A Comparative Analysis of Alternative Slaughter Hog Grading and Pricing Systems

by

Terrence Peter Chabluk

A thesis
presented to the University of Manitoba
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ABSTRACT

The general problem addressed in this study was to examine various techniques for assigning differential prices to pork carcasses. Of interest was whether these techniques could serve to aid in the establishment of grade-pricing efficiency in the slaughter hog market. The specific objectives were:

1. to describe the historical development of slaughter hog grading practices in both Canada and the United States;
2. to compare the ability of various grade-pricing mechanisms to contribute to pricing efficiency;
3. to determine whether the pricing efficiency achieved by the Canadian Index 100 system might be improved;
4. to comment on the practical feasibility of attaining any such improvements.

The first objective was achieved through a thorough review of both Canadian and U.S. literature relevant to the field of hog grading and differential pricing. The literature indicated that the official, compulsory system employed in Canada has tended to be more progressive in comparison to the non-compulsory grading practices in the U.S.

The second, third, and fourth objectives of this study were achieved by using econometric models to represent various grade-pricing mechanisms, and observing the degree of pricing efficiency achieved by these alternative mechanisms. Cutout data were obtained (from Agriculture

Canada) for a stratified sample of 247 pork carcasses. Carcass weight and various measurements of backfat and muscle thickness also were recorded for each carcass. The value of each carcass was calculated (expressed as an index of the mean carcass value) for each of 36 sets of monthly average Canadian wholesale pork price data (spanning 1980, '81, and '82), modified to reflect packers' preferences for specific weight ranges of individual wholesale cuts. Pricing efficiency was measured by examining how closely the value indices assigned by a particular grade-pricing mechanism matched the actual calculated value indices for the sample carcasses. Two measures of pricing efficiency were used. "Bias" measured whether a given grade-pricing mechanism tended to either over or underestimate the actual response of carcass value to differences in carcass weight, backfat, and muscle thickness. "Precision" measured the probability that the index grade assigned to an individual carcass would be within 2 index points of its actual value index. After determining the bias and precision scores for the various grade-pricing mechanisms, an attempt was made to identify the practical benefits and probable costs that would be associated with the actual implementation of a given mechanism. Specific reference was made to the probable benefits and costs associated with incorporating a given mechanism (other than the existing mechanism) into the Canadian Index 100 grading system.

After comparing the ability of various carcass measurements and grade-pricing procedures to contribute to grade-pricing efficiency, it was determined that the current practices employed in the development and maintenance of the Index 100 system provide a level of pricing efficiency upon which only minor practical improvements could be made, given current grading technology. It was suggested, however, that the grade index table be examined at least bi-yearly, and possibly yearly, to ensure that trends in market preferences do not render the grade-price signal to be too biased. Also, the possibility of seasonally adjusting the Index 100 table was examined. It was suggested that if seasonally tailoring the average weight of pork carcasses to packers' preferences could facilitate an improvement in the physical efficiency of packers' operations, a seasonally adjusting system might be justified. Otherwise, seasonal adjustments to the system would be of little value, and may only serve to confuse packers and producers. In addition, the results of this study indicated that the probability of accurately grading carcasses within 2 index points of their actual value indices is limited mostly by the fact that backfat thickness and carcass weight must be used as proxies for commercial yield. Using different carcass measurement sites, or allowing the grade-pricing system to reflect instabilities (over time, or over carcass type) in the actual relationship of carcass value to backfat and weight provide, at best, only minor improvements to grade-pricing precision. Truly accurate differential pricing of individual carcasses requires a grading technology that can provide precise and accurate estimates of carcass yield.

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to all those who contributed, directly or indirectly, to this thesis project.

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Appreciation is expressed also for Agriculture Canada's financial support of this project.

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Chapter I

INTRODUCTION

1.1 BACKGROUND

The hog/pork sectors of Canada and the U.S. are similar in many respects. Production and processing technologies, as well as tastes and preferences of consumers are much the same in both countries. These similarities, coupled with the absence of major trade barriers between the two countries have resulted in a true "North American" hog/pork sector with both the Canadian and U.S. hog industries competing for the North American consumers' meat dollar. Indicative of the close relationship between the two countries is the fact that the balance of trade in hogs and pork has switched six times between 1960 and 1981.[1]

In spite of this close interaction within the North American hog/pork sector, several major differences between the two countries exist, particularly in their respective marketing systems for slaughter hogs. For example, the structure of the Canadian market differs from that in the U.S. as a result of the existence of marketing boards or commissions. Another major difference, and one which this study focuses on, lies in the function of grading.

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[1] P. Weisberger, Canada's Competitive Position in the North American Hog Industry, United States Department of Agriculture (USDA), Economic Research Service, Washington, D.C. 20250, Staff Report No. AGES811216, Dec., 1981, p. 1.

1.2 GRADING DEFINED

McCoy provides the following definition of grading: "Grading is the segregation of units of a commodity into lots, or groupings, which have a relatively high degree of uniformity in specific attributes associated with market preferences and valuation".[2] The remainder of this section will build upon this definition in order to identify the overall objectives of grading, and to isolate its economic objectives.

1.2.1 The Objectives of a Grading System

Grading of a commodity can serve a wide range of functions, as identified by Mehren.[3] These include: the improvement of both physical and pricing efficiency; the provision of a basis for product differentiation, promotion, or new product development; and the improvement of market information. For slaughter hogs, the primary objective of a grading system can be identified as the improvement of marketing efficiency in the slaughter hog market. Marketing efficiency is composed of both physical and pricing efficiency.[4]

Physical efficiency refers to the performance of the physical activities involved in the marketing of a product. It is also known as "oper-

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[2] J.H. McCoy, Livestock and Meat Marketing, second edition, (Westport, Conneticut: Avi Publishing Co. Inc., 1979), p. 283.

[3] G.L. Mehren, "The Functions of Grades in an Affluent, Standardized-Quality Economy", Journal of Farm Economics, vol. 43, (1961), pp. 1371-1383.

[4] See G.S. Shepherd, G.A. Futrell, and J.R. Strain, Marketing Farm Products, sixth edition, (Ames, Iowa: Iowa State Press, 1976), pp. 184-187.

