EVALUATING BEEF CARCASS VALUE: A HEDONIC PRICE ANALYSIS

By Monica de Matos

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfilment of the Requirements
for the Degree of

Master Science

University of Manitoba
Winnipeg, Manitoba

ISBN 0-315-92250-8

Name MONICA DE MATOS

Dissertation Abstracts International is arranged by broad, general subject categories. Please select the one subject which most nearly describes the content of your dissertation. Enter the corresponding four-digit code in the spaces provided.

AGRICULTURAL ECONOMICS | 0503 | U·M·I

SUBJECT TERM | SUBJECT CODE

Subject Categories

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AND THE ARTS

Architecture 0729
Art History 0377
Cinema 0900
Dance 0378
Fine Arts 0357
Information Science 0723
Journalism 0391
Library Science 0399
Mass Communications 0708
Music 0413
Speech Communication 0459
Theater 0465

EDUCATION

General 0515
Administration 0514
Adult and Continuing 0516
Agricultural 0517
Art 0273
Bilingual and Multicultural 0282
Business 0688
Community College 0275
Curriculum and Instruction 0727
Early Childhood 0518
Elementary 0524
Finance 0277
Guidance and Counseling 0519
Health 0680
Higher 0745
History of 0520
Home Economics 0278
Industrial 0521
Language and Literature 0279
Mathematics 0280
Music 0522
Philosophy of 0998
Physical 0523
Psychology 0525
Reading 0535
Religious 0527
Sciences 0714
Secondary 0533
Social Sciences 0534
Sociology of 0340
Special 0529
Teacher Training 0530
Technology 0710
Tests and Measurements 0288
Vocational 0747

LANGUAGE, LITERATURE AND LINGUISTICS

Language
- General 0679
- Ancient 0289
- Linguistics 0290
- Modern 0291

Literature
- General 0401
- Classical 0294
- Comparative 0295
- Medieval 0297
- Modern 0298
- African 0316
- American 0591
- Asian 0305
- Canadian (English) 0352
- Canadian (French) 0355
- English 0593
- Germanic 0311
- Latin American 0312
- Middle Eastern 0315
- Romance 0313
- Slavic and East European 0314

PHILOSOPHY, RELIGION AND THEOLOGY

Philosophy 0422
Religion
- General 0318
- Biblical Studies 0321
- Clergy 0319
- History of 0320
- Philosophy of 0322

Theology 0469

SOCIAL SCIENCES

American Studies 0323
Anthropology
- Archaeology 0324
- Cultural 0326
- Physical 0327

Business Administration
- General 0310
- Accounting 0272
- Banking 0770
- Management 0454
- Marketing 0338

Canadian Studies 0385
Economics
- General 0501
- Agricultural 0503
- Commerce-Business 0505
- Finance 0508
- History 0509
- Labor 0510
- Theory 0511

Folklore 0358
Geography 0366
Gerontology 0351
History
- General 0578
- Ancient 0579
- Medieval 0581
- Modern 0582
- Black 0328
- African 0331
- Asia, Australia and Oceania 0332
- Canadian 0334
- European 0335
- Latin American 0336
- Middle Eastern 0333
- United States 0337

History of Science 0585
Law 0398
Political Science
- General 0615
- International Law and Relations 0616
- Public Administration 0617

Recreation 0814
Social Work 0452
Sociology
- General 0626
- Criminology and Penology 0627
- Demography 0938
- Ethnic and Racial Studies 0631
- Individual and Family Studies 0628
- Industrial and Labor Relations 0629
- Public and Social Welfare 0630
- Social Structure and Development 0700
- Theory and Methods 0344

Transportation 0709
Urban and Regional Planning 0999
Women's Studies 0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES

Agriculture
- General 0473
- Agronomy 0285
- Animal Culture and Nutrition 0475
- Animal Pathology 0476
- Food Science and Technology 0359
- Forestry and Wildlife 0478
- Plant Culture 0479
- Plant Pathology 0480
- Plant Physiology 0817
- Range Management 0777
- Wood Technology 0746

Biology
- General 0306
- Anatomy 0287
- Biostatistics 0308
- Botany 0309
- Cell 0379
- Ecology 0329
- Entomology 0353
- Genetics 0369
- Limnology 0793
- Microbiology 0410
- Molecular 0307
- Neuroscience 0317
- Oceanography 0416
- Physiology 0433
- Radiation 0821
- Veterinary Science 0778
- Zoology 0472

Biophysics
- General 0786
- Medical 0760

EARTH SCIENCES

Biogeochemistry 0425
Geochemistry 0996
Geodesy 0370
Geology 0372
Geophysics 0373
Hydrology 0388
Mineralogy 0411
Paleobotany 0345
Paleoecology 0426
Paleontology 0418
Paleozoology 0985
Palynology 0427
Physical Geography 0368
Physical Oceanography 0415

HEALTH AND ENVIRONMENTAL SCIENCES

Environmental Sciences 0768
Health Sciences
- General 0566
- Audiology 0300
- Chemotherapy 0992
- Dentistry 0567
- Education 0350
- Hospital Management 0769
- Human Development 0758
- Immunology 0982
- Medicine and Surgery 0564
- Mental Health 0347
- Nursing 0569
- Nutrition 0570
- Obstetrics and Gynecology 0380
- Occupational Health and Therapy 0354
- Ophthalmology 0381
- Pathology 0571
- Pharmacology 0419
- Pharmacy 0572
- Physical Therapy 0382
- Public Health 0573
- Radiology 0574
- Recreation 0575
- Speech Pathology 0460
- Toxicology 0383

Home Economics 0386

PHYSICAL SCIENCES

Pure Sciences

Chemistry
- General 0485
- Agricultural 0749
- Analytical 0486
- Biochemistry 0487
- Inorganic 0488
- Nuclear 0738
- Organic 0490
- Pharmaceutical 0491
- Physical 0494
- Polymer 0495
- Radiation 0754

Mathematics 0405
Physics
- General 0605
- Acoustics 0986
- Astronomy and Astrophysics 0606
- Atmospheric Science 0608
- Atomic 0748
- Electronics and Electricity 0607
- Elementary Particles and High Energy 0798
- Fluid and Plasma 0759
- Molecular 0609
- Nuclear 0610
- Optics 0752
- Radiation 0756
- Solid State 0611

Statistics 0463

Applied Sciences

Applied Mechanics 0346
Computer Science 0984

Engineering
- General 0537
- Aerospace 0538
- Agricultural 0539
- Automotive 0540
- Biomedical 0541
- Chemical 0542
- Civil 0543
- Electronics and Electrical 0544
- Heat and Thermodynamics 0348
- Hydraulic 0545
- Industrial 0546
- Marine 0547
- Materials Science 0794
- Mechanical 0548
- Metallurgy 0743
- Mining 0551
- Nuclear 0552
- Packaging 0549
- Petroleum 0765
- Sanitary and Municipal 0554
- System Science 0790

Geotechnology 0428
Operations Research 0796
Plastics Technology 0795
Textile Technology 0994

PSYCHOLOGY

General 0621
Behavioral 0384
Clinical 0622
Developmental 0620
Experimental 0623
Industrial 0624
Personality 0625
Physiological 0989
Psychobiology 0349
Psychometrics 0632
Social 0451

Nom ____

Dissertation Abstracts International est organisé en catégories de sujets. Veuillez s.v.p. choisir le sujet qui décrit le mieux votre thèse et inscrivez le code numérique approprié dans l'espace réservé ci-dessous.

____ SUJET

☐☐☐☐ CODE DE SUJET

U·M·I

Catégories par sujets

HUMANITÉS ET SCIENCES SOCIALES

COMMUNICATIONS ET LES ARTS

Architecture 0729
Beaux-arts 0357
Bibliothéconomie 0399
Cinéma 0900
Communication verbale 0459
Communications 0708
Danse 0378
Histoire de l'art 0377
Journalisme 0391
Musique 0413
Sciences de l'information 0723
Théâtre 0465

ÉDUCATION

Généralités 515
Administration 0514
Art 0273
Collèges communautaires 0275
Commerce 0688
Économie domestique 0278
Éducation permanente 0516
Éducation préscolaire 0518
Éducation sanitaire 0680
Enseignement agricole 0517
Enseignement bilingue et multiculturel 0282
Enseignement industriel 0521
Enseignement primaire. 0524
Enseignement professionnel 0747
Enseignement religieux 0527
Enseignement secondaire 0533
Enseignement spécial 0529
Enseignement supérieur 0745
Évaluation 0288
Finances 0277
Formation des enseignants 0530
Histoire de l'éducation 0520
Langues et littérature 0279
Lecture 0535
Mathématiques 0280
Musique 0522
Orientation et consultation 0519
Philosophie de l'éducation 0998
Physique 0523
Programmes d'études et enseignement 0727
Psychologie 0525
Sciences 0714
Sciences sociales 0534
Sociologie de l'éducation 0340
Technologie 0710

LANGUE, LITTÉRATURE ET LINGUISTIQUE

Langues
- Généralités 0679
- Anciennes 0289
- Linguistique 0290
- Modernes 0291

Littérature
- Généralités 0401
- Anciennes 0294
- Comparée 0295
- Médiévale 0297
- Moderne 0298
- Africaine 0316
- Américaine 0591
- Anglaise 0593
- Asiatique 0305
- Canadienne (Anglaise) 0352
- Canadienne (Française) 0355
- Germanique 0311
- Latino-américaine 0312
- Moyen-orientale 0315
- Romane 0313
- Slave et est-européenne 0314

PHILOSOPHIE, RELIGION ET THÉOLOGIE

Philosophie 0422
Religion
- Généralités 0318
- Clergé 0319
- Études bibliques 0321
- Histoire des religions 0320
- Philosophie de la religion 0322

Théologie 0469

SCIENCES SOCIALES

Anthropologie
- Archéologie 0324
- Culturelle 0326
- Physique 0327

Droit 0398
Économie
- Généralités 0501
- Commerce-Affaires 0505
- Économie agricole 0503
- Économie du travail 0510
- Finances 0508
- Histoire 0509
- Théorie 0511

Études américaines 0323
Études canadiennes 0385
Études féministes 0453
Folklore 0358
Géographie 0366
Gérontologie 0351
Gestion des affaires
- Généralités 0310
- Administration 0454
- Banques 0770
- Comptabilité 0272
- Marketing 0338

Histoire
- Histoire générale 0578
- Ancienne 0579
- Médiévale 0581
- Moderne 0582
- Histoire des noirs 0328
- Africaine 0331
- Canadienne 0334
- États-Unis 0337
- Européenne 0335
- Moyen-orientale 0333
- Latino-américaine 0336
- Asie, Australie et Océanie 0332

Histoire des sciences 0585
Loisirs 0814
Planification urbaine et régionale 0999
Science politique
- Généralités 0615
- Administration publique 0617
- Droit et relations internationales 0616

Sociologie
- Généralités 0626
- Aide et bien-àtre social 0630
- Criminologie et établissements pénitentiaires 0627
- Démographie 0938
- Études de l' individu et de la famille 0628
- Études des relations interethniques et des relations raciales 0631
- Structure et développement social 0700
- Théorie et méthodes. 0344
- Travail et relations industrielles 0629

Transports 0709
Travail social 0452

SCIENCES ET INGÉNIERIE

SCIENCES BIOLOGIQUES

Agriculture
- Généralités 0473
- Agronomie. 0285
- Alimentation et technologie alimentaire 0359
- Culture 0479
- Élevage et alimentation 0475
- Exploitation des péturages 0777
- Pathologie animale 0476
- Pathologie végétale 0480
- Physiologie végétale 0817
- Sylviculture et faune 0478
- Technologie du bois 0746

Biologie
- Généralités 0306
- Anatomie 0287
- Biologie (Statistiques) 0308
- Biologie moléculaire 0307
- Botanique 0309
- Cellule 0379
- Écologie 0329
- Entomologie 0353
- Génétique 0369
- Limnologie 0793
- Microbiologie 0410
- Neurologie 0317
- Océanographie 0416
- Physiologie 0433
- Radiation 0821
- Science vétérinaire 0778
- Zoologie 0472

Biophysique
- Généralités 0786
- Medicale 0760

SCIENCES DE LA TERRE

Biogéochimie 0425
Géochimie 0996
Géodésie 0370
Géographie physique 0368
Géologie 0372
Géophysique 0373
Hydrologie 0388
Minéralogie 0411
Océanographie physique 0415
Paléobotanique 0345
Paléoécologie 0426
Paléontologie 0418
Paléozoologie 0985
Palynologie 0427

SCIENCES DE LA SANTÉ ET DE L'ENVIRONNEMENT

Économie domestique 0386
Sciences de l'environnement 0768
Sciences de la santé
- Généralités 0566
- Administration des hipitaux 0769
- Alimentation et nutrition 0570
- Audiologie 0300
- Chimiothérapie 0992
- Dentisterie 0567
- Développement humain 0758
- Enseignement 0350
- Immunologie 0982
- Loisirs 0575
- Médecine du travail et thérapie 0354
- Médecine et chirurgie 0564
- Obstétrique et gynécologie 0380
- Ophtalmologie 0381
- Orthophonie 0460
- Pathologie 0571
- Pharmacie 0572
- Pharmacologie 0419
- Physiothérapie 0382
- Radiologie 0574
- Santé mentale 0347
- Santé publique 0573
- Soins infirmiers 0569
- Toxicologie 0383

SCIENCES PHYSIQUES

Sciences Pures

Chimie
- Genéralités 0485
- Biochimie 487
- Chimie agricole 0749
- Chimie analytique 0486
- Chimie minérale 0488
- Chimie nucléaire 0738
- Chimie organique 0490
- Chimie pharmaceutique 0491
- Physique 0494
- PolymÇres 0495
- Radiation 0754

Mathématiques 0405
Physique
- Généralités 0605
- Acoustique 0986
- Astronomie et astrophysique 0606
- Electronique et électricité 0607
- Fluides et plasma 0759
- Météorologie 0608
- Optique 0752
- Particules (Physique nucléaire) 0798
- Physique atomique 0748
- Physique de l'état solide 0611
- Physique moléculaire 0609
- Physique nucléoire 0610
- Radiation 0756

Statistiques 0463

Sciences Appliqués Et Technologie

Informatique 0984
Ingénierie
- Généralités 0537
- Agricole 0539
- Automobile 0540
- Biomédicale 0541
- Chaleur et ther modynamique 0348
- Conditionnement (Emballage) 0549
- Génie aérospatial 0538
- Génie chimique 0542
- Génie civil 0543
- Génie électronique et électrique 0544
- Génie industriel 0546
- Génie mécanique 0548
- Génie nucléaire 0552
- Ingénierie des systèmes 0790
- Mécanique navale 0547
- Métallurgie 0743
- Science des matériaux 0794
- Technique du pétrole 0765
- Technique minière 0551
- Techniques sanitaires et municipales 0554
- Technologie hydraulique 0545

Mécanique appliquée 0346
Géotechnologie 0428
Matières plastiques (Technologie) 0795
Recherche opérationnelle 0796
Textiles et tissus (Technologie) 0794

PSYCHOLOGIE

Généralités 0621
Personnalité 0625
Psychobiologie 0349
Psychologie clinique 0622
Psychologie du comportement 0384
Psychologie du développement 0620
Psychologie expérimentale 0623
Psychologie industrielle 0624
Psychologie physiologique 0989
Psychologie sociale 0451
Psychométrie 0632

EVALUATING BEEF CARCASS VALUE:

A HEDONIC PRICE ANALYSIS

BY

MONICA DE MATOS

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

MASTER OF SCIENCE

To Giovani, my husband and best friend.

Para a minha familia Vera, Christiane e Fernanda.

Para minhas queridas amigas, Bea, Xiomara e Regina.

Para uma pessoa muito especial, Valerio de Matos.

ABSTRACT

The main purpose of this study is to investigate factors affecting beef carcass value by focusing on the factors included in the Canadian beef carcass grading system. Three objectives were defined: (1) to review the development of the Canadian beef carcass grading system and describe the actual grading system; (2) to evaluate beef carcass value by comparing the relative explanatory power of the various hedonic price models and (3) to estimate the degree to which beef carcass characteristics influence carcass value.

The carcass characteristics included in this study were: sex, weight, saleable meat yield, muscle score, grade fat, marbling, cutability estimate and week of grading. In total eight hedonic price models were estimated including carcass characteristics believed to affect carcass value. Two full hedonic price models including data on all observed characteristics and three groups of interaction terms were estimated. These models were re-estimated by excluding the interaction terms. Two intermediate models were estimated and two grading system models (including only variables used in the Canadian beef carcass grading system) were estimated as well. After proper accounting for model specification and multicollinearity among variables, an equation with good statistical properties and in agreement with underlying theory was estimated.

The results indicated that the grading system models had poor efficiency in explaining beef carcass values. Saleable yield, muscle score and marbling were found to be significant in explaining carcass values in all models including these characteristics. All factors that underlie the Canadian grading system for beef were found to be

significant. Many of the coefficients were statistically significant, but small, indicating that these individual characteristics generally did not have large effects on overall carcass value.

This analysis demonstrates that development of a component-based pricing system for beef and cattle is possible. Given complete information on component values and system costs it would be possible to develop an effective pricing equation.

ACKNOWLEDGEMENTS

I would like to extend my greatest appreciation to my advisor Dr. Merle Faminow, whose support and knowledge of livestock and hedonic price analysis made this possible. I would also like to sincerely thank Dr. Bob Richmond for the opportunity to be part of the National Beef Carcass Cut Out Study and for his kind and valuable instructions during the process of data analysis. I would like to thank the Manitoba Red Meat Forum for funding to complete the thesis. I would like to thank Dr. Norman Beaton for his important assistance. I also like to thank Wayne Robertson from Agriculture Canada for his data and grading system explanations. As well, I would like to thank Bonnie Warkentine, Debra Henry, Elaine Negrych and Laura Calder for assisting me in the administration of procedures for my graduate program.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1. INTRODUCTION

Several studies that consider the influence of quality on prices have been published since the development of Lancaster's theory in 1966. Lancaster's new approach to consumer theory emphasizes that consumer utility is derived from the characteristics of the good rather than the goods themselves. The empirical application of characteristics demand is represented by a hedonic price function, where product price is a function of the good and its quality characteristics. The hedonic price function allows implicit value of attributes to be estimated and, hence, it has been used broadly in agricultural product price studies.

There is a vast literature examining the impact of a variety of physical attributes on cattle prices. The most common cattle attributes analyzed are weight, sex of animal, breed type, dressing percentage and live weight. Little research into which characteristics are important in the determination of beef carcass values has been conducted in Canada.

The interaction of many factors determines beef carcass prices. Differences in supply and demand of the carcass in various weight and grade categories should be reflected in the price differentials among carcasses. Price should also reflect the demand and supply of the product's characteristics. The major factors determining carcass value to the meat processor are the saleable meat yield and the perceived quality of meat.

There is a strong relationship between grading, quality and price. Grades tend to increase the acknowledgment of value differences by segregating a commodity into different qualities. It also helps the producer of top quality products to be compensated for producing high quality products. The main purpose of beef carcass grading is to provide an estimate of both quality and meat yield so that a settlement price, between producer and beef packer, can be established.

In Canada, grades of beef carcasses are based on two major considerations: quality grade and yield grade. The factors that are examined in determining the quality grades are: maturity, muscling, rib eye muscle, rib eye color, fat color, fat covering and marbling level. Yield grade is determined through computation of the rib eye dimensions and fat thickness.

In 1992, the Canadian beef carcass grading system adopted a grade ruler to predict the yield of boneless cuts. This predictor was verified against actual cut-out data for the first time in the National Beef Carcass Cut Out Study, developed by Agriculture Canada in 1993. This study analyzed the effects of fatness, sex, carcass weight and their interactions on saleable and cut yield.

The underlying problem of this thesis is to investigate factors affecting beef carcass values, focusing on the quality and yield factors included in the Canadian beef carcass grading system. Detailed cut-out and price data were available and permitted estimation of carcass-value equations with individual carcass characteristics as explanatory variables.

Objectives

This study has three main objectives:

1. Review the development of the Canadian beef carcass grading system and describe the actual grading system;

2. Evaluate beef carcass value by comparing the relative explanatory power of the various hedonic price models, focusing on the variable characteristics included in the Canadian beef carcass grading system, and;

3. Estimate the degree to which beef carcass characteristics influence the carcass value by estimating price premiums and discounts associated with each individual characteristic and with different levels of the individual characteristics.

Thesis Outline

Chapter two discusses the theory underlying standardization and grading, the objectives and economic function of a grading system and the benefits and costs associated with grading. It also addresses the importance of grading to consumers and price associated with quality and grading.

Chapter three examines all the factors associated with beef carcass quality and grading. It starts by discussing the concept of dressing percentage and addressing beef carcass characteristics and quality. It also investigates factors affecting carcass value, methods for evaluating carcass composition and elements determining beef quality. This chapter is concluded with a discussion about the actual Canadian grading system for Beef and recent changes.

Chapter four describes the theory that analyzes the influence of quality on prices. An explanation of data and data source and potentially important carcass characteristics to be investigated is also provided. This is followed by a definition of the procedure used in this research and multicollinearity problems.

Chapter five provides the results and analysis of different hedonic price models, evaluates the importance of each individual carcass characteristic investigated and examines the price premiums and discounts associated with each individual characteristic.

Chapter six presents a summary of this research, describes the conclusions, discusses the limitations and provides recommendations for additional studies.

CHAPTER 2. THE THEORY BEHIND STANDARDIZATION AND GRADING

The following sections of this chapter establish the definition of grading, the objectives and economic function of a grading system, the benefits of grading associated with marketing efficiency and the costs of grading related to its implementation. The relationship between grade, quality and price is also discussed in this chapter.

Definition of Grading

According to McCoy and Sarhan (1988, p. 446), grading "is the segregation of items of a commodity into distinct lots or groupings, that have a relatively high degree of uniformity in certain specified attributes associated with market preferences and valuation."

