	32.37			
Steer	142	41.04			
Age					
Mature stock	295	85.26			
Young stock	51	14.74			
Side weight (Kg)			83.22	28.02	25-169
Length(cm)			121.90	10.31	88-150
Conformation					
Level 1	191	55.20			
Level 2	120	34.68			
Level 3	30	8.67			
Level 4	5	1.45			
Fatness					
Level 1	151	43.64			
Level 2	172	49.71			
Level 3	13	3.76			
Level 4	10	2.89			

Attribute	Number	Percent	Mean	Standard Deviation	Range
Kidney fat					
Level 1	244	70.52			
Level 2	89	25.72			
Level 3	13	3.76			
Level 4	0	0.00			
Channel fat					
Level 1	262	75.72			
Level 2	77	22.25			
Level 3	7	2.02			
Level 4	0	0.00			
Colour of fat					
White	166	47.98			
Yellow	174	50.29			
Gelatinous yellow	6	1.73			
Colour of lean					
Cherry red	145	41.91			
Red	188	54.34			
Deep red	13	3.76			
Carcass damage					
No and slight damage	232	67.34			
Moderately and Badly damaged	113	32.66			

Appendix B Correlation Matrix of Carcass Attributes

	Price	D_{local}	D_{beef}	D_{dairy}	D_{bull}	D_{cow}	D_{steer}	D_{young}	D_{mature}	Weight	Length	DC_1
Price	1.000											
D_{local}	-0.296	1.000										
D_{beef}	0.277	-0.675	1.000									
D_{dairy}	0.093	-0.594	-0.192	1.000								
D_{bull}	-0.011	0.095	-0.042	-0.080	1.000							
D_{cow}	-0.149	-0.063	-0.130	0.225	-0.416	1.000						
D_{steer}	0.151	-0.026	0.162	-0.142	-0.502	-0.577	1.000					
D_{young}	-0.240	-0.078	0.061	0.038	0.045	-0.026	-0.015	1.000				
D_{mature}	0.240	0.078	-0.061	- 0.038	- 0.045	0.026	0.015	-1.000	1.000			
Weight	0.684	-0.407	0.401	0.105	0.026	-0223	0.188	-0.242	0.242	1.000		
Length	0.529	-0.362	0.291	0.164	-0.032	-0.029	0.057	-0279	0279	0.792	1.000	
DC_1	-0.596	0.308	-0.291	-0.093	0.003	0.152	-0.146	0.145	-0.145	-0.634	-0.478	1.000

Appendix B continued

	DC_2	DC_3	DC_4	DF_1	DF_2	DF_3	DF_4	KF_1	KF_2	KF_3	KF_4	CF_1
DC_2	1.000											
DC_3	-0.225	1.000										
DC_4	-0.088	-0.037	1.000									
DF_1	-0.188	-0.105	-0.107	1.000								
DF_2	0.138	0.002	-0.024	-0.875	1.000							
DF_3	0.112	0.047	0.231	-0.174	-0.196	1.000						
DF_4	0.019	0.253	0.124	-0.152	-0.172	-0.034	1.000					
KF_1	-0.341	-0.296	-0.187	0.301	-0.118	-0.239	-0.267	1.000				
KF_2	0.349	0.218	0.039	-0.251	0.102	0.231	0.175	-0.910	1.000			
KF_3	0.016	0.209	0.358	-0.143	0.047	0.041	0.238	-0.306	-0.116	1.000		
KF_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
CF_1	-0.281	-0.353	-0.214	0.267	-0.071	-0.243	-0.305	0.772	-0.654	-0.349	0.000	1.000