[5] Ibid., p. 185.

ational",[5] or technical[6] efficiency. The transportation, procurement, processing, and distribution of a commodity should be accomplished with the least cost per unit output (or alternatively, with the greatest output per unit input) possible. Grading of slaughter hogs and/or pork carcasses can serve to improve physical efficiency by facilitating the purchase of animals by description alone (ie., "sight unseen"), and eliminating wasted time and effort involved in "haggling" over the quality of an animal. In order for a grading system to contribute to physical efficiency in the manner stated above, grades must describe, with reasonable accuracy and consistency, those physical attributes of the animal normally associated with its perceived quality.

Pricing efficiency refers to the ability of price to serve as a mechanism for communicating consumers' preferences to producers, in order that producers may allocate their productive resources in accordance with consumer preferences. Grading can contribute to the achievement of pricing efficiency in the slaughter hog market by providing an accurate, unambiguous language for market participants to use when referring to hogs of different quality. This is of particular importance in market price reporting. By making market price reports more meaningful to all market participants, consumers' preferences can be more clearly transmitted to the producer via the price system. Grading of slaughter hogs also can improve pricing efficiency if used as an aid in establishing price differentials reflecting the quality differences between hogs. This requires that the grade standards should provide meaningful de-

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[6] W.D. Purcell, Agricultural Marketing Systems: Systems, Coordination, Cash, and Futures Prices, (Reston, Virginia: Reston Publishing Co., Inc., 1979), p. 8.

scriptions as to the quality of individual animals. It also requires the establishment of a means to translate the grade differentials between individual animals into corresponding price differentials.

1.2.2 Economic Purpose of Grading

From an economic perspective, a grading system should aid in effecting a high degree of pricing efficiency - it should facilitate the communication of consumers' preferences for different qualities of slaughter hogs to producers in the form of quality-related price differentials. Webster defines "quality" both as "a distinguishing attribute" and as "degree of excellence".[7] The former definition refers to the physical characteristics of a commodity, while the latter definition implies preference or value. In this thesis, the word "quality" will be used only the sense of being synonymous with "value"; particularly, economic value. Thus, a distinction is made between McCoy's definition of grading (where the concern is to sort a commodity according to those physical attributes associated with value), and what is referred to in this thesis as "grade-pricing" (where the concern is to sort a commodity according to economic value, and subsequently establish the payment of differential prices reflective of the value differentials between grades). In a market economy, the value of a commodity is measured in terms of "willingness to pay" for that commodity. Consequently, from an economic perspective, a grade-pricing system for slaughter hogs should reflect the packers' relative willingness to pay for an individual animal, in comparison to other animals.

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[7] H.B. Wooll, ed. in chief, The Merriam-Webster Dictionary, (Markham, Ontario: Simon and Schuster of Canada, Ltd., 1974), p. 567.

1.3 GRADE-PRICING SYSTEMS FOR SLAUGHTER HOGS AND/OR PORK CARCASSES - CANADA VS. U.S.

Differences in the development of grade-pricing systems in Canada and the U.S. can be found in the grade-pricing policies (i.e., the "course or method of action selected to guide and determine present and future decisions")[8] followed, and the grade-pricing mechanisms (i.e., "process or technique for achieving a result")[9] currently employed or proposed in the two countries.

1.3.1 Grade-Pricing Policies

Since 1932, Canada has employed a policy of grading all hogs according to official, compulsory grade standards. The initial intent of compulsory grade standards was to encourage a uniform slaughter hog population, with the hope of making Canadian hogs more desireable to pork-importing countries. The Canadian slaughter hog population has in fact achieved a high degree of uniformity in terms of backfat thickness and weight, and this has led the Canadian sector to claim a superior quality for its pork - greater leanness.[10]

Because a single, compulsory grade-pricing system is employed throughout Canada, individual packers (though they may differ in plant size, or in the type of pork products they produce), are not able to tailor the system to suit their unique individual preferences for carcasses of different physical type. Rather, the ability of Canadian packers to influence the design of the system exists only for packers

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[8] Ibid., p. 537.

[9] Ibid., p. 434.

[10] P. Weisberger, op. cit., p. 17.

collectively (through the Canadian Meat Council).

In the U.S., official grades have been established by the USDA, but they are not compulsory. In fact, they are seldom used by U.S. meat packers. Instead, packers are allowed to develop and implement their own grade standards, which they can match to their own individual preferences for pork carcasses. Such a program may, in theory, facilitate a higher degree of pricing efficiency from the perspective of individual packers. However, by allowing individual packers to establish their own grade-pricing systems, there is no guarantee that the resulting systems will encourage the establishment of a uniform slaughter hog population.

A second policy question exists with regards to the role of grade standards in establishing grade-price differentials. In Canada, and in some U.S. packing plants, the grade standards are used to sort hogs according to quality (i.e., value) and also to assign the price differentials associated with the different grades. In such cases, a grade-pricing system is established, with price differentials being administered directly by the system. Alternatively, the grade standards may be used solely for the purpose of describing the physical attributes of an animal, and allowing the market supply and demand for each individual grade to determine the price differentials between grades. In such cases, a grading system is established, leaving the process of establishing differential pricing in the hands of the market. The focus of this thesis is on grade-pricing systems, where price differentials are assigned to animals according to their grade.

The grade-pricing policies adopted in a hog/pork sector are determined by the objectives of that sector (e.g., the establishment of a uniform hog population for export purposes) and/or its philosophy towards government regulation and "free enterprise". It is not the objective of this thesis to comment on the objectives and/or philosophies of the Canadian and U.S. hog/pork sectors. Rather, the focus of this thesis is on the "processes or techniques" by which pork carcasses are priced according to their quality differences.

1.3.2 Grade-Pricing Mechanisms

Both in Canada and the U.S., carcass measurements of backfat and weight are used (and measurements of muscle depth have been proposed) for the definition of grade standards (i.e., these measurements are used to indicate carcass quality). This requires some knowledge as to the relationship of carcass quality to the chosen carcass measurements. Various mechanisms have been used or proposed for the purpose of predicting the quality differentials between carcasses, and establishing payment in accordance with these quality differentials. The basic areas in which these mechanisms differ are in i) the carcass measurements used to indicate carcass quality, and ii) the procedure used in estimating the relationship of quality to the chosen carcass measurements. These differences are more fully described in Chapter 4.