The precision and suitability of a grading procedure relies on many considerations. (1) the relationship between the quality standards and buyer and seller preferences, (2) the range of qualities to be classified, and (3), the significance of the sorting to consumer preferences. The existence of the grading services depends on the preservation of grades that must be acceptable to all levels of the industry structure. In order to remain an effective communication mechanism in the market, grade boundaries may need to be changed from time to time. Changes in grading standards can be associated with changes in market demands or production technology.

Grading frequently involves numerous criteria that are not easily measurable. Subjective interpretation and even biased weighting of many estimates are often needed. Quality grades in beef are basically established on subjective factors. Quality is based on the "eatability" or palatability properties of the lean meat. Cutability, or yield grades for beef are set primarily by objective measurements (McCoy and Sarhan, 1988).

Objectives and Economic function of a Grading System

The grading system has the purpose of linking communication between producers and consumers. It is expected that grades will increase both consumer satisfaction and producers profits. This is true irrespective of whether the grading is done privately or publicly. It is important to stress that governments are not the only one's responsible for grading. In North America most packers have private grades and grade standards. The Canadian and American federal governments have their own live animal and meat grading procedures.

Grades should reflect consumer preferences. If a commodity's grades are designed appropriately, they will satisfy the preferences of consumers, whether or not consumers even see the grade labels. In terms of consumers' point of view, there is some concern that most grades were designed to adapt wholesale trading and many are not of direct concern to consumers (Rhodes, 1987).

Grading is an effort to reduce the cost to consumers of acquiring information on the characteristics and quantities of characteristics which any individual commodity possesses. In the case of heterogenous goods such as agricultural products this is primarily important (Considine, 1986).

Thus, grades are useful if they have significance to buyers and sellers. Consumers are interested in purchasing products commensurate with prices they have to pay for their choices, while the concern of producers is associated with the extent to which grades help them in capturing fair prices. The establishment of clearly preferred grades also supplies information to producers to assist in formulating production decisions.

The concept of quality grade is different from one market level to another. The concept of beef carcass quality provides a good example of that. Beefpackers are quite concerned about dressing percentage because it affects significantly the yield of saleable carcass and consequently live value of fed cattle[1]. Retailers are not interested in dressing percentage, since it is not relevant to carcasses, but they are interested in the yield of trimmed, saleable retail cuts. Consumers are not concerned on either retail yield or dressing percentage, but they are highly interested in the eating qualities of the steaks and roasts and in their proportions of edible lean to fat and bone. It is important that all of these elements relevant to packers and retailers be carried from the producer to the consumer level.

The purpose of grading is commonly confounded with the purpose of inspection. The objective of meat inspection is to secure health by (1) eliminating diseased and otherwise harmful meat from human consumption, (2) preserving sanitary conditions during slaughtering and processing, (3) preventing the addition or use of harmful ingredients, and (4) controlling false or misleading labelling of meat and meat products (McCoy and Sarhan, 1988). Meat quality and meat safety are two distinct concepts. Meat quality depends on palatability factors and appearance, while meat safety deals with the

---

[1]*Fed Cattle* comprise young castrated males (steers) and young females that have never calved (heifers); both are fed special finishing rations in feedlots immediately prior to slaughter.

presence of microbial pathogens and levels of chemical residues (US Food and Nutrition Board, 1990).

Benefits and Costs from Grading

There are numerous potential contributions of grading to marketing efficiency. Marketing efficiency can be described by operational and pricing efficiency. In marketing, operational efficiency is related to the physical movement of products from the production point to the consumption point and to the transformation of products from one form to another. Pricing efficiency is concerned with how well the price system translates changes in consumer demands, how well prices communicate changing demands back to producers and influence an appropriate allocation of resources among alternative productive uses, and how well the price system disseminates income among producers and marketers.

The use of grades can improve operational efficiency because it permits trade by specification. If compared with trading by inspection, trade by specification can result in a reduction in transaction expenses for both buyers and sellers (Rhodes, 1987). It can also lead to a reduction in transportation costs by differentiating between the higher and lower-valued products. The higher-value products can be shipped forward and the lower-valued products can be sold nearer to home. Spoilage can be reduced by separating poorer-quality products from higher-quality ones. The use of grades can also increase the degree of competition in a market by expanding the level of public knowledge. In a perfect competitive market buyers and sellers are assumed to have perfect knowledge of market conditions. Even though grades cannot create perfect knowledge, the use of grading standards can, at least, strengthen the knowledge of traders.

In terms of pricing efficiency, standardization of quality grades has a variety of effects. First, the use of homogeneous quality grades gives motivation for producers to adjust to changing consumer choices. Kohls (1985) points out that "... the use of uniform quality grades provides incentives for producers to adjust to changing consumer preferences". In this sense, producers that shift their production efforts from lower- to higher- valued products are compensated by the price differentials among grades. There would be no incentive at all to produce higher quality products, if producers received the average price for all grades of products. Second, the use of grades gives consumers specific information with which to indicate their preferences to producers. For example, a group of consumers demanding a superior quality are able to get it by paying more for this kind of product, while those demanding a lower quality product, can easily identify and buy it. Third, grades have the ability to narrow price ranges. This is important especially in the case of commodities which have wide price ranges (such as beef cattle).

There are also some problems associated with grading. One is that several criteria often involved in grading are not immediately measurable. Rhodes (1987, p. 259) mentions that " subjective judgments and even subjective weighting of several judgments are often required. Such a situation provides some of the most pressing problems faced by a grading service in training and supervising a staff of graders."

There are also problems related with changes in grade standards. Changes in the grading system may be to the benefit of only one group within the industry structure, while others may contract substantial costs. Considine's et al. (1986) study showed that changes in the Canadian grading system of beef can lead to considerable adjustment costs.

Researching the impact of the 1972 grading system changes on the beef cattle industry, they demonstrated that the period of adjustment for beef producers has been in excess of 10 years. When consumer preferences change over time the need to reconstitute the grading system arises. The 1972 revision in the Canadian grading system was primarily implemented to provide the consumer with a leaner product in the preferred grades. The major criticism involved in Considine's et al study is that the Canadian grading system for beef did not have automatic adjustment mechanisms and that the period of adjustment can be lengthy and costly in the short-run. The history of changes in the beef-grading standards demonstrated that, even changes that have substantial theoretical foundation, are probable to be resisted unless all groups affected by these changes are convinced of the benefits of the proposed modification (Purcell and Nelson, 1976).

Grade as an Indicator of Quality to Consumers

An effective grading system tends to reduce consumers search and transactions costs, saving consumers time and money. In order to spread information to consumers effectively, a grading system needs to classify the product into different classes, each of which has particular significance to consumers . A grading system must also adjust to differences in demand among consumers (Rhodes, 1987).

Consumers obtain information concerning the product by engaging in search activity (such as sorting) before purchasing, especially in the case of a nonhomogeneous good (such as meat). According to Stigler's (1961) cost-benefit method to the acquisition of information, consumers continue to retain in search activity only as long as the marginal benefit derived from additional search exceeds the marginal cost of search. The cost of information search is influenced basically by the opportunity cost of time spent in search and the efficiency of search activity.

Anything that lowers the cost of search will tend to increase the amount of search activity and result in the consumer purchasing a higher quality good. Search costs can be reduced by use of grades which provide extra information prior to the search (Cox, McMullen and Garrod, 1990). In most literature related with grading, it usually is assumed that consumers prefer one grade to another and that they are able to differentiate among grades. If consumers cannot visually discriminate among different grades of a good earlier to purchase, the cost of search activity may be considerably high. This issue is assessed by Bocksteal (1984) where consumer and producer responses to quality standards are analyzed in terms of welfare gains and losses of minimum quality standards. One interesting feature of this study is that its "market model" incorporates the quality aspect into the supply and demand analysis. Bocksteal explains that when consumers can perceive quality before purchase, minimum quality standards induce social losses. Producers can benefit but only at the cost of consumers, and if the standards are measured by a compensation ("i.e., equal welfare weightings"), they unambiguously fail to create positive net social benefits. Bocksteal's results are contradictory to those that defend the argument that quality regulations improves the average quality product in the market. More specifically, this argument stresses that with a higher quality product for the consumer should be associated a higher price and this increases producers returns and consumers satisfaction (Jesse and Johnson, 1981).

In the marketing of beef, information prior to purchase may be very important. First, because consumers of beef do not all agree on a definition of quality and, second because consumers may have difficulty differentiating among beef grades from visual examination. For example, a study by Cox, McMullen and Garrod (1990), identified that consumers do not seem able to visually discriminate internal fat content in beef satisfactorily to make purchases compatible with their preferences. Marbling of beef[2], which is one of the major factors used in the Canadian grading system, is an indicator of high quality to some consumers and low quality to others. Consequently, the demand for beef can be classified as heterogeneous, meaning that all beef consumers do not rank beef quality in the same manner. Their results also implied that consumers who prefer low-fat beef may use price as a quality indicator when, in reality, price is usually positively correlated with marbling.

Price Associated with Quality and Grading

There is a strong relationship between grading, quality and price. Rhodes (1987, p. 256) defines quality as " the sum of the attributes of a commodity that influences its acceptability to many buyers, and hence, the price they are willing to pay for it". As already defined, grading is the classification of unlike lots of products into homogeneous categories, according to quality standards. Grades tend to increase the acknowledgment of value differences by segregating a product into different qualities. It also helps the producer of top quality products to be compensated for producing high quality products.

---

[2]Marbling refers to the fleck of fat distributed among muscle fibers in the lean. The degree of marbling is considered to be associated with flavour, tenderness, and palatability in general.

At a given point in time, price differentials between grades are the result of specific levels of demand and supply for the various grades. With the transition of time, price differentials change with shifts in the supply and demand functions. The changes in quality discounts and premiums depend on the size of shifts in these functions and on the algebraic form and consequent slopes of these functions. Premiums or discounts for "quality" are not always determined on the basis of competitive supply-demand relationships (Tomek and Robinson, 1981). Quality price constitutes the price premiums and/or discounts reflecting value differences paid for each carcass or live animal.

The relationship between price and grading/quality of agricultural products have been examined in various studies. Simmons (1980), derived a model for determining grades prices for Australian wool that were consistent with market valuations of different grades. One of the reasons for this study was that price differentials between different types of wool at auction were partially determined by the Australian Wool Corporation through the processes of market intervention. Simmons' model is based on the traditional Lancaster's theory where the demand for a good is seen as the sum of demand schedules for the individual characteristics. Cross-sectional price equations were defined with price as the dependent variable and the wool characteristics as explanatory variables. In this paper, Simmons (1980) points out that the choice of commodity attributes for inclusion in the model is based on a criterion that the attribute fulfils one or more of the following conditions:

(i) it directly influences processing costs or quantity or quality of the processed output;

(ii) it directly influences the quality of the end products as perceived by the consumer;

(iii) it constrains the end use of the commodity; and

(iv) data on characteristic are available.

The results of his analysis demonstrated the premiums and discounts for additional units or percentage points of each wool attribute.

Hayenga et al. (1985), developed a carcass merit pricing system for pork. Analyzing pork carcass composition and value relationships, they established a framework for determining premiums and discounts that included the use of the packer's own carcass data and prices. In determining the appropriate price premium/discount schedule, carcass value per cwt. was regressed against discrete dummy variables for various backfat categories, carcass weight and USDA muscling score. Their model provides estimates of value difference between each carcass class and the standard carcass selected as the basis for price quotations by the packer.

The prices received for fed cattle are, in part, a function of the grade received by the carcass. The highest ranked grades have consistently received the highest price, and lower grades are discounted by the market. Consequently, the returns received by a producer are a function of the allocation of sales among the various grades (Considine et al., 1986).

Several studies on cattle prices focus on price differences associated with cattle characteristics and quality. Schultz and Marsh (1985) investigated price differences between steer and heifer cattle at the feeder, slaughter, and wholesale levels of the market.

The price differences analyzed were restricted to cattle within the same weight range and grade categories. The issue underlying their study is that some cattle producers believe that the size of price differences for steers and heifers of the same weight and grade are not "justifiable" and that there was a bias against heifers. Explanations for this concern, at the feeder level, is provided by Boggs and Merkel (1979) that assign these price differences to physiological and growth factors in steers versus heifers and to the costs of dealing with pregnant heifers in feedlots. At the slaughter level, it is argued by Riley (1983) that packers usually regard steer carcasses to be better quality than heifer carcasses since they tend to have better marbling characteristics.

Schroeder et al. (1988) examined the impact of a variety of physical characteristics on Kansas feeder cattle prices. Factors affecting feeder cattle prices investigated in their study included health, presence of horns, fill, lot uniformity, and time of sale during auction. Other studies have identified many different physical characteristics probably to influence feeder cattle prices. These characteristics include weight, sex of animal, breed type, (Faminow and Gum, 1986); dressing percentage, live weight, quality grade, yield grade (Ward, 1981); sex, age, breed, grade, frame (Buccola, 1980). Williams, Rolfe and Longworth (1993), examined the effects of weight, fat score, muscle score, breed type, and other market variables on live cattle prices in Australia.

Little research into which characteristics are important in the determination of beef carcass prices has been conducted in Canada. This kind of study has been developed in Australia by Todd and Cowell (1981) and Porter and Todd (1985). The carcass characteristics examined by Porter and Todd (1985) were sex, age, weight, fat depth, meat colour, shape, meat texture, fat texture, ribeye area and marbling. Among these factors, they found age, meat colour, fat colour, sex, fat depth and weight and fat texture interaction to be significant explanators of carcass price variations.

The economic theory underlying the relationship between price and product characteristics (quality) will be discussed in chapter four.

CHAPTER 3. BEEF CARCASS QUALITY AND GRADING

The objectives of this chapter are to explain all the quality factors that influence carcass grading and value and describe the Canadian Grading System for Beef. This chapter is divided in six parts. The first part, discusses the concept of dressing percentage and the factors influencing dressing percentage. The second section analyses all carcass attributes that are used as predictors of quality and yield grade in the Canadian Grading System. The third section, discusses factors affecting carcass value. This is followed by an overview of the methods for carcass composition evaluation and, a discussion on the elements of beef quality. The last section, examines the Canadian Grading System for beef focusing on the evaluation of recent changes and actual grading standards.

Dressing Percentage

Dressing percentage can be defined as the relationship between the live animal immediately before slaughter and the weight of the carcass produced. It is a significant consideration because it influences the price paid for live animals and the time at which animals must be slaughtered so that their carcasses fall into specified weight ranges.

Live and carcass weights can be obtained in many different ways and careful definitions are required for information on dressing percentage to be interpreted correctly. Live weights that are normally used are: liveweights before leaving the farm (starved for 24 hours or average of weights taken on each of two or three days before slaughter), liveweight at the auction market or other point of sale, and liveweight in the lairage before slaughter.

Definitions of carcass weight may also vary: hot carcass weight within one hour of slaughter (with carcass dressed to a given specification), estimated carcass weight after 24 hours' colling, and actual carcass weight obtained from the sum of the parts after cutting and tissue separation.

Dressing-out percentages are very sensitive to the conditions under which the live weights are obtained, so commercial costing and price reporting must be based on the weights that are used in commercial practice. If this is not done, the relationship between live and carcass weight prices can be distorted.

Carcass weights are not so sensitive to the time of weighing but are highly dependent on the dressing procedures used. Kempster (1992) points that the accurate definition of carcass and under what conditions the weights are registered is crucial in selling on a carcass-weight basis and associated classification and grading schemes. He indicates certain points that should be taken into account when dealing with dressing percentage and carcass weight:

(i) Verify whether the head, feet and tail comprise part of the carcass and, if not, how the cutting lines dividing them from the carcass are defined.

(ii) Confirm whether internal fat depots, kidney, perinephric and retroperitoneal fat are considered part of the carcass.

(iii) Make sure whether any trimming of subcutaneous fat or intermuscular fat is permitted from the carcass before weighing.

(iiii) Verify whether the carcasses are weighted hot immediately after slaughter or when cold.

Dressing percentage can be influenced by some factors. First, as the animal grows, dressing percentage normally increases constantly owing to a higher rate of muscle and fat growth in the carcass than growth of components in the body cavity. Second, higher levels of feeding are typically identified with more concentrated diets and increased rates of fattening, so that animals on higher levels of feeding tend to show better dressing percentages.

Dressing percentages are associated with body conformation both within and between breeds. Breed types with better conformation at the same level of fatness tend to present better dressing percentages. Dressing percentages can also be influenced by the fasting period before slaughter. Carcass weights decrease as the time between the last feed and slaughter increases.

Beef Carcass Characteristics and Quality

Some attributes of carcasses are used as predictors of quality grade in the Canadian beef carcass grading system. These attributes are marbling, maturity, color, firmness, and texture. Marbling is the fat deposited intramuscularly and is one of the most important indicators of beef quality. In general, marbling increases with the age of the animal and the level of fattening. Fat is usually accumulated at wide different rates in various parts of the body. Factors such as breed, age, energy in the ration, feeding period, and slaughter weight influence the amount of marbling in a carcass.

There is some debate surrounding marbling and its relationship to overall eating satisfaction. In several studies, marbling has been found to be positively associated with palatability, meaning that beef lacking of marbling is less palatable than beef with some marbling. This debate extends to the use of marbling as a quality grade consideration in the Canadian grading procedure. In 1986, marbling was eliminated as a quality factor from the Canadian beef carcass grading system. In 1990 consumer panels were carried out in three provinces: Quebec, Ontario and Alberta. This study indicated that was a relationship between the amount of marbling and the frequency of unacceptable steaks. It was found that as marbling fat increased from "traces" to "small" the frequency of unacceptable steaks was hugely diminished (McDonnel,1990). As a consequence of this study, a survey of marbling fat in Canadian beef carcasses was conducted by Agriculture Canada at Lacombe Reseach Station, Alberta. The results of this survey were reported by Jones, Tong and Talbot (1991). They concluded that 20.6% of the carcasses studied had small or more marbling, 57.9% had slight marbling, 20.4% had traces of marbling and 1.1% were devoid of marbling. This survey also indicated that factors such as province, abattoir, gender and carcass grade were the most important factors influencing marbling score. Carcass weight and rib fat thickness, whereas significant, accounted for 0.5 and 6%, respectively, of the overall variation in marbling score.

The actual Canadian grading system ranks beef according to the amount of marbling in the carcass: higher grades have more marbling, lower grades have less. Marbling is ranked in the same manner in the American grading system. Cox, McMullen and Garrod (1990) addressed this issue by examining the use of grades and housebrand labels in the American retail beef marketing. Their results suggested that consumers who prefer low-fat beef may use price as a quality indicator when, in fact, price is usually positively correlated with marbling. They argued that a grading system that combines "multiple dimensions" of beef quality (fat content, palatability, tenderness, etc) into a single measure has problems in disseminating information effectively to consumers.

Maturity is represented in terms of either chronologic or physiologic age. There has been also some controversy concerning the relationship between maturity and beef quality. Some studies suggest that meat from older animals is not as tender as meat from younger animals (Martin, 1983). At the same time, beef flavour is raised (within limits) by increased maturity. The maturity of carcasses is recognized by assessing the color and degree of ossification in the cartilage and bones of the carcass.

The color of raw muscle is associated with the nature and amount of the complex protein myoglobin that are responsible for the color of raw muscle. There is an increase in myoglobin concentrations as animals mature resulting in a progressive change in color. Color varies from a light greyish red in very young beef carcasses to a dark red in mature carcasses. A bright cherry red is considered descriptive of desirable fresh-beef muscle colour. When a beef carcass is ribbed, the cut surface of the longissimus muscle has a purplish color. It takes 30 to 40 minutes for the bright red color to develop. This red color is a result of the reaction between the myoglobin and the oxygen, forming the compound oxymyoglobin. If the unprotected cut surface of a muscle is exposed to the air for 12 hours or more, the muscle tends to darken (Martin, 1983). Consumers tend do not accept dark-cutting meat very well so this factor is taken into consideration in the grading standards.

Color of fat is another element considered in the Canadian grading standards. Color of fat is related with breed, age, and feed. Fat with a yellow appearance is associated with older, mature carcasses and with some dairy breeds. The yellow appearance is in part due to the presence of carotenes, and is typical in animals fed rations that have a high concentration of carotenes. Fat with a yellow appearance is usually not desirable, mainly because consumers prefer a white, firm, flaky fat.

Firmness of the longissimus muscle is another element connected with quality and this is because it is positively related to the degree of marbling and finish. It is evaluated on the cut surface of the longissimus muscle between the twelfth and thirteenth ribs. Firmness is an important factor in grading and is related to acceptability and saleability of meat products.

Texture, or grain, is related to the amount of connective tissue associated with a muscle. Within a certain carcass, muscles differ in amount and kind of connective tissue, and consequently tenderness. For example, the eye round, *semitendinosus* muscle, has a higher connective tissue content than the rib eye, *longissimus* muscle, and therefore is coarser in texture. Texture is also related to maturity. The rib-eye muscle becomes gradually coarser with age (Martin, 1993).

Factors Affecting Carcass Value

Because many factors affect carcass quality, this section concentrates on the factors that influence the commercial value of beef carcass by focusing on marketing aspects. Kempster (1992) indicates five factors as the main structural characteristics of commercial importance: weight, proportion of the main tissues (muscle, fat and bone), distribution of these tissues through the carcass, muscle thickness, and chemical composition.

The weight and size of a carcass influence the quantity of the various tissues and the size of the muscles exposed on cutting. This is important because it affects the retailer's ability to supply cuts of appropriate size for consumer specifications.

The price of a beef carcass is determined by both grade and weight. Weight categories are determined by the packers. Prices are set on a standard carcass weight range defined as most adequate by the retail sector. Carcasses without these specific weight ranges (lighter or heavier) are usually discounted various amounts depending on demand for beef. Discounts and weight ranges may diverge between packers. In some cases these discounts are severe and are a pressure on the use of improved breeds and production systems. In relation to processing efficiency, packers seem to benefit from heavier weights because of reduced processing and labour costs per unit weight of marketable product.