Appendix B continued

	CF_2	CF_3	CF_4	D_{white}	D_{yellow}	D_{gel}	D_{cherry}	D_{red}	D_{deep}	D_{none}	$D_{moderate}$	$D_{extensive}$
CF_2	1.000											
CF_3	-0.077	1.000										
CF_4	0.000	0.000	0.000									
D_{white}	0.015	-0.097	0.000	1.000								
D_{yellow}	0.004	0.061	0.000	-0.966	1.000							
D_{gel}	-0.071	0.138	0.000	-0.128	-0.134	1.000						
D_{cherry}	0.053	0.044	0.000	0.122	-0.105	-0.068	1.000					
D_{red}	-0.109	-0.074	0.000	-0.084	0.086	-0.012	-0.926	1.000				
D_{deep}	0.150	0.079	0.000	-0.098	0.044	0.207	-0168	-0.216	1.000			
D_{none}	-0.072	-0163	0.000	0.015	0.010	-0.096	-0.183	0.215	-0.089	1.000		
$D_{moderate}$	0.025	0.173	0.000	-0.005	-0.023	0.105	0.178	-0.203	0.068	-0.948	1.000	
$D_{extensive}$	0.148	-0.022	0.000	-0.032	0.037	-0.020	0.025	-0.052	0.071	-0.221	-0.102	1.000

Appendix B continued

	DC_2	DC_3	DC_4	DF_1	DF_2	DF_3	DF_4	KF_1	KF_2	KF_3	KF_4	CF_1
Price	0.355	0.374	0.188	-0427	0.284	0.188	0.202	-0.469	0.397	0.212	0.000	-0.445
D_{local}	-0.119	-0.292	-0.123	0.086	0.021	-0.156	-0.139	0.298	-0.229	-0.188	0.000	0.329
D_{beef}	0.055	0.338	0.196	-0.016	-0.103	0.106	0.234	-0.227	0.191	0.106	0.000	-0.298
D_{dairy}	0.098	0.019	-0.050	-0.096	0.084	0.092	-0.071	-0.149	0.097	0.135	0.000	-0.112
D_{bull}	-0.012	0.0005	0.037	0.051	-0.010	-0.084	-0.026	0.088	-0.070	-0.050	0.000	0.020
D_{cow}	-0.076	-0.147	0.020	-0.111	0.090	0.091	-0.046	-0.013	0.017	-0.007	0.000	0.003
D_{steer}	0.083	0.140	-0.052	0.059	-0.077	-0.010	-0.066	-0.066	0.047	0.051	0.000	-0.021
D_{young}	-0.132	-0.012	-0.050	0.259	-0.218	-0.039	-0.072	0.126	-0151	0.046	0.000	0.140
D_{mature}	0.132	0.012	0.050	-0.259	0.218	0.039	0.072	-0.126	0.151	-0.046	0.000	-0.140
Weight	0.331	0.434	0.299	-0.334	0.174	0.205	0.236	-0.541	0.421	0.329	0.000	-0.585
Length	0.290	0.268	0.203	-0.311	0.198	0.132	0.179	-0459	0.358	0.276	0.000	-0.475
DC_1	-0.809	-0.342	-0.134	0.265	-0.127	-0.189	-0.191	0.539	-0.467	-0.219	0.000	0.520

Appendix B continued

	CF_2	CF_3	CF_4	D_{white}	D_{yellow}	D_{gel}	D_{cherry}	D_{red}	D_{deep}	D_{none}	$D_{moderate}$	$D_{extensive}$
Price	0.401	0.170	0.000	0.036	-0.039	0.114	0.231	-0.246	0.046	-0.175	0.182	-0.013
D_{local}	-0.298	-0.120	0.000	-0.028	0.053	-0.097	-0.038	0.097	-0.156	0.124	-0.094	-0.099
D_{beef}	0.275	0.093	0.000	0.003	-0.018	0.053	-0.061	-0.010	0.185	-0.060	0.019	0.129
D_{dairy}	0.096	0.058	0.000	0.033	-0.052	0.071	0.117	-0118	0.005	-0.099	0.104	-0.085
D_{bull}	-0.007	-0.040	0.000	0.168	-0.147	-0.080	0.099	-0.065	-0.085	0.029	-0.013	-0.049
D_{cow}	0.001	-0.012	0.000	-0.182	0.181	0.003	-0.062	0.064	-0.007	0.034	-0.040	0.017
D_{steer}	0.006	0.047	0.000	0.022	-0.040	0.069	-0.030	-0.002	0.082	-0.058	0.050	0.028
D_{young}	-0.125	-0.060	0.000	0.123	-0108	-0.055	-0.039	0.037	0.004	0.116	-0.115	-0.010
D_{mature}	0.125	0.060	0.000	-0.123	0.108	0.055	0.039	-0.037	-0.004	-0.116	0.115	0.010
Weight	0.512	0.269	0.000	0.063	-0.066	0.015	0.203	-0.246	0.118	-0.208	0.185	0.082
Length	0.411	0.233	0.000	-0.089	0.075	0.055	0.239	-0.277	0.104	-0.264	0.236	0.100
DC_1	-0.482	-0.159	0.000	-0.089	0.081	0.031	-0.213	0.236	-0.066	0.240	-0.214	-0.093