1.3.3 The Problem

The diversity exhibited in existing and proposed grade-pricing mechanisms in North America indicates a lack of concensus as to which carcass measurements best reflect carcass quality, and as to the most appropriate procedure by which to estimate the relationship of quality to the chosen carcass measurements.

1.4 OBJECTIVES

1. Describe the development of slaughter hog grading practices in both Canada and the U.S. This exercise will provide an understanding of the reasons behind existing and proposed quality-pricing systems.
2. Compare the ability of various grade-pricing mechanisms to contribute to pricing efficiency, with the subsequent objective of,
3. determining whether the pricing efficiency achieved by the Canadian Index 100 system could be improved through modification of its mechanism.
4. If a mechanism change to the Index 100 system can be shown empirically to have potential to improve the system from a pricing efficiency standpoint, comment on its practical feasibility.

1.5 JUSTIFICATION

In this study, the contribution to pricing accuracy by various carcass measurements and various modelling procedures will be compared by applying alternative pricing mechanisms to the same set of data. This data consists of i) a stratified sample of Canadian slaughter hog carcasses, chosen to achieve a uniform distribution across carcass weight and backfat cells,[11] and ii) Canadian prices for wholesale pork cuts, modified to reflect the preferences of the wholesale market for specific weight ranges for the individual pork cuts[12] (monthly average prices for January, 1979 to December, 1981). It is hoped this comparative analysis

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[11] The carcass cutout data is described more fully in Appendix B.

[12] The wholesale price data is described more fully in Appendix C.

will clarify the role of past and current research in the area of hog grading and pricing. Subsequently, whether the accuracy of the Index 100 system can be improved through a modification of its mechanism will be determined. It is hoped this will provide information useful in guiding future research in this field in Canada.

1.6 THESIS OUTLINE

The historical development of hog grading and pricing in North America is presented in Appendix A. The information within this appendix is considered useful "background" information to the area of hog grading and pricing, but it is not essential to the comparative analysis at hand. Those readers already familiar with Canadian and U.S. grading and pricing practices for hogs may find it expedient to omit Appendix A. Chapter 2 of this thesis presents a review of the literature relevant to the question of quality-pricing mechanisms for hogs and/or pork carcasses. In Chapter 3, a framework for examining the relationship between value and price within the context of pricing efficiency is developed. A description of the procedure employed in comparing alternative mechanisms is presented in the fourth chapter, followed in Chapter 5 by the results of the analysis, with accompanying interpretation of these results. The final chapter presents a summary of this study and its conclusions, followed by recommendations suggesting means by which the pricing efficiency achieved by the Index 100 system might be improved.

Chapter II

REVIEW OF RELEVANT LITERATURE

The literature reviewed in this chapter cites several recent studies where the focus is on the examination of various carcass measurements' ability to reflect carcass composition. In addition, a number of studies which have dealt specifically with the pricing of hogs in accordance with their value are cited.

2.1 RECENT STUDIES ADDRESSING CHOICE OF CARCASS MEASUREMENTS

In 1964, a study by Fredeen et al. found a regression incorporating a summed measure of shoulder and loin fat thickness explained 51 percent of carcass yield of ham, loin, picnic, and butt.[13] Similar results were obtained in a study by Fredeen and Bowman in 1968.[14] In 1968, the Index 100 grading/settlement system was introduced in Canada. It incorporated the above fat measurement together with carcass weight to indicate carcass value.

In 1981, Fortin et al., in a comparison of various backfat measurements as yield predictors, found a single measurement over the lumbar region resulted in accuracy of lean prediction comparable to that ob-

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[13] H.T. Fredeen, R.T. Berg, J.P. Bowland, and H. Doornenbal, "Prediction of Yield and Value of Hog Carcasses", Canadian Journal of Animal Science, vol. 44, (1964), pp. 334-346.

[14] H.T. Fredeen and G.H. Bowman, "Backfat Thickness and Carcass Weight as Predictors of the Yield of Hams and Loins of Pig Carcasses", Canadian Journal of Animal Science, vol. 48, (1968), pp. 117-129.

tained by using two fat measurement sites.[15] Other Canadian studies have examined the use of various electronic devices for measuring backfat and muscling. Fredeen and Weiss[16] examined the use of ultrasound, electronic probe, and ruler measurements of backfat thickness on various carcass sites. They found "the relative adequacy of a single 'best' fat measurement vs. a combination of measurements depended both on the (measurement) technique employed and the yield variable of interest".[17] They also noted that the use of discrete fat classes for the purpose of ranking carcasses results in poorer yield prediction than that afforded by the fat measurements themselves.[18] Most recently, Agriculture Canada, in conjunction with the University of Guelph, examined the use of electronic measurements of fat and muscle thickness on various lumbar and thoracic sites for the prediction of yield. They found that a single measurement of fat thickness at the 3-4th last rib was able to account for 40 percent of the variation in commercial yield. By adding an accompanying measurement of muscle depth, this figure was increased to 52 percent.[19]

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[15] A. Fortin, A.H. Martin, D.W. Sim, H.T. Fredeen, and G.M. Weiss, "Evaluation of Different Ruler and Ultrasonic Measurements as Indices of Commercial and Lean Yield of Hog Carcasses for Commercial Grading Purposes", Canadian Journal of Animal Science, vol. 61, (1981), pp. 893-905.

[16] H.T. Fredeen and G.M. Weiss, "Comparison of Techniques for Evaluating Lean Content of Hog Carcasses", Canadian Journal of Animal Science vol. 61, (1981), pp. 319-333.

[17] Ibid., p. 329.

[18] Ibid., p. 331.

[19] A. Fortin, Research Scientist, Research Branch, Agriculture Canada Animal Research Centre, Ottawa, Ontario, personal letter, March 30, 1983.