The proportion of lean meat is the top determinant of yield and commercial value and, hence, it is of great importance to packers. Leanness is the characteristic by which most consumers assess quality and value for money (Kempster, 1989). At the farm level, it seems to make sense the production of leaner carcasses because substantially more energy is demanded to produce a given weight of fat than the same weight lean. At the meat processing level, leaner carcasses reflect better processing productivity through lower energy costs for chilling and less labor to remove excess fat in the production of wholesale cuts (Jones, 1989).

The muscle weight distribution through the carcass is meaningful because there are vast differences between cuts in their retail value. This is a fairly invariable characteristic and there is little change to exploit commercially (Berg and Butterfield, 1976).

The fat distribution is significant because it affects the general efficiency of meat production: excess fat trimmed during retail preparation is of little commercial value if compared with that sold as part of retail cuts. The position of fat in the carcass is also important because subcutaneous fat can be trimmed more easily than intermuscular fat and is preferable in carcass containing fat in excess of consumer requirements (Kempster, 1981).

Muscle thickness' variation from one carcass to another is attributed to weight and fatness variations. Within carcasses of similar weight and fatness, blockier carcasses will tend to have thicker muscles, however this variation has small influence on realized retail values (Kempster, 1992). Retailers tend to favour carcass with good meat thickness, but variations in lean and fat content are considered more important because they have a direct and commonly measurable effect on realization values.

Kempster (1992) mentions that the chemical composition of carcasses does not usually have direct connection on their commercial value since, they are valued on the basis of the physical properties listed above. Chemical composition may although be associated with several factors such as the eating quality of the meat, the processing aspects, the tendency to lose weight between slaughter and consumption, the keeping qualities and the nutritive value.

There are other carcass characteristics and quality factors that are important in terms of commercial value such as breed type, sex, muscling, frame size, and meat yield.

Breed type also influence the price buyers are willing to offer for cattle. Schroeder et al. (1988) investigated the influence of breed type on the prices paid for feeder cattle in Kansas feeder cattle auction. Their results showed that significant discounts were received for Angus, other English crosses, Brahman, dairy, and Longhorn cattle relative to Herefords. Small premiums were realized for the exotic crosses and whitefaced crosses relative to Herefords. Their results were consistent with findings in other studies, in which Hereford cattle received premiums relative to other nonexotic breeds.

Sex of the animal has been an important element in explaining variations in cattle prices and, consequently, has been included in most of the studies related to cattle characteristics and price (Buccola; Schultz and Marsh; Faminow and Gum; Schroeder et al.). Some of these studies have shown price differences between steer and heifer within the same weight range and grade classes. At the feeder level, the explanation for these price differences is related to physiological and growth factors differences and to the costs involved in handling pregnant heifers in feedlots. At the slaughter level, the argument is related to differences in marbling characteristics and to per unit processing costs. Sex has been also connected with proportions of carcass lean content (Jones, Tong and Robertson, 1987).

Muscling refers to the amount of fleshing on the bone structure of the carcass and is identified by the general build, outline and shape of the carcass. A well muscled carcass is usually more desirable than one with medium or defficient muscling. Muscling is generally assessed by the shape of the hip or round. Muscling is also a factor considered in the Canadian grading system. Some argued that muscling served a vital role in standardizing and categorizing carcasses for the purpose of buying and selling. Others emphasize that there are differences in muscling between cattle that are associated with differences in the quantity of saleable meat (Robelin and Tulloh, 1992).

Frame size is used as a major component in the Canadian feeder cattle grading system. There are several reasons that explain the importance of cattle frame size. First, large frame steers and heifers tend to gain faster than smaller frame cattle. Second, if fed to a constant weight or age, large frame cattle are more efficient and, third, frame size cattle must be fed for a longer period to finish.

Schroeder's et al (1988) studying the factors influencing feeder cattle prices also examined the effects of frame size on Kansas feeder cattle prices. According to their results, feeder cattle buyers exhibited a strong preference for large framed, heavy muscled cattle. Discounts for medium and light muscled cattle ranged from approximately 5% to 9% of the average price for heavy muscled cattle. Discounts for small framed and lower half of the medium framed cattle were also significant.

Meat Yield[3] is the percentage of saleable meat in the carcass. It is affected most by the amount of exterior fat on the carcass. As the fat measurement increases, the yield of retail cuts decreases. This is one of the major factors that affect carcass grading and value. Along with quality grade, the yield grade is considered a major factor in the Canadian beef carcass grading procedures. Purcell and Nelson (1976), in examining

---

[3]Two distinct concepts are associated with meat yield: saleable meat yield and cut yield. Saleable meat yield is the sum of the cut weights plus the weights of the trim expressed as a percentage of side weight prior cutting. Cut yield is the sum of the cut weights expressed as a percentage of side weight prior cutting.

differences in cutability in beef carcasses, emphasize that such differences can cause significant variation in carcass value. Because of some opposition to include yield grade in the American grading system, they argue that (1976, p. 482) "the move to required yield grading offers significant potential as a means of increasing pricing efficiency in the beef-marketing system".

Methods for Evaluating Carcass Composition

Beef carcass evaluation is concerned with verifying the monetary value of carcass. A prerequisite for any comparison of carcass evaluation technique is the definition of the baseline against which they are to be compared. Most carcass evaluations are carried out with an economic objective ultimately in mind and centred on those characteristics which have the greatest effect on carcass retail value. Ignoring carcass weight for the moment, meat yield is of most importance.

Techniques for evaluating carcass meat yield in carcass classification and grading are visual assessment and objective measurements such as fat depth measurement, video image analysis, velocity of ultrasound, medical diagnostic equipment, X-ray computed tomography and nuclear magnetic resonance imaging.

Visual assessments have been historically used to identify differences between animals, and continue to be an essential element in beef carcass classification. Visual assessments methods for measuring carcasses in classification and grading schemes in Canada and United States have focused on the measurement of the rib eye muscle and overlying fat on the exposed surface of the ribbed carcass. According to the Canadian grading procedure a beef carcass is initially inspected for maturity. Graders recognize the age (maturity) of carcasses by assessing the colour and degree of ossification in the cartilage and bones of the carcass. Later, the carcass is ribbed at the 12/13th ribs when muscling, meat colour, marbling, fat measurement, fat colour or texture, and pronounced masculinity are examined.

In terms of fat depth measurements, automatic-recording probes designed for inspecting pigs have been evaluated for their potential use on beef carcasses (Chadwik and Kempster, 1983). Individual probe measurements or combinations of probe measurements taken in the rib and loin areas could not predict carcass lean as precisely as visual fat class. However, when probe measurements were used in assession to visual fat assessment, precision of prediction was improved.

Ultrasound has been used extensively in medicine and radiology. It constitutes a complex selection of electronics that produces soundwaves with frequencies too high for human detection. The velocity of ultrasound (VOS) technique has been used to estimate carcass composition in domestic livestock for many years. More specifically, ultrasonic technique has been utilized to estimate fat thickness and longissimus muscle area (Recio et al, 1986; Henderson, Corah and Perry, 1989; Perkins, Green and Hamlin, 1992; Smith et al, 1992). Some studies indicated that ultrasonic measurements of backfat and longissimus muscle area using these technique may be relatively accurate predictors of final carcass fat thickness and longissimus muscle area in beef cattle (Perkins, Green and Hamlin, 1992). Others, concluded that ultrasonic measurements of fat thickness are precise and accurate in determining fat thickness, while muscle area estimates are inconsistent and further investigation is necessary (Smith et al, 1992). Wilson (1992), reviewing the application of ultrasound for genetic improvement suggests that the application of ultrasound for genetic improvement by the swine industry has been successful but further research is still required before application of ultrasound can be supported on a large scale by the beef and sheep industries.

The method of video image analysis (VIA) appears attractive because the carcass attributes appraised visually during classification can be measured objectively. The carcass is either scanned by one camera or viewed from different angles with several strategically placed cameras. The image is converted to a numerical array of grey values by an associated computer. These values can be used to predict conformation and fatness. Wassenberg, Allen and Kemp (1986) evaluated the usefulness of VIA for beef carcass estimation. They concluded that the ability of the VIA to predict both percentage and kilograms of primal lean was equal in accuracy to the USDA factors.

Australia developed a video image analysis which includes a whole carcass assessment on the slaughter floor and a chilled carcass assessment on the cross section of the rib eye. This system was evaluated and compared with the Canadian grade ruler in the National Beef Carcass Cut Out Study developed by Agriculture Canada in the Fall of 1993. The results of this study indicated that the whole carcass VIA system explained over 60% of the variation in saleable meat yield with an error of 1.50%. It had similar accuracy to the grade ruler for predicting cut yield. The chilled carcass VIA system only explained about 26% of the variation in saleable meat yield and 50% of the variation in cut yield with an error of 1.33%.

There are several medical techniques which offer potential for assessing whole body composition, but currently most of these techniques would involve high costs and are difficult to implement. The most common is the X-ray computed tomography(CT). The carcass is placed in the centre of a large wheel which has an X-ray tube and a detector placed at opposite positions on the inner edge. The wheel is rotated around the carcass. The attenuation of the X-ray detected allows construction of a cross-sectional image by a linked computer. Nuclear magnetic resonance imaging allows tissues to be characterized by the measurement of electromagnetic signals given off by protons in the body tissues when a strong magnetic field is applied. As with X-ray CT, no equipment is currently available for measuring beef carcass (Kempster, 1992).

The benefits associated with the use of these techniques in precisely and accurately estimating carcass measurements in live animals should be of advantage to the beef industry, permitting it to move away from the present procedure of pricing cattle on pen averages to a value-based marketing system.

Measuring Beef Quality

There is concern among participants of the meat industry on how to measure the degree of equivalence or dissonance between consumer preferences and a product's characteristics. Branson et al. (1986), reviewing the factors behind the development of a national consumer beef study in United States, provide a combination of reasons for this concern. First, at the producer level, are the changes in the beef production system in terms of breeding and feeding operations and methods responding to consumers preference of leaner meat. Second, at the wholesale (packers) level, are the use of electrical stimulation of beef carcasses to intensify meat tenderness and the adoption of boxed beef. And third, at the retail/consumer level, are the concerns related to shift in beef demand to other products such as chicken and pork and consumers' apprehension regarding diet and health.

According to several studies on beef quality (Kempster; Branson et al.; Capps, Moen and Branson; Jeremiah, Tond and Jones), the most important elements of beef quality are leanness, tenderness and flavour. Leanness is associated with an optimum level of fatness. The controversy around this issue is how much would this optimum level of fatness be. At one side, there are consumers demanding a leaner meat and, on the other side, certain sectors of the meat industry are resisting to changes in fatness level.

Tenderness is considered one of the most important aspects of beef quality and the most difficult to control. There is a general view among retailers that the average level and the variability in tenderness has not improved.

The factors that are important in determining the tenderness of beef and influence other eating quality characteristics are breed, carcass fat content, marbling fat, production system, sex, preslaughter handling (stress), muscle pH, carcass chilling rate, conditioning time and cooking (Kempster, 1992).

There is vast literature on the effects of breed type on meat quality. In general, the conclusions are that breed type is not important on its own but that variation in succulence and tenderness is associated with differences in carcass weight and fatness.

Studies developed in the U.S.A. supports the idea that beef from heavier, fatter carcasses is more tender because the carcass will have cooled more slowly, and even in conventional chilling, lean uninsulated sides can "cold shorten" leading to tough beef (Dikeman, 1987). Other research (Koohmaraier, Seideman and Crouse, 1988) suspects the view that fat simply has an insulating effect. These studies and others imply that marbling fat in loin muscle is essential to provide optimum tenderness (Dikeman, 1987).

In terms of system of production and diet, analysis carried in the United States have demonstrated that grain-fed beef produced in feedlots is more tender than "forage-fed" beef. Early results suggested that this was because grain-fed carcass were heavier and fatter and thus cooled more slowly under normal chilling conditions (Tatum, 1981).

Bull carcasses are generally leaner than those from heifers or steers and some reports have suggested that findings of tougher meat in bulls are explained by greater cold-shortening. However, consistent differences in favour of steers have also been shown in the absence of cold-shortening.

The effects of pre-slaughter handling and resulting stress on tenderness are probably mainly associated with the effects on pH. Australian work shows that in the ultimate pH range 5.4-6.0, increasing pH leads to tougher meat, (Bouton et al, 1973).

Operating post-slaughter such as carcass chilling, electrical stimulation and conditioning are the most critical and the most uncertain in their detailed effects on beef quality. Rapid chilling of carcasses so that muscle temperature reaches approximately 10 C can seriously toughen beef (Marsh and Lee, 1966). High-or low-voltage stimulation can produce tender meat even if sides are then colled rapidly (Bendall et al., 1976).

Canadian Beef Carcass Grading System

The history of the Canadian beef carcass grading system is characterized by many changes. In order to understand the actual Canadian grading system, an evaluation of recent changes is provided. The most important aspects of those changes are discussed in the evaluation of recent changes.

Evaluation of Recent Changes

Beef carcass grading started in Canada in 1929. Since then there is been several changes following the industry changes. One of the major evaluations of the system occurred in 1972. The concept of basing the grade on the yield of a carcass was introduced by the revised system. Research demonstrated that fat covering on the carcass was the major factor affecting the yield of edible cuts more than any other element, such as conformation, muscling, bone percentage, carcass weight or rib eye area.

Before the 1972 Canadian grade changes, grading of beef animals was based on subjective considerations. According to the 1958 Beef and Veal Carcass Grading Regulations, slaughter cattle were classified as excellent, rangy, angular, or irregular. Conformation provided the basis of the grading system. The assumption behind the rationale for the grading system-that there was correlation between consumer preferences and conformation-was never commercially tested (Smith et al., 1975) and vague phrases as "there is no excess proportion of fat at any weight " were employed by the regulation.

At that time, the grading system provided little value to producers and consumers but served wholesaling-retailing groups well. Because the old grading system did not take into account the effects of fat cover on yield of edible cuts, retailers could sell beef which many consumers found excessively fat, as "choice" (the highest grade in the old Canadian System). This excess of fat was usually trimmed off in the consumers' home as waste. The grading system was not transmitting information from the consumer level to the producer level. The result of that was cattle feeders operating longer feeding periods to put on fat which the consumer did not want and often rejected.

Due to producer and consumer concerns the grading of beef was reviewed by committees and discussed in several conferences. Consumers, producers and others sectors of the beef industry got together at the 1966 Canadian Beef Improvement Conference. After this first conference was created an Industry Committee on Beef Grading and Quality. Subcommittees reports, dealing with subjective versus objective methods of grading, affirmed that subjective grading did not adequately reflect beef quality. Following a significant amount of additional research, a proposal for the establishment of a entirely new grading system which would be based on objective measures was put forward. Meat packers did not agree with this complete objective method. They believed that some of the subjective methods should be preserved. An agreement between packers and producers was finally established. The producers were able to obtain points for objective quality standards, and packers were able to get quality standards describing rib lean texture, marbling, colour, and texture of fat (Considine et al., 1986).

On 5 September 1972, the new Canadian beef grading system was introduced. The new grading system was build fundamentally on objective standards and its highest grade, A1, had requirements which were substantially leaner than had been the case under the old grading system. The revised system introduced the concept of basing the grade on the yield of a carcass. Hence, the revised grading system introduced fat measurements for the A and B grades, separating each grade into four fat categories A1, A2, A3 and A4; B1, B2, B3 and B4.

In terms of grading procedures, in order to take fat measurements and assess meat color and marbling, carcasses have been partly separated (knife ribbed) between the front and hind quarters. Since January 1, 1984, this separation has been made between the 12th and 13th ribs. The idea was to adapt the new grading procedure with international standards to simplify trade in beef with other countries. Previously beef carcasses had been separated between the 11th and 12th ribs.

On January 1, 1984, small revisions were also made in the grading system with the purpose to convert the measurements to metric and to use the same measurements for all weights of beef carcasses weighing 330 pounds (150 kg) and more.

The last changes in the Canadian beef grading system occurred on April, 5 of 1992. The primary objectives behind these changes was to make the Canadian and American grading systems comparable on many important issues. Before April, 5 1992, there were 14 grades of carcasses with the grade names Canada A1-A4, Canada B1-B3, Canada C1-C2, Canada D1-D4 and Canada E. With the 1992 revision, A, B and D grades remained unchanged, but the category C was abolished. This was changed to 12 grades of carcasses with the grade names Canada A, AA, AAA, Canada B1-B4, Canada D1-D4 and Canada E.

Two important changes were the adoption of the grade ruler to predict the yield of boneless cuts and the reintroduction of marbling and subsequent identification of 3 quality grades (A,AA,AAA) for young cattle. The grade ruler will be explained in more details in the section describing the actual Canadian grading system.

There were small changes in the factors describing quality grade. Maturity groups were reduced from 3 categories (mature, intermediate and young) to 2 categories (mature and young). After these changes, marbling was assessed at 4 levels: Devoid, Trace, Slight and Small (or greater). For the A grade a minimum of trace levels of marbling was required. The implications of this specific change to the beef industry is that Canadian grade would be able to be converted to its equivalent US quality grade. The yield grade categories were reduced from four (A1, A2, A3 and A4) to three classes (A1, A2 and A3). Fat and meat color criteria were kept the same. These changes are better explained in Table 3.1.

Table 3.1. Changes in the Beef Grading System According to 1992 Revision

Grades	Main Changes
A	1. Marbling - Grade A carcasses are stamped with the following classification : A (trace), AA(slight), & AAA (small and greater). Devoid carcasses fall down into the B1 grade. 2. Yield - Carcasses are classified into three groupings: A1 (59% +), A2 (54%-58%), and A3 (53% -).
B	1. B2-B4 grades - The dark cutting carcasses became B4's and youthful carcasses with yellow fat are classified as B2's. 2. Yield Calculation - It was agreed to wait one year to deal with the issue of measuring the yield of B carcasses.
C	This class was eliminated.
D	Fat thickness break moved to 15 mm from 20 mm for D1 cows.

Besides these changes, there are still many differences between the Canadian and US grading systems. These differences are associated with the definition of carcass weight, maturity, marbling levels, fat and muscle colour, conformation, yield factors calculation and others administrative differences (Jones, 1992).

The Actual Canadian Grading Standards

The actual Canadian beef carcass grading system contains 12 grades of carcasses with the grade names Canada A, Canada AA, Canada AAA, Canada B1, Canada B2, Canada B3, Canada B4, Canada D1, Canada D2, Canada D3, Canada D4 and Canada E.

In Canada, grades of beef carcass are based on two major factors: quality grade and yield grade. The factors that are investigated in defining the quality grades are: maturity, muscling, longissimus muscle, longissimus muscle color, fat color, fat covering and marbling level.

Maturity is determined by the assessment of colour and degree of ossification in the cartilage and bones of the carcasses. It is analyzed the cartilaginous caps on the thoracic vertebrae, lumbar vertebrae, the spinous processes, ribs and sternum. The grading system recognizes two stages of maturity: young and mature. The young class of maturity is for youthful animals in the A, AA, AAA, B1, B2, B3 and B4 grades, while the mature class includes animals in the D1, D2, D3 and D4 grades.

As mentioned before, muscling refers to the amount of fleshing on the bone structure of the carcass and is distinguished by the general build, outline and shape of the carcass. While the muscling requirements for the top grades of beef are not as rigorous as in past grading systems, a well muscled carcass is still more desirable than one with only medium or deficient muscling. Youthful carcasses with at least medium or better muscling are eligible for the A and B grades. Mature cows fall into the D1, D2, D3 and D4 grades. Muscling in these grades varies from "excellent" in the D1's to "from deficient to excellent" in the D4's. The E grade includes beef carcasses of a bull or stag and the beef carcasses that have pronounced masculinity.

The potential cooking and eating quality of meat is also affected by maturity. Carcasses with lean bright red meat that is firm with some marbling, and has a firm white fat cover, produce cuts of meat with the greatest potential to satisfy the consumer. The A grade (A, AA, AAA) consequently requires that the longissimus muscles are firm and bright red and fat cover which is firm an white or slightly tinged with a reddish or amber colour and marbling levels according to Table 3.2. B grades can have a medium dark lean colour, with slightly soft fat cover which may be slightly yellowish in colour. B2 is an exclusive grade for carcasses with yellow fat. B4 grade is exclusive for dark cutting carcasses. The D grades include carcasses with white or slightly tinged with a reddish or amber colour to yellow fat cover. A fat cover that ranges from firm to slightly soft are required for D grades. Quality factors are less important in the E grade.

Table 3.2. Marbling Requirements for Canada A, Canada AA and Canada AAA

Item	Column I Grade	Column II Required Marbling Level
1.	Canada A	At the least, traces, but less than a slight amount
2.	Canada AA	At the least, a slight amount but less than a small amount
3.	Canada AAA	A small amount or more

Source: Department of Agriculture, Canada. Livestock Carcass Grading Regulations.

In 1992, a grade ruler was adopted by the Canadian grading system to predict the yield of boneless cuts. Meat yield is assessed through computation of the rib eye dimensions (length and width) and fat thickness. It is affected most by the amount of exterior fat on the carcass. As the fat measurement increases, the yield of retail cuts decreases. Figure 3.1 has a representation of the grade ruler. The correct fat class is established by positioning the ruler point at the minimum of the fat thickness in the fourth quarter of the loin-eye on the left side of the carcass. This is indicated by number (1) in Figure 3.1. The nine fat classes span the fat thickness range of 4 to 20 mm for A grade carcasses. Table 3.3 shows the grade fat thickness and its respective classes for A, AAA and AAA grade carcasses.