Appendix B continued

	DC_2	DC_3	DC_4	DF_1	DF_2	DF_3	DF_4	KF_1	KF_2	KF_3	KF_4	CF_1
CF_2	0.296	0.304	0.110	-0.233	0.066	0.260	0.198	-0.721	0.703	0.113	0.000	-0.945
CF_3	-0.018	0.175	0.327	-0.126	0.021	-0.028	0.343	-.0222	-0.085	0.727	0.000	-0.254
CF_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D_{white}	0.139	-0.029	-0.116	0.076	-0.075	-0.038	0.042	0.012	0.030	-0.098	0.000	0.017
D_{yellow}	-0.114	-0.002	0.120	-0.081	0.087	0.044	-0.070	-0.009	-0.023	0.075	0.000	-0.024
D_{gel}	-0.097	0.116	-0.016	0.017	-0.044	-0.026	0.109	-0.011	-0.027	0.090	0.000	0.024
D_{cherry}	0.230	-0.012	-0.005	-0.074	0.069	0.048	-0.042	-0.170	0.157	0.048	0.000	-0.066
D_{red}	-0.222	-0.047	0.014	0.070	-0.040	-0.063	-0.015	0.222	-0.177	-0.124	0.000	0.131
D_{deep}	-0.016	0.155	-0.024	0.010	-0.075	0.041	*0.147*	*-0.139*	0.057	0.200	0.000	-0.172
D_{none}	-0.166	-0.136	-0.019	0.078	-0.084	0.008	0.010	0.158	-0.098	-0.154	0.000	0.123
$D_{moderate}$	0.140	0.154	-0.027	-0.086	0.098	-0.031	-0.001	-0.125	0.057	0.167	0.000	-0.081
$D_{extensive}$	0.090	-0.047	0.143	0.020	-0.037	0.071	-0.026	-0.111	0.129	-0.030	0.000	-0.137