Research by U.S. animal scientists also has addressed the prediction of lean yield. Studies by Cross et al. (1973),[20] Smith and Carpenter (1973),[21] Cross, et al. (1975),[22] Fahey, et al. (1977),[23] and Edwards et al. (1981),[24] have indicated the ability of a single measurement of fat depth over the longissimus muscle to aid in the prediction of lean yield and pork carcass composition. A more recent U.S. study, however, focused on the use of last rib fat thickness for value prediction. A task force established by the National Pork Producers Council (NPPC) examined the question of establishing payment for hogs in relation to value by regressing the calculated net value of individual carcasses versus their carcass measurements. A "Lean Guide" index table was developed to serve as a voluntary guideline to buyers and sellers of live hogs and carcasses. This guide uses carcass or live weight and backfat thickness at the last rib, coupled with a subjective evaluation of muscling to suggest appropriate price differentials between animals.[25]

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[20] H.R. Cross, G.C. Smith, and Z.L. Carpenter, "Pork Carcass Cutability Equations Incorporating Some New Indices of Muscling and Fatness", Journal of Animal Science, vol. 37, (1973), pp. 423-429.

[21] G.C. Smith and Z.L. Carpenter, "Evaluation of Factors Associated With the Composition of Pork Carcasses", Journal of Animal Science, vol. 36, (1973), pp. 493-499.

[22] H.R. Cross, G.C. Smith, Z.L. Carpenter, and A.W. Kotula, "Relationship of Carcass Scores and Measurements to Five Endpoints for Lean Cut Yields in Barrow and Gilt Carcasses", Journal of Animal Science, vol. 41, (1975), pp. 1318-1326.

[23] T.J. Fahey, D.M. Schaeffer, R.G. Kauffman, R.J. Epley, P.F. Gould, J.R. Romans, G.C. Smith, and D.G. Topel, "A Comparison of Practical Methods to Estimate Pork Carcass Composition", Journal of Animal Science, vol. 44, (1977), pp. 8-17.

[24] R.L. Edwards, G.C. Smith, H.R. Cross, and Z.L. Carpenter, "Estimating Lean in Pork Carcasses Differring in Backfat Thickness", Journal of Animal Science, vol. 52, (1981), pp. 319-333.

2.2 REVIEW OF STUDIES EXAMINING PRICING AND QUALITY

In 1953, Engelman et al. compared the ability of various live and carcass-based pricing systems to improve on the pricing accuracy achieved by pricing based on live weight alone.[26] Carcass-based pricing was found to be superior to pricing based on live weight.

Using correlation analysis, Wiley et al. examined the importance of various carcass characteristics in explaining the variation in cut-out value of individual hogs.[27] They found that carcass weight plus backfat accounted for as much variation as did carcass weight plus the percentage yield of lean cuts. Gaarder (1962) used multiple regression analysis to construct an equation for estimating the yield of the four lean cuts (as a percentage of carcass weight) using average backfat thickness and carcass weight.[28] In addition, he suggested such an equation could be used in determining differential prices according to grade and weight.

Fredeen et al., (1964) used multiple regression analysis to explore the relationships between various carcass measurements to yield and value of hog carcasses.[29] Canadian A, B, and C grade standards were found

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[25] National Pork Producers Council, P.O. Box 10383, Des Moines, Iowa, 50306, "The Pork Value Approach", pamphlet, undated.

[26] G. Engelman, A.A. Dowell, and R.E. Olson, Relative Accuracy of Pricing Butcher Hogs on Foot and by Carcass Weight and Grade, Minnesota Agricultural Experiment Station Technical Bulletin 208, June, 1953.

[27] J.R. Wiley, D. Paarlberg, and R.C. Jones, Objective Carcass Factors Related to Slaughter Hog Values, Purdue Univ. Agr. Exp. Sta. Bul. 567, Dec., 1951.

[28] R.O. Gaarder, "Relationships Between Physical Characteristics and Value of Live Hogs and Hog Carcasses", (unpublished Ph.D. dissertation, Iowa State University of Science and Technology, 1962).

[29] H.T. Fredeen, R.T. Berg, J.P. Bowland, and H. Doornenbal, "Prediction

to contribute only as much to prediction of carcass value as did sex. Also in 1964, Rosendale used multiple regression methods to develop equations for predicting carcass value.[30] He suggested hog evaluation methods should include sex, weight, loin eye area, backfat thickness, and percentage yield of ham and loin.

Rawls (1969) formulated a theoretical approach by which to determine the appropriate size for grade-price differentials between hogs of varying physical characteristics.[31] His approach centered on the derivation of the derived demand of packers for slaughter hogs, and concluded that price differentials between hogs should, for the derived demand of packers to be communicated perfectly to producers, be equal to the corresponding differentials in net value between hogs.

Pearson et al. examined the relationships between selected characteristics and carcass value using simple correlation coefficients.[32] It was noted that

> "objective carcass pricing systems could be developed which would only require carcass weight and a single backfat measurement. Although the equations may need to be adjusted from time to time to account for changes in wholesale cut prices, adoption should result in more rapid response to changes in market demands which may not be accurately reflected by cur-

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of Yield and Value of Hog Carcasses", Canadian Journal of Animal Science, vol. 44, (1964).

[30] V.M. Rosendale, "Relationships Between Carcass Traits and the Value of Live Hogs and Hog Carcasses, (M.S. thesis, Univ. of Illinois, 1964).

[31] E.L. Rawls, "A Theoretical and Procedural Approach to Estimating the Differential Values of Pork Carcasses and Live Hogs," (unpublished Ph.D. dissertation, Virginia Polytechnic Institute, 1969).

[32] A.M. Pearson, M.L. Hayenga, R.G. Heifner, L.J. Bratzler, and R.A. Markel, "Influence of Various Traits Upon Live and Carcass Value for Hogs", Journal of Animal Science, vol. 31, (1970), pp. 318-322.

rent pricing systems".[33]

In 1971, Hayenga found that backfat thickness (last lumbar region), loin eye area (tenth rib), carcass weight, plus carcass length explained 69 percent of carcass value variation.[34] The performance of various pricing systems were compared by observing the standard deviation of the estimated value about the actual value.