Table 3.3. Grade Ruler Fat Classes and Grade Fat (mm)

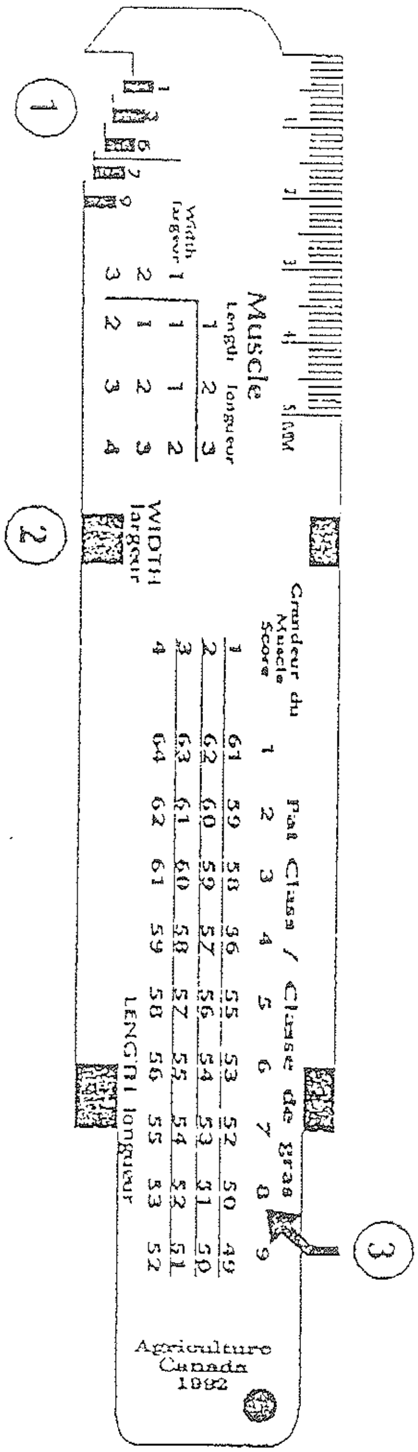
Grade Ruler Fat Class	Grade Fat (mm)
1	4 to 5
2	6 to 7
3	8 to 9
4	10 to 11
5	12 to 13
6	14 to 15
7	16 to 17
8	18 to 19
9	20

The loin-eye length and width are measured and scored 1 (small), 2 (medium), or 3 (large) depending on how the compare to the "width" and "length" boxes. This is indicated by number (2) in Figure 3.1. Table 3.4 describes the measurements associated with rib eye width and length.

Table 3.4. Rib Eye Width and Length Classes and Measurements

Rib	Eye Width	Rib	Eye Length
Class	Measurement (mm)	Class	Measurement (mm)
1	less than 64 mm	1	less than 141 mm
2	64 to 71 mm	2	from 141 to 150 mm
3	greater than 71 mm	3	greater than 150 mm

Figure 3.1. Grade Ruler used by the Canadian Beef Carcass Grading System



Anything between the ruler point and the box is a 1, in the box is a 2, and beyond the box is a 3. The muscle grid is used to define the final muscle score. Using the muscle score and fat class together on the yield grid will give the estimated lean yield or cutability estimate. This is represented by number (3) in Figure 3.1. Cutability estimate is an estimate of the percentage of trimmed, boneless retails cuts expected from the four major wholesale cuts of a side. A yield formula is used to calculate the cutability percentage using muscle score and grade fat measurements. The yield equation is as follows:

$$Y = 63.65 + 1.05 * (\textit{muscle score}) - 0.76 * (\textit{grade fat}) \qquad (3.1)$$

The yield grade and yield class are determined for every beef carcass that is graded Canada A, Canada AA and Canada AAA. A higher yield of retail cuts is expected from an A1 side of beef compared to an A2. Similarly, the yield drops further in the A3. Yield class is stamped in red ink in four places; short loin and rib sections of each side of carcass. The yield classes of a beef carcass that is quality graded Canada A, AA and AAA are represented in Table 3.5.

As stated before, the level and distribution of the fat cover over the whole carcass will affect the yield of meat but this is at least partly evaluated by taking the fat measurements. The degree of muscling and rib eye area have a lesser degree of influence on meat yield. Muscling is more difficult to assess objectively in the grading system.

Appendix 1 provides a copy of the Canadian standards for beef carcass.

Table 3.5. Determination of Yield Class for Carcasses Graded Canada A, AA and AAA

Item	Column I Determined Yield (%)	Column II Yield Class
1.	59 or more	Canada A1
2.	54 to 58	Canada A2
3.	53 or less	Canada A3

Source: Department of Agriculture, Canada. Livestock Carcass Grading Regulations.

CHAPTER 4. DATA AND METHODOLOGY

This chapter addresses the sources and construction of the data and methodology required for the evaluation of beef carcass value and price premiums and discounts. It is divided in five parts. The first part describes the theory underlying a hedonic price technique. The second part discusses the data and data source. The third part examines each individual characteristic included in this study. The fourth part describes the procedure associated with the hedonic (empirical) analysis. And the last part addresses the issue of multicollinearity including its investigation and possible solution.

Theory

The first study that analyzed the influence of quality on prices was published in 1928 by Waugh. In 1939 Court proposed that multiple regression techniques could be used to break down the price of a product into the implicit price of each characteristic multiplied by the quantity of each characteristic included in the product. Many of the theoretical issues of consumer demand for quality was formalized independently by Houthakker and Theil (1951). The link between consumer demand with measurable product characteristics was initially executed by Gorman's (1956) study on quality differentials in the egg market. Later, Lancaster (1966) developed a new approach to consumer theory emphasizing that consumer utility is derived from the attributes of the good rather than the goods themselves. Lancaster's theory of demand plays an important role in the analysis of beef quality data and will be given special attention in this section.

In his approach of consumer theory, Lancaster (1991) assumes that consumption is an activity in which goods, individually or in combination, are inputs in which the output is a collection of attributes. Utilities are assumed to classify collections of attributes and only to classify collections of goods indirectly through the attributes that they possess. The substance of Lancaster's theory can be outlined as follows:

1. It is not the good, per se, that gives utility to the consumer; it possesses attributes, and these attributes give rise to utility.

2. Normally, a good will possess more than one attribute, and many attributes will be shared by more than one good.

3. Goods in combination may posses attributes from those concerning to the goods individually.

Lancaster's model associated with this new consumer approach has some specific assumptions. First, it assumes that the relationship between the level of activity m, Q_m, and the product consumed in that activity to be both linear and objective, so that, if x_j is the jth good we have

$$x_j = \sum a_{jm} Q_m, \tag{4.1}$$

and the vector of total goods required for a given activity vector is given by

$$x = AQ. \tag{4.2}$$

The equations are assumed to hold for all individuals, the coefficients a_{jm} being calculated by the inherent properties of the products themselves and conceivably the conditions of technological knowledge in the society.

Second, it assumes that each consumption activity originates a fixed vector of characteristics and that the relationship is also linear, so that, if c_i is the amount of the *i*th characteristics

$$c_i = \sum b_{im} Q_m \tag{4.3}$$

or

$$c = BQ. \tag{4.4}$$

Third, it is assumed that the individuals possess an ordinal utility function on characteristics *U(c)* and that they will try to maximize *U(c)*. The ordinary convexity properties of a standard utility function is also assumed for U(c).

Considering that consumers are not interested in goods for their own sake but because of the characteristics they possess, the utility of consumption depends on the characteristics that a good has

$$U = U(c_1,...,c_n), \tag{4.5}$$

where c_1, ..., c_n are quantities for the *n* characteristics consumed. Each consumer, then, has a vector of characteristics and subjective weights for varying quantities of characteristics. Consequently, n can be considered to include all possible characteristics which might be important to consumers.

Lancaster (1966) formulated the consumer's utility maximization problem as

$$Max\ U(c) \tag{4.6}$$

subject to

$$P'Q \leq I \qquad BQ = c,\ c \geq 0, \qquad Q \geq 0,$$

where c is a vector of quantities of characteristics, Q and P are vectors of quantities and prices of products, and B is the consumption technology matrix of input-output coefficients. The ith row of $BQ = c$ can be written as

$$\sum b_{ij}\, q_j = c_{oi}\ , \tag{4.7}$$

where b_{ij} is the quantity of the ith characteristics in one unit of product j, and q_j and c_{0i} are the total consumption of each characteristic.

The limitations of Lancaster's model have been discussed by some studies. The criticisms apply to the assumptions of linear consumption technology (Lucas, 1975), that marginal utilities of all characteristics are nonnegative (Hendler, 1975) and that utility depends only upon total quantities of characteristics and not upon their distribution among commodities (Lucas, 1975 and Hendler, 1975). A similar approach to Lancaster's theory was developed by Ladd and Suvannunt (1976) and these limitations do not seem to apply to their model. This approach is called the consumer goods characteristics model (CGCM). There are two hypothesis behind the CGCM: (1) for each product consumed, the price paid by the consumer equals the sum of the marginal monetary values of the goods' attributes, (2) and consumer demand functions for goods are influenced by attributes of the products.

The empirical application of characteristics demand is illustrated by a hedonic price function, where product price is a function of the good and its quality characteristics. A basic form of the hedonic price equation is provided by Lucas (1975):

$$P_i = f\,(c_{i1}\ ,\ .\ .\ .\ .\ ,\ c_{ij}\ ;\ u_i) \tag{4.8}$$

where P_i is the observed price or value of product i; c_{ij}, $j=1,...,J$ measures the amount of some inherent "quality characteristics" for each unit of product i; and u_i is a disturbance term. Hedonic price studies are used to quantify the relationship between product prices and their observed quality attributes. Specific markets do not exist for the attributes themselves and so separate implicit values need to be estimated for each, and independently of additional factors affecting the product price.

The hedonic price function allows implicit value of attributes to be estimated and, consequently, it has been used broadly in agricultural product price studies. Ladd and Martin (1976) used hedonic prices to evaluate U.S. corn grades. Wilson (1989) specified and estimated a hedonic price function in order to measure the magnitude of differentiation and values of quality characteristics in the international wheat market.

Tronstad, Huthoefer and Monke (1992) determined the implicit value of spatial, seasonal, and quality characteristics of apples by estimating a hedonic price model for the U.S. apple industry. The hedonic technique has also been applied to a variety of studies that analyzed the implicit prices of manufactured goods (Gregory and Teartle, 1973), land (Pardew, Shane and Yanagida, 1986), and automobiles (Adelman and Griliches, 1961).

The logic of hedonic analysis of beef carcass prices is that different value of beef carcasses is determined by the particular characteristics they possess. The quantity of each quality characteristics is an argument in the production function. The first-order condition of a firm maximizing a profit function results in a hedonic price function. This simply demonstrates that the market price for an input depends on its characteristics. As specified before, the hedonic price function can be described as:

$$P_{x\,i} = P_y \sum_{j=1} (\partial f_y \,/\, \partial q_{j\,y}) \times (\partial q_{j\,y} \,/\, \partial x_{i\,y}) \qquad (4.9)$$

where P_{xi} is the price of input x, $\partial q_{jy}/\partial x_{iy}$ is the marginal yield of characteristic j in the production of y from input i, and $P_y(\partial f_y/\partial q_{jy})$ is the value of the marginal product characteristic j used in production of y. This function can be simplified by assuming that $P_y(\partial f_y/\partial qj_y)$ is B_j and $\partial q_{jy}/\partial x_{iy}$ is x_{jiy}, and both are constant. The hedonic price function can then be restated as:

$$P_{x\,i} = \sum_{j=1} B_j\,(x_{j\,i\,y}) \qquad (4.10)$$

where x_{jiy} is the quantity of characteristic j contained in each unit of x_{iy}, B_j is the marginal implicit value of characteristics j. Thus, the general empirical specification is a functional relationship between prices and quality characteristics.

Data

The carcass data were collected by Agriculture Canada in two Canadian packing plants, plant A and plant B, located in western and eastern Canada respectively. The period of data collection were from September 14 to October 7, 1993 and from October 19 to October 28, 1993, respectively. A total of 493 carcasses were graded and cut out in both packing plants. In this study, 436 carcasses were utilized, 270 carcass data collected in packing plant A and 166 carcass data collected in packing plant B. The 57 dairy carcasses were not included in this analysis. Carcasses covering the normal commercial range in fat thickness and muscularity were identified on the slaughter floor, selected, graded and placed on a separate rail. All left carcass sides were cut out following a standardized procedure.

The carcasses were divided into specific weight groups according to their warm carcass weight. Groupings were determined by using standard weight groups denominated in pounds. Table 4.1 shows the distribution of carcasses by weight group and animal type for each packing plant. Plant A carcasses were divided into three weight groups: 550-650 lb, 650-750 lb and 750-850 lb. Plant B carcasses were divided into two weight groups: 600-750 lb and 750-850 lb. Among plant A carcasses, 133 (49.3%) are steers and 137 (50.7%) are heifers. Among plant B carcasses, 81 (48.8%) are steers and 85 (51.2%) are heifers.

Table 4.1. Total Number of Carcasses By Plant, Weight Group and Animal Type

Plant A			
Weight Group (lb)	Steer	Heifer	Total
550-650	33	43	76
650-750	56	57	113
750-850	44	37	81
Total	133	137	270
Plant B			
Weight Group (lb)	Steer	Heifer	Total
600-750	39	47	86
750-850	42	38	80
Total	81	85	166

Only carcasses graded Canada A, AA, and AAA were included in this study. In 1992, these top grades accounted for 87% of the carcasses graded in Canada (Richmond, 1994). As mentioned before, all A-Grades of beef must be from youthful animals. Meat must be bright red, firm, fine grained, and fat must be white and firm. All A-Grade carcasses are assessed for a lean meat yield class, determined by measuring exterior fat and the length and width of rib-eye muscle. Those carcasses are placed in one of three classes: A1, A2 and A3.

Figures 4.1 and 4.2 show the percentage of plant A carcasses by quality and yield grade, respectively. Among plant A carcasses, 40.7% are included in the quality grade (marbling level) A, 40% in the quality group AA and 19.3% in the quality group AAA.

In terms of yield grade, 48.5% of the carcasses are included in yield grade A1, 41.5% in yield grade A2 and, 10.0% in yield grade A3.

Figure 4.1. Percentage of Plant A Carcasses By Quality Grade

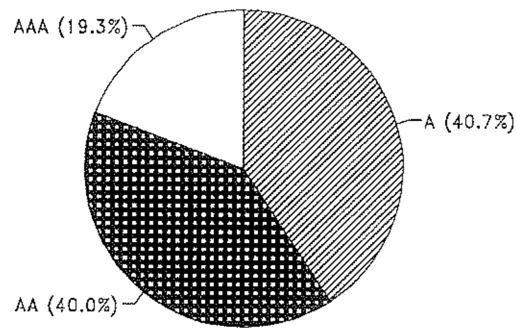


Figure 4.2. Percentage of Plant A Carcasses By Yield Grade

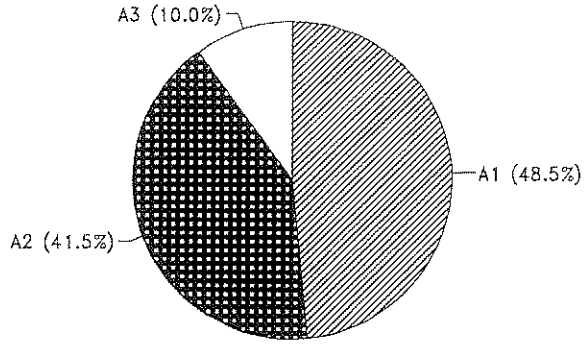


Figure 4.3 and 4.4 illustrate the percentage of plant B carcasses by quality and yield grade, respectively. Among plant B carcasses, 40.4% of the carcasses are included in marbling level A, 39.8% in marbling level AA, 19.9% in marbling level AAA. In terms of yield grade, 54.8% are included in yield grade A1, 34.9% in yield grade A2 and 10.2% in yield grade A3.

Figure 4.3. Percentage of Plant B Carcasses By Quality Grade

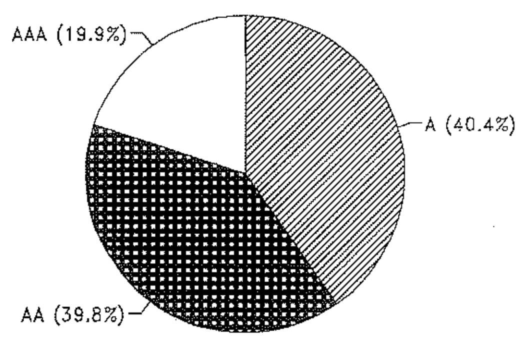
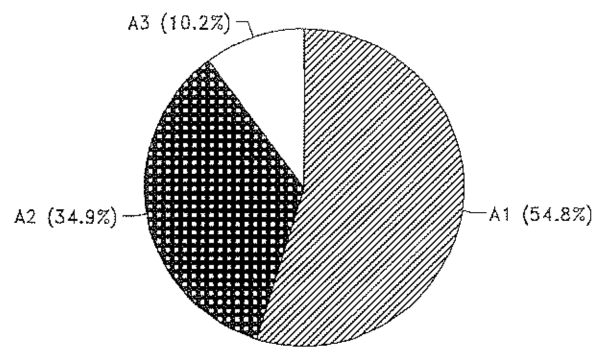


Figure 4.4. Percentage of Plant B Carcasses By Yield Grade



Several variables for characteristics were recorded for each carcass in the two packing plants. Some data explained the same characteristic in different ways, (e.g. grade fat and average fat, both indicate different fat measurements). The data that most fit the objectives of this analysis were chosen to be analyzed. These data include sex, weight, saleable yield, grade fat, muscle score, marbling class and cutability estimate. Each characteristic will be explained in more detail in the procedure section.

This hedonic price analysis was developed in a slightly different way from most of the hedonic price studies. The dependent variable, carcass price in dollars per pound, was calculated by taking the weights of the wholesale cuts, table trim, fat and bone, multiplying by the average market prices for the specific wholesale products and dividing the total carcass value by the carcass weight.

Prices for the wholesale cuts were supplied by the two packing plants and are the weekly average price for week in the data collection period. Fat and bone prices were provided by Rothsay-A Member of Maple Leaf Foods Inc.

Potentially Important Characteristics

Before defining the hedonic price models a careful investigation of the characteristic variables to be included in those models was executed. The starting point for this analysis was the examination of previous economic and technical research. Most of the studies have examined the effect of different characteristics on the price of cattle. The most common characteristics examined in these studies were sex, age, weight, fat score, breed and feed type. Other variables such as lot size, presence of horns, day of sale were also included (Faminow and Gum, 1986; Ward, 1981; Buccola, 1980; Williams, Rolfe and Longworth, 1993). In terms of the relationship between beef carcass prices and carcass characteristics, factors such as sex, age, weight, fat depth, meat colour, fat colour, meat texture, fat texture, ribeye area, fat distribution, marbling and bruising has been analyzed (Todd and Cowell, 1981; Porter and Todd, 1985).

The dependent variable, beef carcass price, was determined by the total value of its components, such as cuts, trim, fat and bone. This will be discussed more in the procedure section. The independent variables examined in this study are sex, week of grading, weight, saleable yield, grade fat, muscle score, marbling, cutability estimate, sex*weight interaction, sex*grade fat interaction, weight*grade fat interaction, sex*cutability estimate interaction and weight*cutability estimate interaction. Because this study was dependent upon the Agriculture Canada research team for data, selection of variables to be included in the analysis was conditioned by availability. However, theory and past research were used as guide for variable inclusion.

Sex was included because most of the previous studies indicated that heifers were discounted in comparison with steers. There are different explanations. Some argue that steer carcasses yield significantly higher proportions of edible meat and bone and less excess fat than heifers (Preston and Willis, 1970). Others, argued that, at the slaughter level, packers usually regard steer carcasses to be better quality than heifer carcasses since they tend to have better marbling characteristics (Riley, 1983). Porter and Todd (1985) found opposite results for sex.

The variable week of grading was included in the model as a "time factor" variable, to take account of price variation related to time. In other words, it is purely a control variable, to account for general price level changes. For plant A, four different week average cut prices were used, considering the period involved in data collection at this plant. For plant B, two different week average cut prices were used.

Weight is an important factor in determining price of beef carcass. Carcasses lighter or heavier than the standard weight are usually discounted. A nonlinear relationship between weight and carcass price is possible, given previous studies. Weight was included as a continuous variable.

Saleable meat yield is the sum of the cut weights plus the weights of the trim, 50, 75 and 85% lean, expressed as a percentage of side weight prior to cutting. It is one of the most important components in determining carcass value to the meat processor. It is expected to have a significant and positive effect on carcass value.

Fat thickness is expected to affect meat yield. As the fat measurement increases, the yield of retail cuts decreases. It is expected to have a negative relationship with carcass value. The variable describing fat thickness is grade fat (minimum fat in the last quadrant). Muscle score is an essential element in the Canadian grading system. Using the muscle score and fat class together will determine the estimated lean yield or cutability estimate.

Marbling is usually associated with meat quality. Besides some controversy surrounding marbling, it is believed to be positively associated with palatability. Marbling is an essential factor in the determination of quality grade in the Canadian grading system.

Cutability estimate is used to determine the yield class (A1, A2 and A3). It was included in a different version of the full, intermediate and grading system models. The sex*weight interaction was included to investigate if the effect of weight on carcass price varies by sex. The sex*fat interaction was included for the same reason. Preston and Willis (1970) suggested that joint relationship could also exist between weight and fatness, with fat generally increasing with weight. This joint relationship was also examined. The sex*cutability estimate and weight*cutability estimate interactions were examined in the model where cutability estimate was included. A detailed specification of each variable included in the models is given in Appendix 2.

Procedure

The first stage in comparing the relative explanatory power of the various hedonic price models and determining the price premiums and discounts was to compose the beef carcass value. The beef carcass value per pound was calculated by taking the weights of the wholesale cuts, table trim, fat and bone for each carcass, multiplying by the average market prices for the specific wholesale products and dividing the total carcass value by the carcass weight. A similar approach was used by Hayenga et al (1985) in estimating price premiums and discounts for pork carcasses. The list of cuts used in the carcass value calculation and their respective average prices is shown in Appendix 3.

The following stages were designed, first, to investigate which factors explain the variation in beef carcass values. Second, to examine the effect of variables defining yield and quality grade on beef carcass value and, third to compare the relative explanatory power of models including only grading variables (yield and quality grade variables) with models containing characteristics which are not part of the grading system for beef.

Initially, full hedonic price models for each packing plant using data on all the characteristics observed and three groups of interaction terms (sex and weight, sex and fat and weight and fat) were estimated. The interactions between sex and cutability estimate and weight and cutability estimate were also considered. These full models were used as a basis of comparison with the other models.