Appendix C R^2 Values of the Auxiliary Regressions of the Attribute Variables

Variable	R^2	Significant Variables at 10%
D_{local}	0.27766	D_{cow}, Weight, DC_{young}, DC_3
D_{beef}	0.30177	Weight, DC_{young}, DC_3, DC_4, DF_2, DF_4, D_{red}, $D_{moderate}$
D_{dairy}	0.15544	D_{cow}, DC, DC, DC, DF_4, KF_3
D_{bull}	0.08804	DF_3, KF_2, D_{yellow}, D_{red}
D_{cow}	0.23332	D_{dairy}, Weight, Length, DF_2, DF_3, D_{yellow}
D_{steer}	0.14255	D_{dairy}, Weight, Length, DC_4, DF_2, CF_2
D_{young}	0.20811	D_{beef}, D_{dairy}, Weight, DF_2, KF_3, CF_3, D_{yellow}
D_{mature}	0.20811	D_{beef}, D_{dairy}, Weight, DF_2, KF_3, CF_3, D_{yellow}
Weight	081254	D_{beef}, D_{cow}, Length, D_{young}, DC_2, DC_3, DC_4, DF_2, DF_3, CF_2, D_{yellow}, D_{gel}
Length	0.70008	D_{cow}, Weight, DC_3, DC_4, D_{yellow}, D_{gel}, D_{red}, $D_{moderate}$
DC_1	0.48886	Weight, KF_2, $D_{moderate}$
DC_2	0.22742	KF_2, D_{yellow}, D_{gel}, D_{red}
DC_3	0.30349	D_{beef}, Weight, Length, DF_4, CF_2, D_{yellow}, D_{gel}, $D_{moderate}$, $D_{extensive}$
DC_4	0.29622	D_{dairy}, D_{bull}, D_{cow}, Weight, DF_3, KF_3, D_{yellow}, D_{deep}, $D_{extensive}$
DF_1	0.21083	D_{cow}, Weight, D_{young}, KF_2
DF_2	0.13512	D_{beef}, D_{cow}, Weight, D_{young}
DF_3	0.15059	DC_4
DF_4	0.24467	D_{beef}, DC_3, CF_2, CF_3, D_{yellow}, D_{deep}, $D_{moderate}$
KF_1	0.64752	D_{bull}, DC_2, DC_3, DF_2, CF_2, CF_3, D_{red}
KF_2	0.54720	DC_2, DF_4, CF_2, CF_3, D_{red}, D_{deep}
KF_3	0.62047	D_{young}, DC_4, CF_2, CF_3, D_{deep}, $D_{extensive}$
KF_4	--	
CF_1	0.67650	D_{bull}, D_{cow}, Weight, DC_3, KF_2, KF_3, D_{red}

Appendix C continued

Variable	R^2	Significant Variables at 10%
CF_2	0.60472	D_{bull}, D_{cow}, Weight, DC_3, KF_2, KF_3, D_{gel}, D_{red}, D_{deep}
CF_3	0.59021	D_{young}, DF_4, D_{gel}, D_{deep}
CF_4	--	
D_{white}	0.15014	D_{dairy}, Weight, Length, D_{young}, DC_4, DF_4
D_{yellow}	0.15014	D_{dairy}, Weight, Length, D_{young}, DC_4, DF_4
D_{gel}	0.10950	D_{dairy}, CF_2, D_{deep}
D_{cherry}	0.16596	D_{beef}, D_{bull} Length, DC_2, KF_2, CF_2, D_{yellow}, $D_{moderate}$
D_{red}	0.16288	Length, KF_2, KF_3, CF_2, $D_{moderate}$
D_{deep}	0.16000	D_{beef}, DC_4, KF_3, CF_3, D_{gel}
D_{none}	0.15179	Length, DC_2, DC_3, DF_4, D_{red}
$D_{moderate}$	0.15118	Length, DC_2, DC_3, DF_4, D_{red}
$D_{extensive}$	0.08373	DC_4, CF_2

Appendix D Survey Questionnaire (Revealed Preferences)

D.1 Introduction

I am involved in a study whose objective is to determine the beef attributes that are important to beef retailers in Kenya. The study is being carried out by a Kenyan student studying in Canada. Information from this study may be useful to animal breeders and beef producers. It may help them in making their decisions about what characteristics to breed for and what to produce respectively.

I would like to ask you to help us obtain data to facilitate the study. Your selection was random and we would like to assure you that the information you provide to us will be treated with confidence. I have a questionnaire here that will guide us through this interview.

D.2 Individual-Specific Data

1. Record time, day, and date of interview. Time _______ Date _______ Day______
2. Name of respondent (optional) ________________________________
3. Is the respondent male or female? Male [___] Female [___]
4. Level of education (Check **one**)
   No formal education [___] Secondary school education [___]
   Primary school education [___] Post-Secondary education [___]
5. Have you had any formal training in meat retailing? Yes [___] No [___]
6. If answer to question 5 is yes, indicate where and the type of training received.
   ____
7. Do you own the retail business? (Check **one**) Yes [___] No [___]
8. Where is your retail business located? ________________________________
9. How long have you been in the beef retail business? (Check **one**)
   <6 months [___] 6 months to 2 years [___] >2 years [___]
10. What is the number of carcasses that are bought for your business in a week? _____
11. What proportion of beef do you sell as special cuts (e g. sirloin, fillet steak, etc) and what proportion do you sell as meat-on-bone?
    Special cuts _____% Meat-on-bone ______%
12. Do you buy from the same wholesaler? (Check **one**)
    >70% of the time [___] 30-49% of the time [___]
    50-70% of the time [___] <30% of the time [___]