Other studies have contributed to the development of hog pricing models by introducing econometric models intended to better reflect the relationship between carcass characteristics and value. Ikerd and Cramer (1970) developed a "two-step" regression procedure employing both cross-sectional data (measurements of selected physical characteristics for a cutout sample of hogs) and time series data (prices of different weights of wholesale cuts over time).[35] Their model produced superior estimates of individual carcass value when compared to a value determination method commonly used by U.S. packers. The importance of changing wholesale prices over time on the changes in wholesale values of pork carcasses was supported in a later study by Couvillion in 1971.[36]

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[33] Ibid., p. 321.

[34] M.L. Hayenga, "Hog Pricing and Evaluation Methods - Their Accuracy and Equity", American Journal of Agricultural Economics, vol. 53, (1971), pp. 507-509.

[35] J.E. Ikerd and C.L. Cramer, "A Practical Computer Method for Pricing Pork Carcasses and Hogs", American Journal of Agricultural Economics, vol. 52, (1970), pp. 242-246.

[36] W.C. Couvillion, Sr., "Pricing Efficiency, Physical Characteristics, and Wholesale Values of Slaughter Hogs", (unpublished Ph.D. dissertation, Univ. of Tennessee, 1971).

A brief look at grading/pricing systems for commodities other than pork reveals a great deal of similarity in terms of methods and procedures for determining characteristics of the product responsible for (or indicative of) the value of the product, and the means for determining appropriate premiums or discounts correspondent with those characteristics. Wool grade-pricing was examined by Simmons (1980), who developed cross-sectional equations with price paid for wool as the dependent variable, and the attributes of the commodity specified as the independent variables.[37] Similarly, an early study by Waugh (1929) employed linear regression to identify the quality factors important in the pricing of asparagus, tomatoes, and cucumbers.[38]

Studies in Australia concerning pig carcass pricing models also have regressed carcass values as a function of various carcass characteristics. One study indicated that the measurements included in the Australian National Pig Carcass Measurement and Information Service (including carcass weight, backfat depth, and sex), if incorporated into a pricing system, could lead to more accurate discrimination between carcasses.[39]

A method for associating quality attributes with price differentials other than that of regression analysis also has been suggested. Martin (1974) discussed the use of linear programming, with emphasis on the concept of duality, as an alternative to linear regression models for

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[37] P. Simmons, "Determinants of Grade Prices for Wool", Review of Marketing and Agricultural Economics, vol. 48, No. 1, (1980), pp. 37-46.

[38] Waugh, F.V., "Quality as a Determinant of Vegetable Prices", (Columbia University, New York, 1929).

[39] G.R. Griffith and L.R. Giles, "Pig Carcass Pricing Models: A Preliminary Investigation", Review of Marketing and Agricultural Economics, vol. 45, No. 4, (1977), pp. 146-157.

determining the prices which should be paid for different characteristics of corn when it is used as a processing input.[40]

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[40] M.B. Martin, "An Economic Analysis of Quality and Grading in Corn Marketing", (unpublished Ph.D. dissertation, Iowa State University, 1974).

Chapter III

THEORETICAL BASIS FOR COMPARING GRADE-PRICING SYSTEMS

3.1 INTRODUCTION

As noted in Chapter 1, the focus of this thesis is on mechanisms for determining appropriate grade-price differentials for pork carcasses. It is assumed that an appropriate set of grade-price differentials is one which reflects, without distortion, the corresponding differentials in the preferences of packers for different physical types of carcasses. By communicating packers' preferences to producers via the medium of price, grade-pricing mechanisms contribute to the establishment of pricing efficiency within the hog/pork market.

The major objective of this thesis is the comparative analysis of the ability of alternative grade-pricing mechanisms to contribute to pricing efficiency. This chapter will identify what is required of a mechanism in this regard, and thereby establish a framework by which the performance of alternative mechanisms can be evaluated empirically.

3.2 VALUE OF INDIVIDUAL HOGS

The value of a hog to a packer is determined by the revenue received through the sale of the various pork products obtained from the animal, less the costs incurred in transforming the live animal into a wholesale-ready form. The grade, or quality of an animal thus can be defined in terms of its net value.

3.2.1 Gross Value

The gross value (as well as the gross value per unit weight) is determined by two factors: 1) the percentage yields of each pork product obtained from the animal, and 2) the price received for each of the pork products. Prediction of gross value therefore requires an understanding of the factors determining carcass cutability, and the prices received for the various wholesale products.

Percentage yields may be determined on either a carcass or live weight basis. The latter provides a poorer indication of cutability, since it is affected by the weight of the stomach contents (referred to as "fill"). In this study, references to percentage yield will always refer to the percentage yield of carcass weight.

If records of individual product yields could be kept for each carcass passing through a packing plant, the gross value of each animal could be calculated easily. However, the collection of complete cutout data for every hog, given current technology, is an impractical method for packers to determine value. The feasible alternative is to predict the value of animals based on one or two quick measurements on the carcass. As outlined in Chapter 2, numerous studies have dealt with the prediction of pork carcass composition. These have suggested various measurements for prediction purposes, including alternative measures of subcutaneous fat thickness, various measures of muscling, and carcass weight. Since such measures have been shown to be indicative of carcass composition, they also have been used to aid in predicting carcass value.[41]

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[41] For example, see M.L. Hayenga, An Evaluation of Hog Pricing and Grading Methods, Michigan State University, Agricultural Economics Report

In conjunction with composition, the prices received for the various wholesale pork products contribute to the determination of the gross value of individual animals. Certain products (such as loins) consistently receive a higher price than other products (such as shoulders). In addition, intermediate and light weights of individual wholesale cuts generally receive a higher price in comparison to heavier cuts.[42] Since the weight of a carcass is positively related to the size of cuts obtained,[43] this suggests carcass weight also may be useful in predicting gross value.

The effect of wholesale prices on gross value is complicated further by the fact that the price differences between different wholesale cuts, and between different weights of the same cuts, vary over time. For example, loins generally fetch a higher price than hams, but in the few weeks prior to both Easter and Christmas, this price difference tends to decrease, and may even invert.[44]

No. 192, May, 1971.

[42] This is clearly the case in the U.S. wholesale pork market, as evidenced by price quotations in The National Provisioner Daily Market and News Service (Chicago, Illinois) "Yellow Sheet". Weight-related pricing of wholesale cuts is less prominent in Canada, but since the two markets are closely linked by mutual trade, it is assumed that Canadian packers value more highly those wholesale cuts falling in the weight ranges preferred by the American market.