In this stage, two variations of the full model are estimated for each packing plant. The difference between the two full models is that in model F1 grade fat (GF) and muscle score (MS) are used to specify yield grade variables. In model F2, these two variables are substituted for cutability estimate (CE), an alternative yield grade variable. These two different models are specified in order to explore the explanatory power of different yield grade variables. Model F1 and model F2 are specified as follows:

Model F1:

$$CP = f\ (\ S,\ WE_j\ ,\ W,\ SY,\ GF,\ MS_k\ ,\ MB_m\ ,\ S*W,\ S*GF,\ W*GF\ ) \tag{4.11}$$

where CP is carcass value in dollar per pounds; WE is the week in which grading occurred (where j=1,2, 3 or 4 for Plant A and j=1 or 2 for Plant B); W is carcass weight in pounds; SY is saleable meat yield in %; GF is grade fat in mm; MS is muscle score (where k=1, 2, 3 or 4); MB is marbling level (where m=1, 2 or 3); S*W is an interaction term between sex and weight; S*GF is an interaction term between sex and grade fat and W*GF is an interaction term between weight and grade fat. A detailed specification of each variable and the subscripts included in the model is given in Appendix 2.

Model F2:

$$CP = f\ (\ S,\ WE_j\ ,\ W,\ SY,\ CE,\ MB_m\ ,\ S*W,\ S*CE,\ W*CE\ ) \tag{4.12}$$

where CE is cutability estimate in %, S*CE is an interaction term between sex and cutability estimate, W*CE is an interaction term between weight and cutability estimate and all other variables as previously defined.

The next stage was to re-estimate these equations excluding the three groups of interaction terms due to the multicollinearity problems they create (see discussion on multicollinearity). Model M1 and M2 are specified as follows:

Model M1:

$$CP = f\ (\ S,\ WE_j\ ,\ W,\ SY,\ GF,\ MS_k\ ,\ MB_m\ ) \tag{4.13}$$

Model M2:

$$CP = f\ (\ S,\ WE_j\ ,\ W,\ SY,\ CE,\ MB_m\ ) \tag{4.14}$$

The following stage was to estimate intermediate models (model I1 and I2) by excluding all variables (and their interactions terms) representing characteristics not included in the current Canadian grading system. The only variable included in these models that is not part of the grading system model is the dummy variable for the week. The reason for keeping this variable is to take account of price variation related to time. Model I1 and I2 are represented as follows:

Model I1:

$$CP = f\ (\ WE_j\ ,\ GF,\ MS_k\ ,\ MB_m\ ) \tag{4.15}$$

Model I2:

$$CP = f\ (\ WE_j\ ,\ CE,\ MB_m\ ) \tag{4.16}$$

Finally, the models including only the characteristics incorporated in the grading system model without any interaction terms (model G1 and G2) were estimated and compared with the full model. The difference between the intermediate models, I1 and I2, and the grading models, G1 and G2, is that in those two last models the variable for the week of grading is also excluded. Models G1 and G2 are indicated bellow:

Model G1:

$$CP = f\ (\ GF,\ MS_k\ ,\ MB_m\ ) \tag{4.17}$$

Model G2:

$$CP = f\,(\,CE,\; MB_m\,) \tag{4.18}$$

After estimating those eight models for each packing plant, the next step was to investigate the contribution of each of the characteristics to the explanatory power of the full, intermediate and grading system models. For this purpose the F-test technique discussed by Judge et al (1985) was used to test whether a characteristic or group of characteristics had a significant effect on price. To determine whether or not the above characteristics were important explanators of carcass prices, F-tests were utilized to compare the "complete" model against the restriction that a variable or group of variables were significant. A misspecification test for each model, called the RESET test, plus heteroskedasticity and autocorrelation tests were also carried out.

The final stage was to estimate premiums and discounts associated with each characteristic and with different levels of each characteristic compared with a base level for the characteristic. The full model M1 (excluding interaction terms) was chosen as the one to be analyzed in term of price premiums and discounts.

Multicollinearity Problems

In this statistical analysis, special attention is given to the multicollinearity problems. One basic assumption of the classical normal linear regression model is that none of the explanatory variables be perfectly correlated with any other explanatory variable or with any linear combination of other explanatory variables (Kmenta, 1986). Multicollinearity refers to the violation of this basic assumption.

Two major practical problems are associated with a high degree of multicollinearity. First is the effect of multicollinearity on regression coefficients. If multicollinearity exists, it is difficult to measure the separate (net) effect of one explanatory variable because the OLS (Ordinary Least Square) estimate of that effect will reflect that variable's relationship with the other explanatory variable. Second, the effect of multicollinearity is to increase the variance estimates. This leads to what is usually mentioned as instability of the regression estimates. If there is correlation among the variables in the sample, it can happen that the coefficient of some variables will be significant in some formulations and not significant in others. It is in this setting that the estimates are said to be "unstable".

Some related studies on hedonics have presented contradicting results in terms of the importance of specific variables as a determinant of carcass and cattle prices. For example, Porter and Todd (1985) recognize strong correlations in their sample. They found that weight was not a significant determinant of price but on the other hand, the weight*fat interaction was significant. It is believed that this may be a result caused by a high degree of multicollinearity between the weight and weight*fat variables.

There are several approaches to detect the presence, severity and form of multicollinearity. Judge et al (1988) indicate some common measures for the severity of multicollinearity: simple correlations among regressors, determinant of $X'X$, variance inflation factors, auxiliary regressions, Theil's multicollinearity effect and matrix decomposition.

The first step adopted in this study trying to discover multicollinearity problems was to determine the extent of the multicollinearity within the data set and to detect what form the dependencies take. This helped to identify which of the regressors are likely to have coefficient estimates which are adversely affected by the collinearities. It also revealed coefficient estimates which are relatively isolated from the collinearity problems and thus likely to be accurate.

Initially, the simple correlation coefficient between pairs of the explanatory variables were investigated. Strong correlation was found between variables such as sex and sex*weight interaction, sex and sex*grade fat interaction, weight and weight*grade fat interaction, sex*cutability estimate interaction and weight*cutability estimate interaction. The econometrics literature points out that comparisons of correlations can be inadequate, specially when more than two explanatory variables are involved (Judge et al, 1988; Kmenta, 1986). For this reason, the matrix decomposition method was also applied. In this method the eigenvalues and condition indices (CIs) of the scale matrix of the explanatory variables, $X'X$, are examined. The ith CI is defined to be

$$\sqrt{\frac{\lambda_1}{\lambda_i}}$$

where λ_1 is the largest eigenvalue, and λ_i is the ith eigenvalue of the normalised $X'X$. Belsley, Kuh and Welsh (1980) conducted several studies were they concluded that if the regressors have been normalized to unit length (but not centered) and if the condition indices are between 30 and 100, then moderate to strong dependencies exist. Severe multicollinearity is indicated by CIs greater than 100. This level of multicollinearity may seriously affect the standard errors of the estimated coefficients.

If the existence of such multicollinearity is indicated by the CIs, the next step is to determine the nature and likely effect of the multicollinearity on the parameter estimates of the model. For high CIs, the presence of high variance proportions for two or more coefficients indicates that a relationship may exist between those variables. A simple rule of thumb is provided by Besley, Kuh and Welsh (1980): estimates are considered to be degraded by multicollinearity when more than 50 per cent of the variance of the two or more coefficients is associated with a single high CI. Analyzing the data set, CIs greater than 300 were detected, with associated high variance proportions for several coefficients. The problem variables were found to be the interaction terms and the sex, weight, grade fat and cutability estimate variables. These were the only variables involved in the collinearities. The other variables coefficient estimates were unaffected by inflated variances and the related instability of the estimates.

Because the presence of multicollinearity results in a loss of precision in the estimates, it is necessary to search for a means of addressing the problem. Unfortunately, there are not many solutions. To obtain a new sample or collect more data may not solve the problem - especially if the relationship is intrinsic as it is in this case. A possible means of coping with the problem of multicollinearity is to eliminate one or more of the disturbing variables. It is important to mention that deleting relevant variables can result in the introduction of bias into the estimates of the coefficients of the variables retained in the equation.

CHAPTER 5. RESULTS AND ANALYSIS

The theoretical and empirical work discussed in chapter two and three, and methodology of chapter four, provided requirements to undertake an analysis of hedonic price models and premiums/discount for beef carcass. The first section of this chapter shows and analyses the overall explanatory power of the various hedonic price models. The second section provides the results and discusses the evaluation of the importance of the various individual characteristics. The last section examines the premiums/discounts associated with each individual characteristic and with different levels of the individual characteristics.

Comparison of the Relative Explanatory Power of the Hedonic Price Models

Table 5.1 presents a comparison of the relative explanatory power of the various hedonic models. Full model F1, incorporating all the characteristics being analyzed, the grade fat and muscle score variables and the three sets of interaction terms, explained between 87 per cent to 93 per cent[4] of the carcass value variation observed at the two packing plants. Excluding the disturbing interaction terms (model M1) did not substantially reduce the explanatory power of the equations for plant A and plant B. Full model M1, explained between 86 per cent to 92 per cent of the carcass value variation at the two packing plants.

Full model F2[5], including all the characteristics being analyzed, the cutability estimate variable and the three sets of interaction terms, explained between 86 per cent

[4]These percentages represent the value of the adjusted R^{2}.

[5]In this model, grade fat and muscle score were replaced by the cutatility estimate representing the yield grade variable.

to 92 per cent of the carcass value variation observed at the two packing plants. Excluding the disturbing interaction terms (model M2) did not substantially reduce the explanatory power of the equations for plant A and plant B. Model M2 explained between 85 per cent to 91 per cent of the carcass value variation observed at the two packing plants.

Table 5.1. Comparison of Hedonic Models

Model	Statistics	Plant A	Plant B
Model F1 full model, including interactions	R^2 R^2 (adjusted)	0.8727 0.8652	0.9317 0.9258
Model F2 full model, including interactions	R^2 R^2 (adjusted)	0.8664 0.8602	0.9264 0.9216
Model M1 full model F1, excluding interactions	R^2 R^2 (adjusted)	0.8707 0.8646	0.9289 0.9243
Model M2 full model F2, excluding interactions	R^2 R^2 (adjusted)	0.8645 0.8598	0.9232 0.9128
Model I1 intermediate model, including variable week, GF and MS	R^2 R^2 (adjusted)	0.5980 0.5841	0.6369 0.6208
Model I2 intermediate model, including variable week and CE	R^2 R^2 (adjusted)	0.5310 0.5202	0.5886 0.5783
Model G1 grading system model, including GF and MS	R^2 R^2 (adjusted)	0.4328 0.4199	0.6189 0.6045
Model G2 grading system model, including CE	R^2 R^2 (adjusted)	0.3598 0.3526	0.5784 0.5706

Intermediate Model I1, incorporating the week of grading variables, grade fat, muscle score and marbling, explained between 58 per cent to 62 per cent of the value variation observed at the two packing plants. Comparing models F1 and F2 with model I1 and I2, respectively, a substantial decrease in the explanatory power of those models (I1 and I2) is observed with respect to F1 and F2. Between the two intermediate models, model I1 seems to perform better than model I2 explaining between 58 per cent to 62 per cent of value variation observed at the two packing plants.

Models G1 and G2, incorporating only the variables included in the grading system for beef had the worst performance among all models (full, intermediate and grading system). Model G1, including grade fat, muscle score and marbling explained between 42 per cent to 60 per cent of the value variation observed at the two packing plants. Model G2, including only the cutability estimate and marbling, explained between 35 per cent to 57 per cent of the value variation observed at the two packing plants. Analyzing the two grading system models (G1 and G2), it is again observed that the model including grade fat, muscle score and marbling better explains beef carcass values than the model which includes the cutability estimate and marbling (model G2).

The results from Table 5.1 demonstrate that:

1. The exclusion of the interaction terms from the two full models (compare models M1 and M2 to model F1 and F2) did not have any sizeable effect on the explanatory power of those models.

2. All models estimated for beef packing plant B had higher R^2's than the ones estimated for beef packing plant A.

3. All the models (full, intermediate and grading system) that included grade fat and muscle score as predictors of yield grade had a higher R^2's than the models including cutability estimate as a predictor of yield grade. This is a logical finding because the cutability estimate is in effect a proxy variable summarizing the interaction from grade fat and muscle score, and should lead to somewhat lower R^2 levels as a result.

4. The grading system models (model G1 and G2) did poorly in explaining beef carcass values in both packing plants. This suggests that there is useful information excluded from consideration. Other variables that could be included in the grading system model and potentially improve explanatory power.

Evaluation of the Importance of the Various Individual Characteristics

Tables 5.2 through 5.9 presents the results of F-tests by which the importance of each individual characteristics included in each model was evaluated. A regression specification error test (RESET test), proposed by Ramsey (1969), was conducted to investigate misspecification problems in all individual models and it is also represented in tables 5.2 through 5.9. The RESET test is computed by SHAZAM (pp. 94) by "...running three additional regressions of the dependent variable on the independent variables, and on powers of YHAT (the predicted dependent variable - YHAT2, YHAT3, YHAT4) included in the same regressions. The RESET test is an F test that tests whether the coefficients on the YHAT variables are zero". The insignificance of the Reset(2), Reset(3) and Reset(4) indicate that a specification error has not occurred.

Table 5.2. shows the importance of all characteristics incorporated in the full model F1 (including the interaction terms). Sex was not found to be relevant at both

packing plants. Weight, grade fat[6], the weight*grade fat interaction and week of grading were found to be significant at plant packing plant A and not significant at plant B. The interaction between sex and weight was not found to be significant in both plants. The interaction between sex and grade fat was found to be significant only in plant B. Saleable yield, muscle score and marbling were significant in both packing plants. The collinearities in the data set can be clear seen in plant B results: the F-statistic formed by excluding the broad group of variables (all sex, weight and grade fat) and (all weight, sex and grade fat)[7] was significant, but those formed by excluding any individual set of variables within the broad group was not found to be significant. The insignificant RESET tests suggested that misspecification error was not found in model F1.

[6]Different definitions of weight and grade fat were utilized, including quadratic forms (e.g. weight-squared, fat-squared) but these were not significant.

[7]The F-statistic for (all sex, weight and grade fat) and (all weight, sex and grade fat) is that formed by the joint test whether all the variables of that group are significant explanatory variables.

Table 5.2. Tests of the Significance of Characteristics of Beef Carcass using the Full Model F1, including interactions

Excluded Variable (s)	Plant A	Plant B
Sex	0.28[1]	1.58[1]
Weight	9.62[1]***	0.22[1]
Grade Fat	7.37[1]***	0.26[1]
Sex*Weight	0.32[1]	0.10[1]
Sex*Grade Fat	0.39[1]	5.97[1]**
Weight*Grade Fat	3.81[1]*	0.25[1]
(All sex, weight and grade fat)	2.68[5]**	5.28[5]***
(All weight, sex and grade fat)	16.14[5]***	5.86[5]***
Week of Grading	45.96[3]***	0.76[1]
Saleable Yield	449.28[1]***	578.64[1]***
Muscle Score	12.57[3]***	4.74[3]***
Marbling	10.51[2]***	4.62[2]***
Reset (2)	0.50	0.06
Reset (3)	1.19	0.63
Reset (4)	1.11	0.71
R^2	0.8727	0.9317
R^2 (adjusted)	0.8652	0.9258
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the full model, including interaction terms, are significant explanatory variables.

Table 5.4. demonstrates the importance of the characteristics included in the full model F2[8] (including interaction terms). Sex, weight, sex*weight and weight*cutability estimate were not found to be significant at both plants. The sex*cutability interaction was significant only at plant B. Cutability estimate and week of grading were significant only at plant A. Saleable yield and marbling were found to be significant at both plants. The same multicollinearity problem detected in full model F1 was presented in the results of full model F2.

Table 5.5. demonstrates the importance of the characteristics included in the full model M1 (excluding interaction terms). The reason for estimating regression models excluding the interactions terms was due to the detection of strong levels of multicollinearity in model F1 and F2. The problem of multicollinearity was minimized by excluding the interaction terms for these specific models. Sex was not found to be significant at plant A, but it was significant at plant B. Weight, saleable yield, muscle score and marbling were found to be significant at both packing plants. Grade fat and week of grading were found to be significant at plant A and not significant at plant B. It can be seen from those results that the interaction terms affected the significance of some variables (see sex and weight at plant B) in model F1. The exclusion of the interaction terms did not affect model M1 specification. This is demonstrated by the insignificance of the RESET test.

In this analysis, all disturbing multicollinearity problems were eliminated with the exclusion of the interaction terms (model M1 and M2). In this case, the CIs fell from

[8]The difference between full model F1 and full model F2 is that an alternative grade variable (cutability estimate) is used instead of grade fat and muscle score.

inadequate high values to levels below 20. Table 5.3 presents the assessment of multicollinearity indicated by the CIs.

Table 5.3. Assessement of Multicollinearity Indicated By the CIs

Model	CI Range		Assessment of Multicollinearity
	Plant A	Plant B	
F1	1.00 - 138.08	1.00 - 153.26	Strong
F2	1.00 - 320.63	1.00 - 259.50	Strong
M1	1.00 - 19.00	1.00 - 15.91	Low
M2	1.00 - 17.99	1.00 - 19.98	Low
I1	1.00 - 5.23	1.00 - 5.18	Low
I2	1.00 - 5.47	1.00 - 4.46	Low
G1	1.00 - 4.29	1.00 - 4.57	Low
G2	1.00 - 2.72	1.00 - 2.68	Low

Table 5.4. Tests of the Significance of Characteristics of Beef Carcass using the Full Model F2, including interactions

Excluded Variable (s)	Plant A	Plant B
Sex	2.11[1]	2.54[1]
Weight	1.15[1]	0.99[1]
Cutability estimate	5.85[1]**	0.72[1]
Sex*Weight	0.04[1]	1.05[1]
Sex*Cutability estimate	2.50[1]	6.05[1]**
Weight*Cutability estimate	1.47[1]	0.99[1]
(All sex, weight and cutability estimate)	21.17[5]***	6.08[5]***
(All weight, sex cutability estimate)	21.99[5]***	2.51[5]**
Week of Grading	45.60[3]***	1.69[1]
Saleable Yield	549.85[1]***	622.60[1]***
Marbling	7.54[2]***	4.45[2]**
Reset (2)	0.46	0.12
Reset (3)	2.00	0.61
Reset (4)	1.59	0.48
R^2	0.8664	0.9264
R^2 (adjusted)	0.8602	0.9216
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the full model, including interaction terms, are significant explanatory variables.

Table 5.5. Tests of the Significance of Characteristics of Beef Carcass using the Full Model M1 (full model F1, excluding interactions)

Excluded Variable (s)	Plant A	Plant B
Sex	1.06[1]	6.41[1]**
Weight	14.74[1]***	7.46[1]***
Grade Fat	46.70[1]***	2.52[1]
Week of Grading	45.72[3]***	1.40[1]
Saleable Yield	465.37[1]***	595.94[1]***
Muscle Score	11.59[3]***	4.87[3]***
Marbling	9.86[2]***	3.34[2]**
Reset (2)	0.71	0.002
Reset (3)	1.08	0.51
Reset (4)	0.80	0.64
R^2	0.8707	0.9289
R^2 (adjusted)	0.8646	0.9243
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the full model are significant explanatory variables.

Table 5.6. shows the results of F-tests by which the importance of characteristics included in full model M2 (excluding interaction terms) was evaluated. All characteristics except sex were found to be significant at plant A. Weight and week of grading were not significant at plan B while all the other variables were found to be significant. The results of the F-test for weight at plant A, plus sex and cutability estimate for plant B demonstrate, again, the effect of multicollinearity on model F2 (including the interaction terms). Misspecification of the regression was not a problem in the full model M2 as seen from RESET test results.

Table 5.6. Tests of the Significance of Characteristics of Beef Carcass using the Full Model M2 (full model F2, excluding interactions)

Excluded Variable (s)	Plant A	Plant B
Sex	2.26[1]	11.80[1]***
Weight	6.38[1]***	1.75[1]
Cutability estimate	105.07[1]***	6.82[1]***
Week of Grading	44.80[3]***	2.10[1]
Saleable Yield	574.13[1]***	642.05[1]***
Marbling	7.46[2]***	3.32[2]**
Reset (2)	0.41	0.01
Reset (3)	1.22	0.49
Reset (4)	0.89	0.36
R^2	0.8645	0.9232
R^2 (adjusted)	0.8598	0.9198
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the full model are significant explanatory variables.

Table 5.7 and 5.8 present the results of F-tests evaluated for variables included in these two versions of the intermediate model (models I1 and I2). All variables included in these two models were found to be significant at both plants. The RESET tests carried out, suggested that misspecification was not a problem in model I1. In model I2, some slight misspecification problems are indicated by the values of the RESET tests at plant A and B. This suggests that exclusion of variables begins to lead to specification problems in model I2.

Table 5.7. Tests of the Significance of Characteristics of Beef Carcass using the intermediate model I1

Excluded Variable (s)	Plant A	Plant B
Week of Grading	35.61[3]***	7.82[1]***
Grade Fat	25.17[1]***	41.79[1]***
Muscle Score	29.90[3]***	18.25[3]***
Marbling	17.95[2]***	6.99[2]***
Reset (2)	0.75	0.38
Reset (3)	1.25	0.94
Reset (4)	1.35	0.63
R^2	0.5980	0.6369
R^2 (adjusted)	0.5841	0.6208
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the intermediate model are significant explanatory variables.

Table 5.8. Tests of the Significance of Characteristics of Beef Carcass using the intermediate model I2

Excluded Variable (s)	Plant A	Plant B
Week of Grading	31.99[3]***	3.95[1]**
Cutability Estimate	98.03[1]***	120.22[1]***
Marbling	12.32[2]***	5.32[2]***
Reset (2)	3.43*	0.79
Reset (3)	1.85	2.06
Reset (4)	1.46	2.45*
R^2	0.5310	0.5886
R^2 (adjusted)	0.5202	0.5783
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
NR denotes that the variable was not relevant
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the intermediate model are significant explanatory variables.