D.3 Transaction Data

13. Location where the transaction occurred.

    Name and location of slaughterhouse ______________________________

14. Record the following details about the carcass:

    14.1 Breed of animal (Check **one**) Improved beef [___] Improved dairy [___] Local dual-purpose [___]

    14.2 Gender of the animal (Check **one**) Bull [___] Cow/Heifer [___] Steer [___]

    14.3 Age of the animal (Check **one**) Milk teeth [___] 1-2 incisors [___] 3-4 incisors [___] 5-6 incisors [___] 7-8 incisors [___]

    14.4 Carcass weight (kg) ________________________

    14.5 Carcass length (cm) ________________________

    14.6 Conformation Score (where **1** is **poorest** and **4** is **best**) (Check **one**)

    1 [___] 2 [___] 3 [___] 4 [___]

    14.7 Fatness Score (where **1** is **lean** and **4** is **excessively fat**) (Check **one**)

    1 [___] 2 [___] 3 [___] 4 [___]

    14.8 Amount of kidney fat (Check **one**)

    Scanty [___] Fat [___] Very fat [___]

    14.9 Amount of channel fat (Check **one**)

    Scanty [___] Fat [___] Very fat [___]

    14.10 Colour of fat; Use the visual aid provided and indicate the score (Check **one**)

    Yellow [___] White [___] Gelatinous Yellow [___]

    14.11 Colour of lean; Use the visual aid provided and indicate the score (Check **one**)

    Cherry Red [___] Red [___] Deep Red [___]

    14.12 What is the wholesale price paid for the carcass? (Ksh/kg) _______

15. Record any visible damages on the carcass.

    ____

16. What factor(s) made you decide to buy this carcass?

    (a) ____

    (b) ____

    (c) ____

    (d) ____

17. On the supplementary sheets attached, record characteristics of five carcasses that the respondent could have purchased but did not buy. For each carcass indicate whether it was chosen at random or whether the respondent had shown prior interest.

D.4 Closing the Interview Session

Thank you for your time and cooperation. You have been very helpful.

D.5 Data for Non-Purchase ***Sheet 1-5***

1. Carcass randomly selected?

   Yes [___] Go to 3. No [___] Go to 2.

2. What factor(s) made you decide against buying this carcass?

   (a) ____

   (b) ____

   (c) ____

   (d) ____

3. Record the following details about the carcass:

   3.1 Breed of animal (Check **one**) Improved beef [___]
   Improved dairy [___] Local dual-purpose [___]

   3.2 Gender of the animal (Check **one**) Bull [___]
   Cow/Heifer [___] Steer [___]

   3.3 Age of the animal (Check **one**) Milk teeth [___] 1-2 incisors [___]
   3-4 incisors [___] 5-6 incisors [___] 7-8 incisors [___]

   3.4 Carcass weight (kg) ____________________

   3.5 Carcass length (cm) ____________________

   3.6 Conformation Score (where **1** is **poorest** and **4** is **best**) (Check **one**)
   1 [___] 2 [___] 3 [___] 4 [___]

   3.7 Fatness Score (where **1** is **lean** and **4** is **excessively fat**) (Check **one**)
   1 [___] 2 [___] 3 [___] 4 [___]

   3.8 Amount of kidney fat (Check **one**)
   Scanty [___] Fat [___] Very fat [___]

   3.9 Amount of channel fat (Check **one**)
   Scanty [___] Fat [___] Very fat [___]

   3.10 Colour of fat; Use the visual aid provided and indicate the score (Check **one**)
   Yellow [___] White [___] Gelatinous Yellow [___]

   3.11 Colour of lean; Use the visual aid provided and indicate the score (Check **one**)
   Cherry Red [___] Red [___] Deep Red [___]

   3.12 What is the wholesale price paid for the carcass? (Ksh/kg) _______

4. Record any visible damages on the carcass.

   ____

Appendix E Survey Questionnaire (Stated Preferences)

E.1 Introduction

I am involved in a study whose objective is to determine the beef attributes that are important to beef retailers in Kenya. This study is being carried out by a Kenyan student studying in Canada. Information from this study may be useful to animal breeders and beef producers. It may help them make decisions about what characteristics to breed for and what to produce respectively.