[43] H.T. Fredeen and G.H. Bowman found the correlation coefficient between trimmed weights of ham and loin to carcass weight to be 0.87 and 0.84, respectively, in "Backfat Thickness and Carcass Weight as Predictors of the Yield of Hams and Loins of Pig Carcasses", Canadian Journal of Animal Science, vol. 48, (1968), p. 119.

[44] Based on observations of wholesale pork price quotations from the "Yellow Sheet", op. cit., Jan., 1980 to Dec., 1982.

By defining the gross value of a slaughter hog to a packer as being determined by the percentage yields of its various parts, together with the wholesale prices received for these parts, a number of simplifying omissions are made with regards to other factors which may, in actual practice, affect carcass value. For example, approximately 34 percent (155 mill. kgs.)[45] of the pork products produced by Canadian packers are classified as "processed meats" (e.g., sausages and prepared luncheon meats). The price received for such meats can be relatively high, though a large proportion of this price is due to the value added through the processing function. Since processing techniques vary between firms, and it is difficult to distinguish the value of the meat from the value of the processing services, the inclusion of processed meat products in determining the gross value of a carcass is impractical. For this reason, the analysis in this study does not include the value or costs associated with the production of processsed meat products. Rather, carcass valuation is based on the assumption that all carcasses are "processed" only to the extent of producing fresh primal cuts for the wholesale pork market.

Another simplifying omission is made in regards to the palatability of the meat obtained from a carcass. A small percentage of carcasses will produce meat exhibiting extreme PSE (pale, soft, exudative) or DFD (dark, firm, dry) characteristics. Such carcasses generally are considered unsuitable for the production of fresh wholesale cuts. Since this study defines the gross value of a carcass in terms of the value of its fresh wholesale products, it is assumed that all carcasses included in

[45] From data in Agriculture Canada, Food Systems Branch, "The Canadian Pork System", 1976, Chart 5, p. 66.

the analysis are acceptable for the production of fresh primal cuts.

An additional assumption is made in regards to small differences in the texture, marbling, or color of the meat which may exist between carcasses. These factors are not considered in the pricing of either retail or wholesale pork. Therefore, it is assumed that consumers distinguish pork quality on the basis of i) which part of the animal the pork meat comes from (i.e., certain retail pork cuts are valued more highly than others), and ii) the size of the particular retail pork cut. Other characteristics, such as texture, marbling, etc., are assumed not to affect consumers' definition of pork quality.

If quantitative measures of quality factors such as texture, marbling, etc., could be developed, and if consumers and packers were to include these factors in distinguishing pork quality, a grade-pricing system then would be required to determine the economic value of these characteristics in a pork carcass. Under this more discriminating definition of carcass quality, the household production function framework (which facilitates the valuation of a good according to the value of its individual characteristics) may be required for the estimation of quality-price differentials for pork carcasses.

3.2.2 Costs

The functions performed in transforming a live animal into wholesale-ready form include assembling, killing, dressing, chilling, cutting, and trimming. It is assumed that these functions are all performed on each animal, and that the sum of these costs constitutes the total cost of processing for each hog. Furthermore, it is assumed that the total cost is the same for each animal in a given time period, regardless of its physical characteristics. The nature of the assembling, killing, dressing, and chilling operations are such that the cost per-head of performing these operations is obviously constant across carcasses. With regards to cutting, each carcass is assumed to be broken (cut) to produce the same five primal cuts (ham, loin, belly, butt, and picnic), and since cutting is now a highly mechanized operation employing power knives and saws, it is reasonable to assume that cutting costs are also unaffected by physical characteristics such as carcass size or fat cover. Also, though carcasses differ in fat cover, it is assumed that this does not result in differential trimming costs per head. While fatter animals require that a greater amount of fat be removed, the difference in time required to remove a thin layer of fat as opposed to a heavy layer is assumed to be negligible. Finally, since it is assumed that total per-head processing costs are constant over all carcasses, when costs are expressed per unit weight of carcass, it follows that heavier carcassses are assumed to have a lower per-unit cost in comparison to lighter carcasses.

3.3 PRICE DETERMINATION FOR SLAUGHTER HOGS

Pricing efficiency requires that packers' preferences for slaughter hogs be communicated without distortion to producers through the medium of price.

3.3.1 The Base Price

The interaction of the derived demand for pork with the primary supply of slaughter hogs establishes their market price level, referred to here as the "base" price. Tomek and Robinson describe the concepts of primary and derived demand as follows:

> The ultimate consumer is the one who determines the shape and position of the demand function. For this reason, consumer demand relationships are often referred to as 'primary demand'.... The term 'derived demand' is used to denote demand schedules for inputs which are used to produce the final products."[46]

Similarly, "primary supply" refers to the supply schedules of raw product inputs (in this case, live slaughter hogs) while "derived supply" refers to supply schedules for products which have had utility of time, space, or form added to a raw product input. For the hog/pork sector, consumers determine the primary demand for retail pork cuts. This primary demand may be affected by things such as income levels, tastes, prices of substitute products, health fads, population changes, religious practices, et cetera. Retailers derive their demand for pork based on the retail value of pork and the costs incurred in pork retailing. Wholesalers (the wholesaling function is often performed by the packers themselves) likewise derive their demand for pork from the demand of retailers, less wholesaling costs. Packers then observe the wholesale demand for pork, and taking account of their processing costs, determine their derived demand for slaughter hogs.

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[46] W.G. Tomek and K.L. Robinson, Agricultural Product Prices, second edition, (London, England: Cornell University Press, 1981), p. 41.

In like manner, the primary supply of slaughter hogs is determined by producers. Their "supply price" is based on both their real and opportunity costs of production. Packers' supply price of pork then is determined by the addition of processing costs to the price paid for slaughter hogs. Wholesalers and retailers then add their respective costs to eventually determine the supply price of retail pork faced by consumers.

For a given point in time, in a given market, the base price is common to all slaughter hogs. It reflects the average value of a slaughter hog, given the existing derived demand and primary supply conditions in the market. Over time, this base price will change in response to any changes in the overall demand for pork and/or supply of hogs.