Tables 5.9 and 5.10 describe the results of F-tests evaluated for the characteristics included in the grading system model G1 and G2. All variables included in these two models were found to be significant, but misspecification problems, demonstrated by the RESET tests, were also detected, particularly in plant A results.

The misspecification problem detected in the intermediate model I2 and grading system models G1 and G2 have an important effect on the results. First, the omission of relevant variables leads to biased estimators of the regression slopes of the included relevant variables if the omitted relevant variables are correlated with the included variables. Second, the standard tests of significance are not appropriate since these tests require that estimates of the parameters be unbiased. Third, the presence of bias may result in estimated coefficients that are substantially different from what was expected in terms of sign or magnitude. The results of F-tests for the characteristics included in these three models should not be viewed with confidence and although they are included in the price premiums/discount analysis, should be discussed appropriately.

Table 5.9. Tests of the Significance of Characteristics of Beef Carcass using grading system model G1

Excluded Variable (s)	Plant A	Plant B
Grade Fat	28.36[1]***	47.49[1]***
Muscle Score	22.27[3]***	15.58[3]***
Marbling	21.08[2]***	12.41[2]***
Reset (2)	8.85***	0.78
Reset (3)	4.68***	1.69
Reset (4)	3.58**	1.33
R^2	0.4328	0.6189
R^2 (adjusted)	0.4199	0.6045
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the grading system model are significant explanatory variables.

Table 5.10. Tests of the Significance of Characteristics of Beef Carcass using the grading system model G2

Excluded Variable (s)	Plant A	Plant B
Cutability Estimate	89.68[1]***	118.78[1]***
Marbling	16.01[2]***	9.43[2]***
Reset (2)	17.01***	0.87
Reset (3)	8.47***	2.70*
Reset (4)	9.65***	1.90
R^2	0.3598	0.5784
R^2 (adjusted)	0.3526	0.5706
Sample Size	270	166

Number in bracket [] indicates number of excluded variables
*** significant at 1% level
** significant at 5% level
* significant at 10% level

Note: The figures described are F-statistics, constructed by testing the restriction of whether individual variables or subgroups of variables from the grading system model are significant explanatory variables.

Heteroskedasticity was examined by the use of the Breusch-Pagan test indicating no violation of the assumption regarding homoskedasticity. Additionally, first-order autocorrelation was also inspected by the use of the Durbin-Watson test and no significant autocorrelation problem was encountered.

The main conclusions from the analysis of the results of F-tests evaluated for each individual characteristic included in the five models (models F1, F2, M1, M2 and I1)[9] are as follows:

1. Saleable yield, muscle score and marbling were found to be significant in all models including these characteristics.

[9]The results of F-tests for the characteristics included in the intermediate model I2 and grading system models G1 and G2 were not considered in this conclusion.

2. Sex was found to be significant in the full models (excluding interaction terms) M1 and M2 only at plant B.

3. Weight was found to be significant in the full model (including interaction terms) F1 and in the full model M1 and M2 (excluding interaction terms) at plant A. It was also significant in the full model M1 at plant B.

4. Grade fat was found to be significant in all models at plant A and in the intermediate model for plant B.

5. The sex*weight and weight*cutability estimate interaction terms were never found to be significant. The sex*grade fat and sex*cutability estimate interaction terms were found to be significant in full model F1 at plant B. Weight*grade fat was found to be significant in the full model F1 at plant A.

6. The effects of multicollinearity problems were clear in the models including the interaction terms (full model F1 and F2).

7. Misspecification problems were detected in the intermediate model I2 and in the grading system models G1 and G2, indicating that exclusion of explanatory variables led to misspecification in these models.

8. In terms of factors that underlie the Canadian grading system for beef, all factors (grade fat, muscle score, cutability estimate and marbling) were found to be significant.

9. Variables not included in the grading system model seem to be important explanators of beef carcass values. Those variables are weight, saleable yield and the time factor (week of grading). Of course, week of grading reflects general movements in the price level and was primarily used as a control variable.

Price Premiums and Discounts

In order to analyze the price premiums and discounts associated with each individual characteristic and with different levels of the characteristics, full model M1 excluding interactions was selected among the other models. Full results for the other models are presented in tables 5.12 through 5.18, but only discussed in general terms. Table 5.11 gives the estimated premiums and discounts derived from the full model M1 (excluding interactions). The t-statistics for each specific characteristic is also provided. These coefficients are interpreted as the implicit marginal values of a marginal change in the yield of these characteristics. Because the regression equations control for variation in other explanatory variables, these coefficients isolate the impact of each characteristic on carcass values.

The sample's average carcass value at plant A was 1.63 $/lb and at plant B was 1.70 $/lb. The coefficient estimates for categorial variables are interpreted in relation to the reference category. Sex was not found to be a significant explanator of carcass values at plant A while at plant B sex was found to be significant. This result indicates that heifer carcasses should have a premium of 0.0066 $/lb in comparison with steer carcasses. The sign of this coefficient is inconsistent with general expectations and with previous research, which generally held that heifers are discounted. These results suggest that heifers presented a greater average saleable yield than steers after controlling for quality related characteristics. This results are consistent with recent research (Jones at al.,1994 and Matos, Faminow and Richmond, 1994), draw from the same base data but using different methodology.

Table 5.11. Estimated Premiums and Discounts from the Full Model M1 excluding interactions

Variable (s)	Plant A	Plant B
Sex - Male Female	Used as base 0.0026(1.03)	Used as base 0.0066(2.53)***
Week of Grading 1 Week of Grading 2 Week of Grading 3 Week of Grading 4	0.0096(2.55)*** -0.0252(-6.98)*** Used as base -0.0209(-5.99)***	-0.0033(-1.18) Used as base
Weight	-0.0001(-3.83)***	-0.0001(-2.73)***
Saleable Yield	0.0207(21.57)***	0.0216(24.41)***
Grade Fat	-0.0023(-6.83)***	-0.0007(-1.59)*
Muscle Score 1 Muscle Score 2 Muscle Score 3 Muscle Score 4	-0.0143(-4.15)*** -0.0039(-1.26) Used as base 0.0161(3.59)***	-0.0128(-2.72)*** -0.0053(-1.64)* Used as base 0.0076(2.22)**
Marbling Class A Marbling Class AA Marbling Class AAA	Used as base -0.0095(-3.67)*** -0.0125(-3.89)***	Used as base -0.0067(-2.25)** -0.0088(-2.32)**
Constant	0.1336(1.73)	0.1754(2.56)***
Reset (2) Reset (3) Reset (4)	0.71 1.08 0.80	0.002 0.51 0.64
R^2 R^2 (adjusted)	0.8707 0.8646	0.9289 0.9243
Sample Size	270	166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

Weight was included in the model as a continuous variable and was found to be significant at both packing plants. The relationship between weight and carcass value was negative indicating that as weight increases carcass value decreases by 0.0001 $/lb at both plants. Although statistically significant, this discount in value is not substantive from a carcass value point of view.

Saleable meat yield was found to be a highly significant characteristic in explaining carcass value as expected. The results indicate that increasing the saleable meat yield by 1% carcass value would increase by 0.021 $/lb at plant A and B. For an animal with 500 pounds of saleable meat yield this would improve value by $10.50.

The relationship between grade fat[10] and carcass value was negative as expected. Plant A results indicate that increasing the grade fat by 1 mm would decrease the carcass value by 0.0023 $/lb. For example, decreasing grade fat from 14mm to 7mm (considering muscle score constant and equal to 1), which would result in an A2 classification becoming A1, would change carcass value by 0.016 $/lb.

Muscle score was included as a categorial variable. Four muscle score groups were analyzed (muscle score 1,2,3 and 4). Muscle score 3 was arbitrarily chosen as the reference category. The estimate signs seem to be consistent with lower muscle score carcasses having lower values in comparison to higher muscle score carcasses. Plant A results indicate that carcass with muscle score 1 were significantly lower in relation to carcasses with muscle score 3, by about 1.5 cents per pound. Muscle score 2 was not found to be significant and carcasses with muscle score 4 had a higher value (in relation to carcasses with muscle score 3). Plant B results, show that carcasses with muscle score 1 and 2 had a lower value in comparison with carcasses with muscle score 3 (reference

---

[10]Grade fat measures the fat thickness in the loin area (in mm).

category). A high value for carcasses with muscle score 4, by 1 cent per pound was also indicated.

Marbling was found to be significant when included as a categorial variable. It should be emphasized that actual meat prices used in the analysis did not vary by marbling class, so the effect of this characteristic is indirect through its relationship to actual meat yield. Marbling class A (trace marbling) was chosen as the reference category. The results demonstrate that carcasses with higher amount of marbling had lower values in comparison with carcass presenting lower amount of marbling. Plant A results indicate that carcasses classified in the marbling class AA (slight marbling) had values that were lowered by 0.009 $/lb in comparison with carcasses classified in the marbling class A (trace marbling). Carcasses classified in the marbling class AAA[11] (small marbling) were 0.012 $/lb lower. Plant B results demonstrate that carcasses classified in the marbling class AA and AAA were lower in a statistical sense, but not overly substantive. As mentioned before, a study by Jones, Tong and Talbot (1991) indicated that marbling score was significantly related to carcass weight but only explained about 0.5% of the variation in marbling score. Based on that, they concluded that carcass weight would have little significance for the prediction of marbling score. Similar results were found for fat thickness.

Marbling is associated with eating qualities and according to the Canadian grading system classification, grade AAA has the best overall eating quality. Because marbling

[11]Quality grade AAA represents the highest amount of marbling and grade A the lowest amount of marbling.

lowers value these results also provide a guide to quality premium needed to compensate for value loss through cutability.

Some conclusions can be drawn from the examination of the carcass characteristics influencing beef carcass prices at the two packing plants:

1. Comparing the results of the two packing plants, the estimates generally had consistent signs and magnitude.
2. The estimate for grade fat, saleable yield and muscle score had the expected signs.
3. Carcasses with better muscle scores (4) had higher values and poorer muscle scores (1 and 2) lower values as compared with the base level of muscle score (3).
4. In terms of marbling, the results demonstrated that carcasses with higher amount of marbling (AA and AAA) had lower values in comparison with carcass presenting lower amount of marbling (A).
5. Many of the coefficients were statistically significant, but fairly small, indicating that the effects of these individual characteristics were quite often fairly small.

Table 5.11 through 5.17 shows the estimated price premiums and discounts derived from the other models. These results are presented in order to demonstrate robustness and stability of the results. However, problems associated with misspecification and multicollinearity are highlighted through their influence on parameter levels and testing.

Overall, signs and significance testes are very consistent across comparable models. For example, comparing models M1 and M2, where alternate measures for cutability are used, signs and significance levels are identical. Similarly, comparing across specification (M1 to I1 and G1; M2 to I2 and G2) shows similar results. Signs and significance tend to be quite consistent implying that the results are robust. In most cases coefficient values are stable, but some variation does occur.

The effects of multicollinearity on the coefficient estimates can be seen by comparing the results of model F1 with those of model M1 (Table 5.11), and model F2 with model M2. Initially, comparing the results of model F1 with M1, it is observed that sex had a slight change in magnitude but did not change signs. Grade fat had a change in sign at plant B. In terms of magnitude, there was some change in both plants.

Comparing model F2 (Table 5.13) with model M2 (Table 5.14), inconsistency in sign and magnitude for the coefficient for sex is observed at plant B. Weight presented inconsistency in sign at plant A, although it is not significant when positive. Cutability estimate showed inconsistency in sign and a big change in magnitude at plant B. The variables not included as interaction terms (saleable yield, muscle score and marbling) presented consistency in sign and magnitude in all models, meaning there were not affected by multicollinearity problems. It is important to mention that the exclusion of interaction terms was necessary to minimize the multicollinearity problems although these interaction terms can be in fact important.

The effect of misspecification can be noticed by comparing the results of model M2 (Table 5.14) with I2 (Table 5.16) and G2 (Table 5.18) and the results of G1 with M1. The coefficient of cutability estimate had a substantial change in magnitude from model M2 to model I2, particularly at plant B. Week of grading coefficients changed in sign and magnitude at plant B. Comparing the coefficients of model M2 and G2, it is observed some change in magnitude. Comparing the coefficients of the marbling class variables of model G1 and M1, changes in magnitude are also detected.

Table 5.12. Estimated Premiums and Discounts from the Full Model F1, including interactions

Excluded Variable (s)	Plant A	Plant B
Sex - Male Female	Used as base 0.0120(0.53)	Used as base 0.0303(1.25)
Weight	-0.0001(-3.10)***	-0.00002(-0.47)
Grade Fat	-0.0083(-2.71)***	0.0018(0.51)
Sex*Weight	-0.00002(-0.57)	-0.00001(-0.32)
Sex*Grade Fat	0.0004(0.62)	-0.0016(2.44)***
Weight*Grade Fat	0.000008(1.95)**	-0.000002(-0.50)
Week of Grading 1 Week of Grading 2 Week of Grading 3 Week of Grading 4	0.0101(2.68)*** -0.0248(-6.80)*** Used as base -0.0211(-6.02)***	-0.0025(-0.87) Used as base
Saleable Yield	0.0204(21.19)***	0.0213(24.05)***
Muscle Score 1 Muscle Score 2 Muscle Score 3 Muscle Score 4	-0.0149(-4.30)*** -0.0052(-1.64)*** Used as base 0.0177(3.82)***	-0.0132(-2.77)*** -0.0044(-1.39)* Used as base 0.0071(2.08)**
Marbling Class A Marbling Class AA Marbling Class AAA	Used as base -0.0098(-3.80)*** -0.0129(-4.01)***	Used as base -0.0082(-2.74)*** -0.0101(-2.64)***
Constant	0.2034(2.36)***	0.1623(2.09)**
Reset (2) Reset (3) Reset (4) R^2 R^2 (adjusted) Sample Size	0.50 1.19 1.11 0.8727 0.8652 270	0.06 0.63 0.71 0.9317 0.9258 166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

Table 5.13. Estimated Premiums and Discounts from the Full Model F2, including interactions

Excluded Variable (s)	Plant A	Plant B
Sex - Male Female	Used as base 0.0675(1.45)	Used as base -0.0736(-1.59)*
Weight	0.0003(1.07)	-0.00030(-0.99)
Cutability Estimate	0.0090(2.41)***	-0.0034(0.85)
Sex*Weight	0.000006(0.21)	-0.00003(-1.02)
Sex*Cutability Estimate	-0.0011(-1.58)*	0.0018(2.45)***
Weight*Cutability Estimate	-0.000006(-1.21)	0.000005(0.99)
Week of Grading 1 Week of Grading 2 Week of Grading 3 Week of Grading 4	0.01122(2.90)*** -0.0248(-6.71)*** Used as base -0.0200(-5.68)***	-0.0032(-1.08) Used as base
Saleable Yield	0.0216(23.44)***	0.0221(24.95)***
Marbling Class A Marbling Class AA Marbling Class AAA	Used as base -0.0085(-3.28)*** -0.0107(-3.31)***	Used as base -0.0082(-2.66)*** -0.0103(-2.63)***
Constant	-0.5103(-2.31)**	0.2815(1.19)
Reset (2) Reset (3) Reset (4) R^2 R^2 (adjusted) Sample Size	0.46 2.00 1.59 0.8664 0.8602 270	0.12 0.61 0.48 0.9264 0.9216 166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

Table 5.14. Estimated Premiums and Discounts from the Full Model M2, excluding interactions

Excluded Variable (s)	Plant A	Plant B
Sex - Male Female	Used as base 0.0038(1.05)	Used as base 0.0087(3.43)***
Weight	-0.00004(-2.53)***	-0.00002(-1.32)*
Cutability Estimate	0.0039(10.25)***	0.1350(2.61)***
Week of Grading 1 Week of Grading 2 Week of Grading 3 Week of Grading 4	0.01137(2.96)*** -0.0242(-6.64)*** Used as base -0.0196(-5.57)***	-0.0042(-1.45)* used as base
Saleable Yield	0.0218(23.96)***	0.0224(25.33)***
Marbling Class A Marbling Class AA Marbling Class AAA	Used as base -0.0084(-3.28)*** -0.0106(-3.27)***	Used as base -0.0067(-2.18)*** -0.0092(-2.37)***
Constant	-0.2345(-3.50)***	0.0008(0.0016)
Reset (2) Reset (3) Reset (4) R^2 R^2 (adjusted) Sample Size	0.41 1.22 0.89 0.8645 0.8598 270	0.01 0.49 0.36 0.9232 0.9198 166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

Table 5.15 Estimated Premiums and Discounts from the Intermediate Model II

Excluded Variable (s)	Plant A	Plant B
Grade Fat	-0.0028(-5.01)***	-0.0053(-6.46)***
Week of Grading 1	0.0100(1.52)*	0.0163(2.79)***
Week of Grading 2	-0.0324(-5.62)***	Used as base
Week of Grading 3	Used as base	
Week of Grading 4	-0.0408(-6.90)***	
Muscle Score 1	-0.0348(-6.71)***	-0.0382(-4.79)***
Muscle Score 2	-0.0127(-2.43)***	-0.0186(-2.74)***
Muscle Score 3	Used as base	Used as base
Muscle Score 4	0.0281(3.71)***	0.0275(3.26)***
Marbling Class A	Used as base	Used as base
Marbling Class AA	-0.0214(-4.88)***	-0.0205(-3.23)***
Marbling Class AAA	-0.0286(-5.21)***	-0.0275(-3.31)***
Constant	1.7054(223.64)***	1.7681(180.37)
Reset (2)	0.07	0.38
Reset (3)	1.25	0.94
Reset (4)	1.35	0.63
R^2	0.5980	0.6369
R^2 (adjusted)	0.5841	0.6208
Sample Size	270	166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

Table 5.16. Estimated Premiums and Discounts from the Intermediate Model I2

Excluded Variable (s)	Plant A	Plant B
Cutability Estimate	0.0067(9.90)***	0.0097(10.96)***
Week of Grading 1	0.01380(1.95)**	0.0119(1.98)**
Week of Grading 2	-0.0291(-4.71)***	Used as base
Week of Grading 3	Used as base	
Week of Grading 4	-0.0400(-6.31)***	
Marbling Class A	Used as base	Used as base
Marbling Class AA	-0.0196(-4.19)***	-0.0173(-2.57)***
Marbling Class AAA	-0.0244(-4.17)***	-0.0266(-3.07)***
Constant	1.2704(31.63)***	1.1362(21.03)***
Reset (2)	3.43*	0.78
Reset (3)	1.85	2.06
Reset (4)	1.46	2.45*
R^2	0.5310	0.5886
R^2 (adjusted)	0.5202	0.5783
Sample Size	270	166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

Table 5.17. Estimated Premiums and Discounts from the Grading System Model G1

Excluded Variable (s)	Plant A	Plant B
Grade Fat	-0.0035(-5.32)***	-0.0057(-6.89)***
Muscle Score 1	-0.0344(-5.63)***	-0.0349(-4.33)***
Muscle Score 2	-0.0134(-2.16)**	-0.0157(-2.30)***
Muscle Score 3	Used as base	Used as base
Muscle Score 4	0.0304(3.41)***	0.0230(3.07)***
Marbling Class A	Used as base	Used as base
Marbling Class AA	-0.0255(-4.98)***	-0.0262(-4.27)***
Marbling Class AAA	-0.0375(-5.86)***	-0.0346(-4.30)***
Constant	1.6932(227.36)***	1.7833(214.11)***
Reset (2)	8.85***	0.78
Reset (3)	4.67***	1.69
Reset (4)	3.37***	1.33
R^2	0.4328	0.6189
R^2 (adjusted)	0.4199	0.6045
Sample Size	270	166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

Table 5.18. Estimated Premiums and Discounts from the Grading System Model G2

Excluded Variable (s)	Plant A	Plant B
Cutability Estimate	0.0073(9.47)***	0.0098(10.89)***
Marbling Class A	Used as base	Used as base
Marbling Class AA	-0.0237(-4.41)***	-0.0220(-3.45)***
Marbling Class AAA	-0.0339(-5.05)***	-0.0325(-3.96)***
Constant	1.2142(26.30)***	1.1440(21.04)***
Reset (2)	17.01***	0.87
Reset (3)	8.47***	2.70*
Reset (4)	9.65***	1.90
R^2	0.3598	0.5784
R^2 (adjusted)	0.3526	0.5706
Sample Size	270	166

*** significant at 1% level
** significant at 5% level
* significant at 10% level
t-statistics shown in brackets

CHAPTER 6. SUMMARY AND CONCLUSIONS

This last chapter summarizes the research, provides the major conclusions, discusses the limitations and addresses some recommendations for further study.

Summary and Results

The objectives of this study were to review the development of the beef carcass grading system in Canada, discuss the actual grading system, evaluate beef carcass value focusing on the factors considered in the Canadian beef carcass grading system and evaluate the effects of each individual beef carcass characteristic on carcass value.

Chapter one presented the underlying problem of this research, addressed the objectives mentioned above and provided the thesis outline.

Chapter two addressed the theory behind standardization and grading. The objectives and economic function of a grading system were discussed along with several aspects associated with the benefits and costs from grading. The importance of grades as an indicator of quality to consumers was also examined. Special attention was given to the marketing of beef where information prior to purchase may be very meaningful to consumers. The relationship between grading, quality and price was considered and some studies examining this issue were also reviewed. Most of the studies examined investigated price differences associated with cattle characteristics and quality. A few studies evaluating carcass characteristics were reviewed as well.

Chapter three investigated several quality factors affecting carcass grading and value. The aspect of dressing percentage and factors affecting dressing percentage were discussed in this chapter. Carcass attributes used as predictors of quality grade in the

Canadian grading system were examined. These attributes were marbling, maturity, meat and fat color, firmness and texture. Factors influencing the commercial value of beef carcasses such as weight, proportion of the main tissues (muscle, fat and bone), distribution of these tissues through the carcass, muscle thickness, chemical composition, breed type, sex, muscling and meat yield were discussed. Methods for evaluation of carcass composition and the most important elements of beef quality were examined as well. Chapter three was finalized by reviewing the recent changes in the Canadian beef carcass grading system.