We would like to ask you to help us obtain data to facilitate the study. Your selection was random and we would like to assure you that the information you provide to us will be treated with confidence. I have a questionnaire here that will guide us through this interview.

E.2 Individual-Specific Data

1. Name of respondent (optional) ______________________________
2. Is the respondent male or female? Male [___] Female [___]
3. Level of education (Check **one**)
   No formal education [___] Secondary school education [___]
   Primary school education [___] Post-Secondary education [___]
4. Have you had any formal training in meat retailing? Yes [___] No [___]
5. If answer to question 5 is yes, indicate where and the type of training received.
   ____
6. Do you own the retail business? (Check **one**) Yes [___] No [___]
7. Where is your retail business located? ______________________________
8. How long have you been in the beef retail business? (Check **one**)
   <6 months [___] 6 months to 2 years [___] >2 years [___]
9. What is the number of carcasses that are bought for your business in a week? _______
10. What proportion of beef do you sell as special cuts (e.g. sirloin, fillet steak, etc) and what proportion do you sell as meat-on-bone?
    Special cuts ______% Meat-on-bone ______%
11. Do you buy from the same wholesaler? (Check **one**)
    >70% of the time [___] 30-49% of the time [___]
    50-70% of the time [___] <30% of the time [___]

E.3 Stated Preference Data

Now I am going to present you with descriptions of several sets of carcasses of different quality attributes. Pictures will help reinforce the descriptions of the attributes. The carcasses we describe have different levels of conformation, fatness, and weight. The price per kilogram is also given. Consider all the attributes associated with each alternative and assume that you are at the slaughterhouse on a typical trip to purchase wholesale beef. In each case indicate the proportion of each alternative that you would purchase.

Block 1

SET # 1:

	A	**B**	**C**
Price (Ksh./kg):	90	70	70
Conformation:	3	3	1
Fat Cover:	3	3	1
Carcass Weight:	140	80	80

Indicate the proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

SET # 2:

	A	**B**	**C**
Price (Ksh./kg):	90	120	70
Conformation:	2	2	1
Fat Cover:	1	2	1
Carcass Weight:	80	220	80

Indicate the proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

SET # 3:

	A	**B**	**C**
Price (Ksh./kg):	105	105	70
Conformation:	1	3	1
Fat Cover:	4	4	1
Carcass Weight:	80	300	80

Indicate the proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

SET # 4:

	A	B	C
Price (Ksh./kg):	70	105	70
Conformation:	2	4	1
Fat Cover:	2	1	1
Carcass Weight:	300	80	80

Indicate proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

SET # 5:

	A	B	C
Price (Ksh./kg):	105	90	70
Conformation:	4	2	1
Fat Cover:	2	1	1
Carcass Weight:	140	140	80

Indicate proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

SET # 6:

	A	B	C
Price (Ksh./kg):	70	90	70
Conformation:	3	1	1
Fat Cover:	4	4	1
Carcass Weight:	220	220	80

Indicate proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

SET # 7:

	A	B	C
Price (Ksh./kg):	120	120	70
Conformation:	1	1	1
Fat Cover:	3	3	1
Carcass Weight:	300	140	80

Indicate proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

SET # 8:

	A	B	C
Price (Ksh./kg):	120	70	70
Conformation:	4	4	1
Fat Cover:	1	2	1
Carcass Weight:	220	300	80

Indicate proportion of each carcass that you would purchase.

A _____ **B** _____ **C** _____

E.4 Closing the Interview Session

Thank you for your time and cooperation. You have been very helpful