3.3.2 The Quality Price

Since hogs are not a manufactured, homogeneous commodity, the physical traits of individual animals are expected to differ. Certain traits (such as superior lean yield) result in an animal being of above average value to the packer, while other traits (such as excess fat cover) lead to a below average value. Price premiums and/or discounts reflecting these value differences constitute the "quality prices" (or "grade prices") paid for each hog. For pricing efficiency with respect to quality to be achieved, the quality prices paid for different carcass types should reflect packers' preferences for each carcass type. These preferences are based on the net values of individual carcasses compared to that of an average carcass. Therefore, if it is assumed that the purpose of a grade-pricing system is to improve the communication of packers' preferences to producers through appropriate prices, the performance of the system can be assessed by analyzing the relationship between the net value and the price paid for individual hogs. Such an analysis requires that the appropriate relationship between value and price first be identified.

3.4 PRICE IN RELATION TO VALUE

In 1969, Rawls determined the relationship required between value and price in order for packers' preferences to be communicated accurately to producers.[47] This was achieved by deriving the packers' input demand function for slaughter hogs. The derivation uses the "net value of the raw product approach", where the net value of the raw product input, slaughter hogs, is calculated by subtracting processing costs (which are defined to include an allowance for a normal rate of return for the processor) from the gross revenue per hog. In this approach, it is assumed that hogs are a necessary input which cannot undergo substitution. All other inputs, on the other hand, are allowed free substitution. The derivation begins with the premise that packers face a given price for each grade of hog. It is assumed that packers know the net value that can be obtained from each grade-type of hog. The quantity of raw product input use (i.e., the quantity of hogs demanded) which will maximize the firm's profits in the long run then is determined. Since price is assumed as given, this in effect derives the long run price-quantity

[47] Rawl's derivation is not repeated here. For the complete derivation and presentation of the theoretical conclusions the reader is directed to E.L. Rawls, "A Theoretical and Procedural Approach to Estimating the Differential Values of Pork Carcasses and Live Hogs," (unpublished Ph.D. dissertation, Virginia Polytechnic Institute, 1969), pp. 27-58.

equilibrium in the slaughter hog market. The relationship between the net value and the long run equilibrium price for each grade is thus established. This relationship is described by Rawls as follows:

> The prices P1 and P2 for hogs of Grades 1 and 2 are determined by the interaction of supply and demand in the marketplace. If at a given point in time and space the price of Grade 1 (P1) equals the price of Grade 2 (P2), the processor should continue to purchase and process each grade until NV1 (net value of Grade 1) = P1 = NV2 (net value of Grade 2) = P2. If Grade 1 has a greater yield of the higher value parts than Grade 2 and/or can be processed for a lower marginal cost than Grade 2 causing NV1 > NV2, then if the market is in equilibrium, P1 should exceed P2 by the same amount. In equilibrium, the difference in the net value for the two grades should be equal to the difference in their prices. If the (differences in) net values do not equal the difference(s) in prices, the firm is not maximizing its profits, and price differences are not reflecting the true differences in the value of the two grades to the processor.[48]

These theoretical conclusions were developed by Rawls to show the relationship required between the actual prices paid, and the net values of, different grades of hogs for the achievement of overall pricing efficiency in the slaughter hog market. These same conclusions can be applied to both the base price and the quality price components of total price. It will be shown in the following section that the implications arising from the application of these theoretical conclusions differ depending upon which component of price is being examined.

3.4.1 Base Price in Relation to Average Value

Pricing efficiency in the slaughter hog market requires that, for any given time period, i) the base price paid for slaughter hogs should equal the average net value of all grades of hogs to the packer, and ii) the quality price paid for each individual hog should equal the differ-

[48] Ibid., pp. 56-57.

ence of the net value of that animal from the average net value of all hogs.

The implications of requiring pricing efficiency with respect to the base price extend beyond the domain of a quality-pricing system. Since the theoretical conclusions of Section 1.4 are based on a definition of net value which includes an allowance for "normal" profits in the determination of processing costs, these conclusions imply that for pricing efficiency with repect to the base price to be achieved, packers cannot earn excess profits in their overall processing operations. The consistent presence of excess margins would imply that a lack of competition allows packers to overcharge their customers, underpay their input suppliers, or both. That is, a lack of competition may allow packers to exercise monopoly (or collusive oligopoly) power. Such a situation cannot be altered by the use of a grade-pricing system as such. The question of pricing efficiency in regards to the base price requires an analysis of the structure, conduct, and subsequent performance of the packing industry. The intent of this study does not include an examination of the degree of competition among packers. For this reason, the analysis does not include an examination of the base price in relation to the average value of hogs (and consequently, total price in relation to total net value is not a concern of this study). Rather, this study limits the role of a grade-pricing system to that of identifying the differences in value between animals, and establishing quality prices for slaughter hogs corresponding to these value differentials.

3.4.2 Quality-Prices in Relation to Differential Values

In reference to quality prices, the theoretical conclusions state that the difference between the price paid for an individual hog and the average price of all slaughter hogs should be equal to the difference between the net value of that animal and the average net value of all slaughter hogs. Since it has been defined that quality is determined by net value, the required condition for pricing efficiency with regards to quality is that price differentials must be equated to their corresponding net value differentials.

3.5 AN EMPIRICAL MEASURE FOR CARCASS QUALITY

The ability to predict net value differentials between animals is a crucial aspect of the performance of a grade-pricing system. More specifically, this is a function of the mechanism component of grade-pricing systems, since the mechanism has been defined to be concerned with the prediction of quality,[49] and quality has been defined as being determined by net value. To achieve the establishment of grade-prices reflective of net value differentials, a mechanism must be able to sort hogs according to their net value differentials. This requires that it recognize those factors which contribute to the differential values of animals at a given point in time, as well as those factors which can cause the structure of differential values between physical types of hogs to change over time.

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[49] See Chapter 1, Section 1.3.2

For a given point in time, it has been shown that the differential values between animals are determined by their composition, size, and the prices received for wholesale pork products. For a given point in time, then, a grade-pricing mechanism only need identify the absolute net value differentials between animals. The definition of grades in this case is straightforward; grades must simply reflect the absolute net value differences between animals.