In chapter four, the theory underlying hedonic price analysis is discussed. The data, data source and procedure were presented.The potentially important characteristics included in the analysis and multicollinearity problems were also discussed. The various hedonic price models estimated in this study were presented. Special attention was given to multicollinearity because of its effects on the coefficient estimates.

Results and analysis of eight hedonic price models estimated for each packing plants were presented in chapter five. Initially, the overall explanatory power of the various hedonic price models were investigated. This was followed by an evaluation of the importance of each individual carcass characteristic. Price premiums and discounts associated with each individual characteristics and with different levels of the individual characteristics were examined.

Principle empirical results are:

1. The exclusion of the interaction terms from the two full models (compare models M1 and M2 to model F1 and F2) did not have any sizeable effect on the explanatory power of those models.

2. All models estimated for beef packing plant B had higher R^2's than the ones estimated for beef packing plant A.

3. All the models (full, intermediate and grading system) that included grade fat and muscle score as predictors of yield grade had a higher R^2's than the models including cutability estimate as a predictor of yield grade. This is a logical finding because the cutability estimate is in effect a proxy variable summarizing the interaction from grade fat and muscle score, and should lead to somewhat lower R^2 levels as a result.

4. The grading system models (model G1 and G2) did poorly in explaining beef carcass values in both packing plants. This suggests that there is useful information excluded from consideration. Other variables that could be included in the grading system model and potentially improve explanatory power.

5. Saleable yield, muscle score and marbling were found to be significant in all models including these characteristics.

6. Sex was found to be significant in the full models (excluding interaction terms) M1 and M2 only at plant B. Heifers had higher carcass values when compared with steers.

7. Weight was found to be significant in the full model (including interaction terms) F1 and in the full model M1 and M2 (excluding interaction terms) at plant A. It was also significant in the full model M1 at plant B.

8. Grade fat was found to be significant in all models at plant A and in the intermediate model for plant B.

9. The sex*weight and weight*cutability estimate interaction terms were never found to be significant. The sex*grade fat and sex*cutability estimate interaction terms were found to be significant in full model F1 at plant B. Weight*grade fat was found to be significant in the full model F1 at plant A.

10. The effects of multicollinearity problems were clear in the models including the interaction terms (full model F1 and F2).

11. Misspecification problems were detected in the intermediate model I2 and in the grading system models G1 and G2, indicating that exclusion of explanatory variables led to misspecification in these models.

12. In terms of factors that underlie the Canadian grading system for beef, all factors (grade fat, muscle score, cutability estimate and marbling) were found to be significant.

13. Variables not included in the grading system model seem to be important explanators of beef carcass values. Those variables are weight, saleable yield and the time factor (week of grading). Of course, week of grading reflects general movements in the price level and was primarily used as a control variable.

14. Comparing the results of the two packing plants, the estimates generally had consistent signs and magnitude.

15. The estimate for grade fat, saleable yield and muscle score had the expected signs.

16. Carcasses with better muscle scores (4) had higher values and poorer muscle scores (1 and 2) lower values as compared with the base level of muscle score (3).

17. In terms of marbling, the results demonstrated that carcasses with higher amount of marbling (AA and AAA) had lower values in comparison with carcass presenting lower amount of marbling (A).

18. Many of the coefficients were statistically significant, but fairly small, indicating that the effects of these individual characteristics were quite often fairly small.

Conclusions

In Canada, most beef cattle are marketed on a liveweight basis meaning that packers purchase live animals using rules of thumb that reflect basic value characteristics. As a result cattle are priced according to average premiums and discounts for quality characteristics. There can be a substantial range in quality from one carcass to another. Value differences can be associated with cutability and quality differences. This kind of pricing system reduces the incentive for producers to supply carcasses demanded by consumer preferences. The pricing system could be more effective if producers were paid according to the composition of the carcass they supply.

The purpose of beef carcass grading is to provide an estimate of both meat yield and quality so that a settlement price between producer and beef packer can be determined. Because most cattle are purchased by packers on a liveweight basis, buyers must attempt to estimate the ultimate yield and quality of the carcass on the basis of assessing live animals. This introduces errors and pricing values must be based on averages. In addition the results of this study indicated that the variables included in the grading system did poorly in explaining beef carcass values. This implies that there is useful information excluded from consideration and that more effective representation of carcass value is possible.

The saleable meat yield variable was found to be an important explanator of carcass value and its inclusion in the grading system would well justified. However, the grading variables (grade fat, muscle score and cutability estimate), used to predicted the percentage of trimmed, boneless retail cuts did not explain beef carcass values by themselves. This indicates that those variables are not predicting saleable meat yield appropriately.

The implications of misspecification in equation used for valuing carcass is that a carcass with high actual value will have a tendency to be undervalued, and carcasses with low actual carcass value will have a tendency to be overvalued if the price is paid based on inappropriate yield estimates. This bias will be also reflected in the value attached to animals that produce the carcasses.

In terms of quality factors, the results demonstrated that carcasses with higher amount of marbling had lower values in comparison with carcasses presenting lower amount of marbling. Because the actual meat prices used in the analysis did not vary by marbling class, there must be some relationship between marbling and actual meat yield underlying this finding. Unless quality premiums are paid for more highly marbled beef, the lower meat yield on highly marbled beef acts as a discounting mechanism. Some previous studies have results different from the data reported here, suggesting that marbling is not always directly related to the amount of external fat, so lean carcasses can have AAA marbling while over-fat carcasses can have very little. These studies suggest that this is explained by genetic differences.

A more efficient grading procedure could be adopted by considering the value of all products from the carcass and establishing a framework for determining premiums and discounts that includes use of the packer's own carcass data and prices.

Limitations and Recommendations for Further Studies

The carcass characteristics analyzed in this study was limited to the data available. Only beef carcasses that were graded Canada A, AA and AAA were included in this study. As a result of that, only one quality characteristic (marbling) and yield grade were included in this analysis.

Even considering that these top grades accounted for 87 per cent of the carcasses graded in Canada in 1992, further studies should also include carcasses graded Canada B, D and E. The reason for investigating these lower grades is that other characteristics such as maturity, muscle color and fat color could be also examined. Including this other variables a more complete investigation of the Canadian grading system in terms of carcass value would be done.

Another limitation is related to the fact that the results originated from this study were estimated from data produced in two packing plants at two specific points in time. The implication of this is that the results could be unusual.

The dependent variable, carcass price in dollars per pound, was calculated by taking the weights of the wholesale cuts, table trim, fat and bone, multiplying by the weekly average price for the specific wholesale products and dividing the total carcass value by the carcass weight. The element price was limited to a weekly average basis. This may incorporate some bias in carcass value calculations and, hence, in the estimated premiums and discounts. In particular, including by-product fat and bone value in the calculation of the dependent variable may be viewed as problematic by some industry members.

The carcass value differences in this study do not reflect differences in slaughtering-processing costs. A component-based pricing system for beef cattle could be developed incorporating individual slaughtering-processing costs plus accurate "drop values" in the study. The procedure utilized in this study could be used by any beef packer to establish the value differences for various type of carcasses and live animals. This component-based value system could provide more pricing precision than the standard liveweight purchase system adopted by most beef packers.

REFERENCES

Bendall, J. R., C. C. Ketteridge and A. R. George, (1976). "The Electrical Stimulation of Beef Carcass". ***Journal of Science and Food Agriculture***. 27:1123-1131.

Berg, R. T. and R. M. Butterfield, (1976). ***New concepts of Cattle Growth***. Sidney University Press.

Belsley, Kuh an Welsh, (1980). **Regression Diagnotics**. Wiley, New York.

Bockstael, Nancy, (1984). "The Welfare Implications of Minimum Quality Standards". ***American Journal of Agricultural Economics***. 467-471.

Boggs, D. L. and R. A. Merkel, (1979). ***Live Animal Carcass Evaluation and Selection Manual***. Kendall-Hunt Publishing Co., Dubuque. 69-79.

Bouton, P. E., F. D. Carrol, A. L. Fisher, P. V. Harris and W. R. Shorthose, (1973). "Effect of Altering Ultimate pH on Bovine Muscle Tenderness". ***Journal of Food Science***. 38:816-820.

Branson, R. E., H. Russel Cross, Jeff W. Savell, Gary C. Smith, and Richard A. Edwards, (1986). "Marketing Implications from the National Consumer Beef Study". ***Western Journal of Agricultural Economics***. 82-91.

Buccola, Steven T., (1980). "An Approach to the Analysis of Feeder Cattle Price Differentials. ***American Journal of Agricultural Economics***. 62: 574-80.

Capps, O. Jr., D. S. Moen and R. E. Branson, (1988). "Consumer Characteristics Associated with Selection of Lean Meat Products". ***Agribusiness***. 549-57.

Considine, J. J., W. A. Kerr, G. R. Smith and S. M. Ulmer, (1986). "The Impact of a New Grading System on the Beef Cattle Industry: The Case of Canada". ***Western Journal of Agricultural Economics***. Dec., vol. 11 (2), 184-194.

Cox, L. J., B. S. McMullen and P. V. Garrod, (1990). "An Analysis of the Use of Grades and Housebrand Labels in the Retail Beef Market". ***Western Journal of Agricultural Economics***. 245-253.

Cross, H. R. and A. D. Whittaker, (1992). "The Role of Instrument Grading in a Beef Value-Based Marketing System". ***Journal of Animal Science***. March, vol. 70 (3), 984-989.

Department of Agriculture, Canada, (1992). Livestock Carcass Grading Regulations. p. 3821-3853.

Dikeman, M. E., (1987). "Fat reduction in animals and the Effects on Palatability and Consumer Acceptance of Meat Products". Proc. Recip. Meat Conf, 40:93-102.

Dolezal, H. G.; D. R. Gill and L. D. Yates, (1991) ***Value-Based Marketing:Impact of Beef Carcass Quality and Cutability***. Animal Science, Oklahoma State University.

Faminow, M. D. and Russell L. Gum, (1986). "Feeder Cattle price Differentials in Arizona Auction Markets". ***Western Journal of Agricultural Economics***. 11(2), 156-163.

Gorman, W. M., (1956). "A Possible Procedure for Analyzing quality Differentials in the Egg Market". **Review of Economic Studies**. 843-56.

Griliches, Zvi, (1971). Price Indexes and Quality Change: Studies in New Methods of Measurement. Cambridge, Massachusetts: Harvard University Press.

Hayenga, M. L., B. S. Grisdale, R. G. Kauffman, H. R. Cross, and L. L. Christian, (1985). "A Carcass Merit Pricing System for the Pork Industry". ***American Journal of Agricultural Economics***. May, 315-319.

Henderson-Perry, S. C., L.R. Corah, and R. C. Perry, (1989). "The Use of Ultrasound in Cattle to Estimate Subcutaneous Fat Thickness and Ribeye Area". ***Journal of Animal Science***. 67: 433.

Houthakker, H., (1951). "Compensated Changes in Quantities and Qualities Consumed". **Review of Economic Studies**. 155-64.

Jeremiah, L.E., G. C. Smith and J.K. Hillers, (1970). "Utilization of breed and Traits Determined from the Live Beef Steer for Prediction of Marbling Score". ***Journal of Animal Science***. 31: 1089.

Jeremiah, L.E., A. K. W. Tong, S. D. M. Jones and C. McDonell, (1992). "Consumer Acceptance of Beef with Different Levels of Marbling".***Journal Consumer Studies and Home Economics***. December, 375-387.

Jesse, E. V. and A. C. Johnson, Jr., (1981). "Effectiveness of Federal Marketing Orders for Fruits an Vegetables". Washington DC: U.S. Department of Agriculture, ESS AGR. Econ. REp. NO. 471.

Jones, S. D. M., (1992). A Comparison of Red Meat Grading System in Canada and the United States: Factors Influencing Competitiveness. Manitoba Red Meat Forum.

Jones, S. D. M., A. K. W. Tong and S. M. Robertson, (1987). "The Effects of Carcass Grade and Sex on the Lean Content of Beef Carcasses".***Canadian Journal of Animal Science***. March, vol. 67, 205-208.

Jones, S. D. M., A. K. W.Tong and S. Talbot, (1991). "A Survey of Marbling Fat in Canadian Beef Carcasses". ***Canadian Journal of Animal Science***. December vol. 71(1), 987-991.

Jones, S. D. M., (1989). "Future Trends in the Red Meat Processing - An Overview. ***Canadian Journal of Animal Science***. March, 69: 1-5.

Jones, S. D. M. et al.,(1994). "The National Beef Carcass Cut Out Study". Technical Report. Agriculture Canada, Lacombe Station.

Judge et al, (1985). ***The Theory and Practice of Econometrics.*** Wiley Series in Probability and Mathematical Statistics, second edition.

Judge at al, (1988). ***Introduction to the Theory and Practice of Econometrics.*** John Wiley & Sons, second edition.

Kaufman, P. R., and C. R. Burbee, (1984). "Beef: Graded and Ungraded in the Meat Counter". ***National Food Review***, NFR - 27:3-5, Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture.

Kempster, A. J., (1992). ***Carcass Characteristics and Quality***. World Animal Science, Beef Cattle Production. Chapter 8, 169-187.

Kempster, A. J., (1989). " Carcass and Meat Quality Research to Meet Markets Needs". ***Animal Production***. 48: 483-496.

Kempster, A. J., (1981). " Fat Partition and Distribution in the Carcass of Cattle, Sheep and Pigs: A Review". ***Meat Science***. 5: 83-98.

Kenney, M. C., (1984). "Commodity Grades Help Consumers". National Food Review, Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture, 1-2.

Kmenta, Jan, (1986). ***Elements of Econometrics***. Macmillan Publishing Company, second edition.

Kilmer, R. L. and W. J. Armbruster, (1987). **Economic Efficiency in Agricultural and Food Marketing**. Iowa State University Press/Ames.

Kohls, R. L. and J. N. Uhl, (1985). ***Marketing of Agricultural Products***. Sixth Edition, McMillan Publisher.

Koohmaraie, M., S. C. Seideman and J.D. Crouse, (1988). " Effect of Subcutaneous Fat and High Temperature Conditioning on Bovine Meat Tenderness". ***Meat Science***, 23:99-109.

Ladd, G. W. and Marvin B. Martin, (1976). "Prices and Demand for Input Characteristics". ***American Journal of Agricultural Economics***. 58: 21-30.

Lancaster, K. J., (1966). "A New Approach to Consumer Theory". ***Journal of Political Economy***. 132-57.

Lancaster, K. J., (1971). ***Consumer Demand. A New Approach***. N.Y.:Columbia University Press.

Lancaster, K. J., (1991). ***Modern Consumer Theory***. N.Y.: Columbia University.

Lucas, R. E., (1975). "Hedonic Price Functions". **Economic Inquiry**, 13(157-78).

Marsh, B. B. and N.G. Lee, (1966). " Studies in Meat Tenderness." ***Journal of Food Science***. 31:450-459.

Martin, E. L., (1983). "Measuring Beef Quality". ***The Feedlot***. 237-257.

Matos, M., M. D. Faminow and R. J. Richmond, (1994)."Meat and Live Animal Value Variations". Technical Report. Department of Agricultural Economics, University of Manitoba.

McCoy, J. H. and M. E. Sarhan, (1988). ***Livestock and Meat Marketing***. Third Edition.

McDonell, C., (1990). "Meeting the Consumer's Requirements for Beef Quality". Proceeding of the Beef Improvement Federation, Hamilton, Ontario.

Park, B. and A. D. Whittaker, (1990). "Ultrasonic Frequency Analysis for Beef Quality Grading". ***American Society of Agricultural Engineers.***

Porter, D. and M. Todd, (1985). "The Effect of Carcass Quality on Beef Carcass Auction Prices". ***Australian Journal of Agricultural Economics***. Dec., vol. 29 (3), 225-231.

Purcell, W.D. and K. E. Nelson, (1976). "Recent Changes in Beef Grades: Issues and Analysis of the Yield Grade Requirement". ***American Journal of Agricultural Economics***. August, vol. 58, 475-483.

Purcell, W.D. and Teresa Altizer, (1988). **Key Issues in Livestock Pricing: A Perspective for the 1990s**. Blacksburg Virginia: Research Institute on Livestock Pricing.

Purcell, Wayne D., (1990). "Economics of Consolidation in the Beef Sector: Research Challenges". ***American Journal of Agricultural Economics***. 1210-1218.

Ramsey, J. B.,(1969). "Tests for Specification Errors in Classical Linear Least-squares Regression Analysis". ***Journal of the Royal Statistical Society***. Series B, pp. 350-371.

Recio, H. A., J.W. Savell, H. R. Cross, and M. J. Harris, (1986). "Use of Real-time ultrasound for Predicting Beef Cutability". ***Journal of Animal Science***. 63: 260 (Abstr.).

Reilling, B. A., G. H. Rouse and D. A. Duello, (1992). "Predicting Percentage of Retail Yield from Carcass Measurements, the Yield Grading Equation, and Closely Trimmed, Boxed Beef Weights". ***Journal of Animal Science***. 2151-2158.

Richmond, B., (1994). "Targeting Production for Future Beef Market Demands". Animal Industry Branch, Manitoba Agriculture. Unpublished.

Riley, J., (1983). "A Look at Ways to Handle Pregnancy in the Feedlot". ***BEEF***, April.

Rhodes, J. V., (1987). ***The Agricultural Marketing System***. John Wiley and Sons Third Edition.

Robelin J. and N.M. Tulloh, (1992). "Patterns of Growth of Cattle". ***Beef Cattle Production. World Animal Science***. 111-129.

Schroeder, T. James Mintert, Frank Brazle, and Orlen Grunewald, (1988). "Factors Affecting Feeder Cattle Price Differentials". ***Western Journal of Agricultural Economics***. 13(1), 71-81.

Schultz, R. W. and John M. Marsh, (1985). " Steer and Heifer Price Differences in The Live Cattle and Carcass Markets". ***Western Journal of Agricultural Economics***. 10(1), 77-92.

Simmons, P., (1980). "Determination of Grade Prices for Wool". ***Review of Marketing and Agricultural Economics***. April, vol. 48, 37-46.

Stigler, G.J, (1961). "The Economics of Information". ***Journal of Political Economics***. 69:213-25.

Tatum, D., (1981). "Is Tenderness Nutritionally Controlled?". Proc. Recip. Meat Conf., 34:65-67.

Todd, M.C. and M.D. Cowell, (1981). "Within-Sale price Variation at Cattle and Carcass Auctions". ***Australian Journal of Agricultural Economics***. 30-47.

Tomek, W. G. and K. L. Robinson, (1981). ***Agricultural Product Prices***. Cornell University Press.

Tronstad, Russel, Lori Stephens Huthoefer, and Eric Monke, (1992). "Market Windows and Hedonic Price Analyses: An Application to the Apple Industry". ***Journal of Agricultural and Resource Economics***. 17(2): 314-322.

US Food and Nutrition Board, Institute of Medicine, National Academy of Science, (1990). ***Cattle inspection***. Washington, D. C.

Wassenberg, R.L., D. M. Allen and K. E. Kemp, (1986). "Video Image Analysis Prediction of Total Kilograms and Percent Primal Lean and Fat Yield of Beef Carcasses". ***Journal of Animal Science***. 62:1609-1616.

Waugh, F. V., (1928). "Quality Factors Influencing Vegetable Prices." ***Journal of Farm Economics***. 10:185-96.

White, K. J., S. A. Haun, N. G. Horsman and S. D. Wong, (1990). ***Shazam Econometrics Computer Program, User's Reference Manual***, Ver. 6.2, McGraw-Hill, New York

Wilkes, D., (1991). " The Future of Beef Quality Grading". ***Animal Agricultural Update Newsly***. College park, Md.: Cooperative Extension Service, University of Maryland, 13-16.

Williams, Christine H., John Rolfe and John W. Longworth, (1993). "Does Muscle Matter? An Economic Evaluation of Live Cattle Characteristics". ***Review of Marketing and Agricultural Economics.*** Vol. 61, No. 2, August, 169-189.

APPENDIX 1. CANADIAN BEEF CARCASS GRADING SYSTEM

Extract
Canada Gazette, Part II
October 7, 1992

Extrait
Gazette du Canada, Partie II
Le 7 octobre 1992

DEPARTMENT OF AGRICULTURE

MINISTÈRE DE L'AGRICULTURE

Livestock Carcass Grading Regulations

Règlement sur la classification des carcasses de bétail

QUEEN'S PRINTER FOR CANADA, OTTAWA, 1992

IMPRIMEUR DE LA REINE POUR LE CANADA, OTTAWA, 1992

ANNEXE III

(*paragraphe 22(2) et article 23*)

TABLEAU DES INDICES POUR LA CATÉGORIE CANADA INDICE

	Colonne I	Colonne II	Colonne III	Colonne IV	Colonne V	Colonne VI	Colonne VII	Colonne VIII	Colonne IX	Colonne X
		Poids de la carcasse								
Article	Catégorie de rendement	40 à 64,99 kg	65 à 69,99 kg	70 à 74,99 kg	75 à 79,99 kg	80 à 84,99 kg	85 à 89,99 kg	90 à 94,99 kg	95 à 99,99 kg	100 kg ou plus
1.	1	80	100	110	114	114	112	107	101	81
2.	2	80	96	107	112	112	110	104	97	81
3.	3	80	92	104	109	109	108	100	93	81
4.	4	80	88	102	107	107	105	96	89	81
5.	5	80	85	100	104	104	101	92	82	81
6.	6	80	83	96	100	100	97	88	82	81
7.	7	80	82	90	96	96	94	82	82	81

SCHEDULE IV
(*Section 26*)

BACKFAT LEVEL REQUIREMENTS FOR CANADA SOW GRADES

	Column I	Column II
Item	Grade	Required Backfat Level as Determined by Yield Ruler (mm)
1.	Canada Sow 1	18.9 or less
2.	Canada Sow 2	19.0 to 29.9
3.	Canada Sow 3	30.0 to 47.9
4.	Canada Sow 4	48.0 to 63.9
5.	Canada Sow 5	64.0 to 79.9
6.	Canada Sow 6	80.0 or more

PART III

GRADE NAMES AND GRADE STANDARDS FOR BEEF CARCASSES

General

29. There shall be 12 grades of beef carcasses with the grade names Canada A, Canada AA, Canada AAA, Canada B1, Canada B2, Canada B3, Canada B4, Canada D1, Canada D2, Canada D3, Canada D4 and Canada E.

30. (1) Subject to subsection (2), a grader shall determine the fat level of a beef carcass by measuring the fat on the left side between the twelfth and thirteenth ribs at the minimum point of thickness in the fourth quarter from the vertebrae along the longitudinal axis of the *Longissimus* muscles and perpendicularly to the outside surface of the fat.

ANNEXE IV
(*article 26*)

ÉPAISSEUR DU GRAS DORSAL POUR LES CATÉGORIES CANADA TRUIE

	Colonne I	Colonne II
Article	Catégorie	Épaisseur du gras dorsal, déterminée au moyen de la réglette de rendement (en mm)
1.	Canada Truie 1	18,9 ou moins
2.	Canada Truie 2	19,0 à 29,9
3.	Canada Truie 3	30,0 à 47,9
4.	Canada Truie 4	48,0 à 63,9
5.	Canada Truie 5	64,0 à 79,9
6.	Canada Truie 6	80,0 ou plus

PARTIE III

NOMS ET NORMES DES CATÉGORIES DE CARCASSES DE BOEUF

Dispositions générales

29. Sont établies 12 catégories de carcasses de boeuf portant les noms suivants : Canada A, Canada AA, Canada AAA, Canada B1, Canada B2, Canada B3, Canada B4, Canada D1, Canada D2, Canada D3, Canada D4 et Canada E.

30. (1) Sous réserve du paragraphe (2), le classificateur détermine l'épaisseur de gras d'une carcasse de boeuf en prenant une mesure du gras sur le côté gauche entre les douzième et treizième côtes au point d'épaisseur minimale dans le quatrième quartier, au niveau des vertèbres, le long de l'axe longitudinal des muscles *longissimus* et perpendiculairement à la surface extérieure du gras.

(2) Where it is impossible to take an accurate fat measurement of a beef carcass, the grader shall determine the fat level through an assessment of the external fat on the beef carcass or by an examination of the fat on the right side of the beef carcass after it has been knife-ribbed.

(3) A grader shall determine the yield and yield class of every beef carcass that is graded Canada A, Canada AA or Canada AAA.

(4) A grader shall determine the yield of a beef carcass that is graded Canada A, Canada AA or Canada AAA by using the prediction equation approved by the Minister.

(5) The yield class of a beef carcass that is graded Canada A, Canada AA or Canada AAA and that has a yield set out in column I of an item of the table to this section is the yield class set out in column II of that item.

TABLE

Determination of Yield Class for Carcasses Graded Canada A, Canada AA and Canada AAA

Item	Column I Determined Yield (%)	Column II Yield Class
1.	59 or more	Canada A1
2.	54 to 58	Canada A2
3.	53 or less	Canada A3

Grade Standards for Canada A, Canada AA and Canada AAA

31. The standards for a beef carcass of the grade Canada A, Canada AA or Canada AAA are the following:

(*a*) the maturity characteristics set out in Schedule I to this Part;

(*b*) muscling that ranges from good, with no deficiencies, to excellent;

(*c*) *Longissimus* muscles that, 10 minutes after being exposed by knife-ribbing, are firm and bright red in colour;

(*d*) the required marbling level set out for that grade in the table to this section; and

(*e*) a fat covering that is

(i) firm and white or slightly tinged with a reddish or amber colour, and

(ii) not less than 4 mm in thickness at the measurement site.

(2) S'il est impossible de prendre une mesure précise du gras de la carcasse de boeuf, le classificateur détermine l'épaisseur de gras de la carcasse par une appréciation du gras de couverture de celle-ci ou par un examen du gras sur le côté droit de la carcasse, après que l'incision transversale a été pratiquée.

(3) Le classificateur détermine le rendement et la catégorie de rendement de chaque carcasse de boeuf classée dans l'une des catégories Canada A, Canada AA ou Canada AAA.

(4) Le classificateur calcule le rendement de la carcasse de boeuf classée dans l'une des catégories Canada A, Canada AA ou Canada AAA à l'aide de l'équation de prédiction approuvée par le ministre.

(5) La catégorie de rendement de la carcasse de boeuf classée dans l'une des catégories Canada A, Canada AA ou Canada AAA est celle prévue à la colonne II du tableau du présent article, d'après le rendement calculé qui est indiqué à la colonne I.

TABLEAU

Détermination de la catégorie de rendement des carcasses classées dans l'une des catégories Canada A, Canada AA ou Canada AAA

Article	Colonne I Rendement calculé (%)	Colonne II Catégorie de rendement
1.	59 ou plus	Canada A1
2.	de 54 à 58	Canada A2
3.	53 ou moins	Canada A3

Normes des catégories Canada A, Canada AA et Canada AAA

31. Les normes applicables aux carcasses de boeuf des catégories Canada A, Canada AA ou Canada AAA sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe I de la présente partie;

b) une musculature qui varie de bonne, sans aucune déficience, à excellente;

c) des muscles *longissimus* qui, 10 minutes après avoir été exposés par l'incision transversale, sont fermes et d'un rouge vif;

d) un persillage conforme aux exigences énoncées dans le tableau du présent article;

e) une couche de gras qui :

(i) est ferme et blanche ou légèrement rougeâtre ou ambrée,

(ii) mesure au moins 4 mm d'épaisseur à l'endroit où la mesure du gras est effectuée.

TABLE

Marbling Requirements for Canada A, Canada AA and Canada AAA

Item	Column I Grade	Column II Required Marbling Level
1.	Canada A	At the least, traces, but less than a slight amount
2.	Canada AA	At the least, a slight amount, but less than a small amount
3.	Canada AAA	A small amount or more

Grade Standards for Canada B1

32. The standards for a beef carcass of the grade Canada B1 are the following:

(*a*) the maturity characteristics set out in Schedule I to this Part;

(*b*) muscling that ranges from good, with no deficiencies, to excellent;

(*c*) *Longissimus* muscles that, 10 minutes after being exposed by knife-ribbing, are firm and bright red in colour; and

(*d*) a fat covering that is firm and white or slightly tinged with a reddish or amber colour.

Grade Standards for Canada B2

33. The standards for a beef carcass of the grade Canada B2 are the following:

(*a*) the maturity characteristics set out in Schedule I to this Part;

(*b*) muscling that ranges from deficient to excellent;

(*c*) *Longissimus* muscles that, 10 minutes after being exposed by knife-ribbing, are bright red in colour; and

(*d*) a fat covering that is yellow.

Grade Standards for Canada B3

34. The standards for a beef carcass of the grade Canada B3 are the following:

(*a*) the maturity characteristics set out in Schedule I to this Part;

(*b*) muscling that ranges from deficient to good;

(*c*) *Longissimus* muscles that, 10 minutes after being exposed by knife-ribbing, are bright red in colour; and

(*d*) a fat covering that is white or slightly tinged with a reddish or amber colour.

Grade Standards for Canada B4

35. The standards for a beef carcass of the grade Canada B4 are the following:

TABLEAU

Exigences de persillage pour les catégories Canada A, Canada AA et Canada AAA

Article	Colonne I Catégorie	Colonne II Persillage
1.	Canada A	Présence de traces, jusqu'à un degré moindre que très peu abondant
2.	Canada AA	Très peu abondant, jusqu'à un degré moindre que peu abondant
3.	Canada AAA	Peu abondant ou plus

Normes de la catégorie Canada B1

32. Les normes applicables aux carcasses de boeuf de la catégorie Canada B1 sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe I de la présente partie;

b) une musculature qui varie de bonne, sans aucune déficience, à excellente;

c) des muscles *longissimus* qui, 10 minutes après avoir été exposés par l'incision transversale, sont fermes et d'un rouge vif;

d) une couche de gras qui est ferme et blanche ou légèrement rougeâtre ou ambrée.

Normes de la catégorie Canada B2

33. Les normes applicables aux carcasses de boeuf de la catégorie Canada B2 sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe I de la présente partie;

b) une musculature qui varie de déficiente à excellente;

c) des muscles *longissimus* qui, 10 minutes après avoir été exposés par l'incision transversale, sont d'un rouge vif;

d) une couche de gras de couleur jaune.

Normes de la catégorie Canada B3

34. Les normes applicables aux carcasses de boeuf de la catégorie Canada B3 sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe I de la présente partie;

b) une musculature qui varie de déficiente à bonne;

c) des muscles *longissimus* qui, 10 minutes après avoir été exposés par l'incision transversale, sont d'un rouge vif;

d) une couche de gras qui est blanche ou légèrement rougeâtre ou ambrée.

Normes de la catégorie Canada B4

35. Les normes applicables aux carcasses de boeuf de la catégorie Canada B4 sont les suivantes :

(*a*) the maturity characteristics set out in Schedule I to this Part;

(*b*) muscling that ranges from deficient to excellent;

(*c*) *Longissimus* muscles that, 10 minutes after being exposed by knife-ribbing, are dark red in colour; and

(*d*) a fat covering that has a colour ranging from white to yellow.

Grade Standards for Canada D1

36. The standards for a beef carcass of the grade Canada D1 are the following:

(*a*) the maturity characteristics set out in Schedule II to this Part;

(*b*) muscling that is excellent; and

(*c*) a fat covering that

(i) extends well over the ribs and loins and moderately well over the hips and chucks,

(ii) is firm and white or slightly tinged with a reddish or amber colour, and

(iii) is less than 15 mm in thickness at the measurement site.

Grade Standards for Canada D2

37. The standards for a beef carcass of the grade Canada D2 are the following:

(*a*) the maturity characteristics set out in Schedule II to this Part;

(*b*) muscling that ranges from medium, with some deficiencies, to excellent; and

(*c*) a fat covering that

(i) extends moderately well over the ribs and loins and lightly over the hips and chucks,

(ii) ranges from firm to slightly soft,

(iii) has a colour ranging from white to yellow, and

(iv) is less than 15 mm in thickness at the measurement site.

Grade Standards for Canada D3

38. The standards for a beef carcass of the grade Canada D3 are the following:

(*a*) the maturity characteristics set out in Schedule II to this Part;

(*b*) muscling that is deficient to a degree of emaciation; and

(*c*) a fat covering that is less than 15 mm in thickness at the measurement site.

Grade Standards for Canada D4

39. The standards for a beef carcass of the grade Canada D4 are the following:

(*a*) the maturity characteristics set out in Schedule II to this Part;

a) les caractéristiques d'âge mentionnées à l'annexe I de la présente partie;

b) une musculature qui varie de déficiente à excellente;

c) des muscles *longissimus* qui, 10 minutes après avoir été exposés par l'incision transversale, sont d'un rouge foncé;

d) une couche de gras dont la couleur varie du blanc au jaune.

Normes de la catégorie Canada D1

36. Les normes applicables aux carcasses de boeuf de la catégorie Canada D1 sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe II de la présente partie;

b) une musculature qui est excellente;

c) une couche de gras qui :

(i) recouvre bien les côtes et les longes et modérément bien les cuisses et les blocs d'épaule,

(ii) est ferme et blanche ou légèrement rougeâtre ou ambrée,

(iii) mesure moins de 15 mm d'épaisseur à l'endroit où la mesure du gras est effectuée.

Normes de la catégorie Canada D2

37. Les normes applicables aux carcasses de boeuf de la catégorie Canada D2 sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe II de la présente partie;

b) une musculature qui varie de moyenne, avec quelques déficiences, à excellente;

c) une couche de gras qui :

(i) recouvre modérément bien les côtes et les longes et légèrement les cuisses et les blocs d'épaule,

(ii) est de texture ferme à légèrement molle,

(iii) est d'une couleur variant du blanc au jaune,

(iv) mesure moins de 15 mm d'épaisseur à l'endroit où la mesure du gras est effectuée.

Normes de la catégorie Canada D3

38. Les normes applicables aux carcasses de boeuf de la catégorie Canada D3 sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe II de la présente partie;

b) une musculature déficiente allant jusqu'à l'émaciation;

c) une couche de gras qui mesure moins de 15 mm d'épaisseur à l'endroit où la mesure du gras est effectuée.

Normes de la catégorie Canada D4

39. Les normes applicables aux carcasses de boeuf de la catégorie Canada D4 sont les suivantes :

a) les caractéristiques d'âge mentionnées à l'annexe II de la présente partie;

(*b*) muscling that ranges from deficient to excellent; and

(*c*) a fat covering that is 15 mm or more in thickness at the measurement site.

Grade Standards for Canada E

40. The standards for a beef carcass of the grade Canada E are the following:

(*a*) the beef carcass is the carcass of a bull or stag; and

(*b*) the beef carcass has pronounced masculinity.

SCHEDULE I
(*Sections 2 and 31 to 35*)

MATURITY CHARACTERISTICS FOR BEEF CARCASSES

1. Cartilaginous caps on the thoracic vertebrae that are no more than half-ossified.
2. Lumbar vertebrae that have evidence of cartilage or at least a red line present on the tips of the spinous processes.
3. Spinous processes that are generally porous and red when split.
4. Ribs that are narrow, round and red.
5. A sternum that shows distinct divisions.

SCHEDULE II
(*Sections 2 and 36 to 39*)

MATURITY CHARACTERISTICS FOR BEEF CARCASSES

1. Cartilaginous caps on the thoracic vertebrae that are more than half-ossified.
2. Lumbar vertebrae that have no evidence of cartilage or of a red line present on the tips of the spinous processes.
3. Spinous processes that are generally hard, white and flinty when split.
4. Ribs that are wide, flat and white.
5. A sternum that shows advanced ossification.

b) une musculature qui varie de déficiente à excellente;

c) une couche de gras qui mesure 15 mm ou plus d'épaisseur à l'endroit où la mesure du gras est effectuée.

Normes de la catégorie Canada E

40. Les normes applicables aux carcasses de boeuf de la catégorie Canada E sont les suivantes :

a) une carcasse provenant d'un taureau ou d'un mâle castré;

b) des caractéristiques masculines prononcées.

ANNEXE I
(*articles 2 et 31 à 35*)

CARACTÉRISTIQUES D'ÂGE DES CARCASSES DE BOEUF

1. Les prolongements cartilagineux des vertèbres thoraciques ne sont pas ossifiés plus que de la moitié.
2. Les vertèbres lombaires ont des prolongements cartilagineux ou au moins une ligne rouge apparaissant sur le bout des apophyses épineuses.
3. Lorsqu'elles sont fendues, les apophyses épineuses sont généralement poreuses et rouges.
4. Les côtes sont étroites, arrondies et rouges.
5. Le sternum montre des séparations distinctes.

ANNEXE II
(*articles 2 et 36 à 39*)

CARACTÉRISTIQUES D'ÂGE DES CARCASSES DE BOEUF

1. Les prolongements cartilagineux des vertèbres thoraciques sont ossifiés plus que la moitié.
2. Les vertèbres lombaires n'ont pas de prolongements cartilagineux ni de ligne rouge sur le bout des apophyses épineuses.
3. Lorsqu'elles sont fendues, les apophyses épineuses sont généralement dures, blanches et cassantes.
4. Les côtes sont larges, plates et blanches.
5. Le sternum présente un état avancé d'ossification.

SCHEDULE III

(*Section 2*)

GRADE STAMP

SCHEDULE IV
(*Subsection 10(2)*)

ROLLER BRANDS

Item	Column I Grade	Column II Roller Brand*	Column III Colour of Ink
1.	Canada A	Canada A1, Canada A2 or Canada A3	Red
2.	Canada AA	Canada A1, Canada A2 or Canada A3	Red
3.	Canada AAA	Canada A1, Canada A2 or Canada A3	Red
4.	Canada B1	Canada B1	Blue
5.	Canada B2	Canada B	Blue
6.	Canada B3	Canada B	Blue
7.	Canada B4	Canada B	Blue
8.	Canada D1	Canada D1	Brown
9.	Canada D2	Canada D	Brown
10.	Canada D3	Canada D	Brown
11.	Canada D4	Canada D	Brown
12.	Canada E	Canada E	Brown

*Roller brands are shown in this Schedule without roller codes.

ANNEXE III

(*article 2*)

ESTAMPILLE DE CLASSIFICATION

ANNEXE IV
(*paragraphe 10(2)*)

MARQUES D'ESTAMPILLAGE

Article	Colonne I Catégorie	Colonne II Marque d'estampillage*	Colonne III Couleur de l'encre
1.	Canada A	Canada A1, Canada A2 ou Canada A3	Rouge
2.	Canada AA	Canada A1, Canada A2 ou Canada A3	Rouge
3.	Canada AAA	Canada A1, Canada A2 ou Canada A3	Rouge
4.	Canada B1	Canada B1	Bleu
5.	Canada B2	Canada B	Bleu
6.	Canada B3	Canada B	Bleu
7.	Canada B4	Canada B	Bleu
8.	Canada D1	Canada D1	Brun
9.	Canada D2	Canada D	Brun
10.	Canada D3	Canada D	Brun
11.	Canada D4	Canada D	Brun
12.	Canada E	Canada E	Brun

*Les marques d'estampillage sont indiquées dans la présente annexe sans le code d'estampillage.

[25]

APPENDIX 2. SPECIFICATION OF VARIABLES AND SUBSCRIPTS USED IN THE MODEL

Variable	Description
CP	= Carcass price in \$ per pound.
S	= Dummy variable for sex, where S=0 for steer and S=1 for heifer.
WE_k	= Categorial variable for the weeks of grading of the period being analyzed.
Plant A model:	
D1	= 1 if the week of grading is week 1.
D2	= 1 if the week of grading is week 2.
D3	= 1 if the week of grading is week 3 (reference category).
D4	= 1 if the week of grading is week 4.
Plant B model:	
D1	= 1 if the week of grading is week 1.
D2	= 1 if the week of grading is week 2 (reference category).
W	= carcass weight prior grading in pounds;
SY	= saleable meat yield (the sum of the cut weights plus the weights of the trim, 50, 75 and 85% lean, expressed as a percentage of side weight prior to cutting).
GF	= grade fat. Measures the fat thickness in the loin area (minimum fat in the last quadrant) in mm.
MS_j	= Categorial variable for muscle score.
MS1	= 1 if the carcass muscle score is 1.
MS2	= 1 if the carcass muscle score is 2.
MS3	= 1 if the carcass muscle score is 3 (reference category).
MS4	= 1 if the carcass muscle score is 4.
CE	= Cutability estimate in %.
MA_m	= Dummy variable for marbling.
MA	= 1 if trace marbling (reference category).
MAA	= 1 if slight marbling.
MAAA	= 1 if small marbling.
S*W	= Interaction between sex and weight.
S*GF	= Interaction between sex and grade fat.
W*GF	= Interaction between weight and grade fat.
S*CE	= Interaction between sex and cutability estimate.
W*CE	= Interaction between weight and cutability estimate.

APPENDIX 3. LIST OF WHOLESALE CUTS AND THEIR RESPECTIVE PRICES

Plant A Wholesale Cut and Prices

Cut	Average Price of Cut of week of: (lb)			
	Sept.13-17	Sept.20-24	Sept.27-Oct. 1	Oct. 4-8
Blade eye	2.36	2.37	2.37	2.35
Short cut clod	2.12	2.25	2.26	2.26
Chuck tender	1.99	1.99	2.04	2.02
Flat iron piece	1.74	1.73	1.79	1.76
Neck	1.49	1.52	1.52	1.48
Shoulder	1.43	1.46	1.46	1.41
Brisket point	1.45	1.51	1.56	1.58
Boneless navel	0.95	0.95	0.95	0.95
Inside skirt	2.39	2.39	2.42	2.42
Outside skirt	1.77	1.77	1.77	1.77
Foreshank	1.44	1.46	1.47	1.45
2x3 Steak Style rib	3.75	3.72	3.72	3.82
Blade Meat	1.97	1.97	1.97	1.97
Short ribs (full cut)	1.67	1.67	1.67	1.67
Inside round	2.26	2.22	2.22	2.22
Gooseneck	1.86	1.86	1.92	1.82
Sirloin tip (peeled)	2.44	2.48	2.48	2.48
Hind shank	1.47	1.47	1.47	1.47
1x0 Striploin	5.22	5.12	5.07	5.02
Top butt	2.52	2.52	2.52	2.47
Trip tip	2.92	2.92	2.87	2.82
Ball tip	2.02	2.02	2.07	2.02
Full tenderloin	6.62	6.62	6.72	6.57
Flank Steak	3.37	3.47	3.37	3.32
50% Table trim	0.64	0.63	0.63	0.57
75% Table trim	1.19	1.18	1.18	1.18
85% Table trim	1.44	1.44	1.46	1.45

Plant B Wholesale Cut and Prices

Cut	Average Price of Cut of week of: (lb)	
	Oct. 18-22	Oct. 25-29
Blade eye	2.45	2.45
Short cut clod	2.25	2.25
Chuck tender	2.38	2.38
Flat iron piece	2.30	2.30
Neck	1.75	1.75
Shoulder	1.75	1.75
Brisket point	2.11	2.13
Boneless navel	1.06	1.05
Inside skirt	2.38	2.43
Outside skirt	1.90	1.93
Foreshank	1.18	1.18
2x3 Steak Style rib	4.25	4.25
Blade Meat	2.25	2.25
Short ribs (full cut)	1.70	1.70
Inside round	2.35	2.33
Gooseneck	2.18	2.18
Sirloin tip (peeled)	2.65	2.61
Hind shank	1.63	1.63
1x0 Striploin	4.45	4.40
Top butt	2.43	2.43
Trip tip	2.65	2.65
Ball tip	1.94	1.97
Full tenderloin	6.20	6.20
Flank Steak	3.75	3.75
50% Table trim	0.72	0.70
75% Table trim	1.24	1.24
85% Table trim	1.63	1.63