When grades are defined to make them meaningful across time periods, their definition becomes more complicated. For a given sample of hogs, the net value differentials will change over time as changes occur in the relative structure of wholesale prices and processing costs. As a result, the absolute size of the net value differentials between any two animal types is likely to change over time. However, such changes do not always imply an accompanying change in packers' preferences for individual grades of hogs. For example, if prices for all wholesale pork products and processing costs all increase proportionately, due to inflation, the absolute net value per kg. differential between two carcasses will be affected (see Figure 3.1). However, nothing has occurred to make one carcass more "desireable" than the other. The desireability of one carcass in relation to another is measured in terms of the number of carcasses of type "A" a packer would be willing to give up in order to obtain one carcass of type "B". In Figure 3.1, we see that while the absolute difference in net value increased, the relative net value of Carcass A to Carcass B remained unchanged. This example illustrates that the preferences of packers for hog carcasses are best measured by relative, rather than absolute measures of their net value per unit weight.

Assume there are two grades of carcasses, "A" and "B", each yielding 2 wholesale pork products, "1" and "2". Also assume the absence of weight-based price differentials.

Time period 1

P1 = $2/kg. P2 = $1/kg. Proc. Costs = $10/head

Carcass	A	B
% Yield of Product 1	50	40
% Yield of Product 2	50	60
Carcass Weight	100	150
Weight of Product 1	50	60
Weight of Product 2	50	90
Total Value	$150	$210
Total Value/Carcass Weight	$1.50	$1.40
Proportional Value of A to B	1.50/1.40 = 1.07	
Processing Cost/Carcass Weight	$0.10	$0.07
Net Value/Carcass Weight	$1.40	$1.33
Proportional Net Value of A to B	1.40/1.33 = 1.05	
Absolute Net Value Diff. of A to B	1.40-1.33 = 0.07	

Time period 2

P1 = $4/kg. P2 = $2/kg. Proc. Costs = $20/head

Total Value	$300	$420
Total Value/Carcass Weight	$3.00	$2.80
Proportional Value of A to B	3.00/2.80 = 1.07	
Processing Cost/Carcass Weight	$0.20	$0.13
Net Value/Carcass Weight	$2.80	$2.67
Proportional Net Value of A to B	2.80/2.67 = 1.05	
Absolute Net Value Diff. of A to B	2.80-2.67 = 0.13	

Effect of a Proportionate Change in Wholesale Pork Prices and Processing Costs on Net Value Differentials

Figure 3.1: Quality Measured as Proportional Values

Thus, to examine how well a grade-pricing mechanism can predict quality differentials between animals for more than one time period requires that quality be defined in terms of the relative preferences of packers for hogs of different physical makeup. These can be expressed by measuring the net value (per unit weight) differentials between grades in terms of percentage differentials. For any given point in time, these percentage differentials can conveniently be expressed by comparing the value of each individual grade with that of a chosen "standard" grade. In this study, the standard grade is chosen (arbitrarily) to be that grade which returns an average net value to the packer. The quality of an individual carcass thus is measured by expressing its net value as an index of the average net value of all carcasses - i.e., a "value index" is calculated.[50]

The performance of a grade-pricing mechanism can, therefore, be empirically evaluated by comparing the value indices predicted by the mechanism with the actual calculated value indices between different physical types of hogs.

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[50] In the regressions described in Chapter 5, value indices for individual carcasses were expressed as the difference in the value index of an individual carcass from the average value index of 100; e.g., a carcass whose net value indexed at 105 percent of the average net value over all carcasses would receive an "value index" of 5.

3.6 SUMMARY

In chapter 1 the quality, and thus the grade of a slaughter hog was defined as being determined by the value of that animal to the packer. More specifically, it was shown that it is the net value (the difference between gross value and processing costs) which is of interest. The gross value of an animal was shown to be determined by percentage yield characteristics, the size of the primal cuts obtained, the prices for individual pork products, and the prices for specific weight ranges for individual cuts. It was assumed (for simplicity) that PSE and DFD syndromes are of no relevance in determining the net value of animals. It also was assumed that all carcasses are sold to the wholesale pork market in the form of fresh primal cuts. The total cost per animal incurred in processing a live animal into wholesale-ready form was assumed to be unaffected by the physical characteristics of the animal.

The price of slaughter hogs was shown to be determined by the interaction of the derived demand of packers and the primary supply from the farm level. The price for an individual animal was conceived to be composed of a base price and a quality price component. It was determined that a grade-pricing system can concern itself only with the establishment of appropriate quality prices. Applying the conclusions of a theoretical framework developed by Rawls in 1969 for the prediction of value differentials in hogs, the required condition for pricing efficiency with respect to quality was identified. It was shown that for any given point in time, the quality price for an individual animal should be equal to the difference of its net value from the mean net value. Alternative grade-pricing policies thus can be examined in reference to their effect on the market's ability to achieve this condition. Lastly, it was shown that for a grade-pricing mechanism to establish grade pricing efficiency, it must be able to predict accurately the percentage differentials in net value per unit weight between animals for any point in time.

Chapter IV

PROCEDURE FOR COMPARING QUALITY-PRICING MECHANISMS

This chapter describes the data and procedure employed in comparing the pricing performance of alternative quality-pricing mechanisms for pork carcasses. The objective of this comparative analysis is, as stated in Chapter 1, to evaluate the ability of various mechanisms to contribute to pricing efficiency. From this, a subsequent objective, that of determining whether the pricing efficiency of the Index 100 system could be improved through modification of its quality-pricing mechanism, will be addressed.

4.1 THE RAW DATA

To facilitate the empirical tests required for the above objectives, data was obtained from a cutout test performed on a stratified sample of 247 pork carcasses. A description of the cutout sample is contained in Appendix B. The "quality" (i.e., the value index) of each of the above carcasses was determined for each of 36 monthly time periods (spanning from January, 1980 to December, 1982, inclusive). Monthly average wholesale pork prices were used in calculating the values of these carcasses. These prices are more fully described in the following paragraphs, where the method and underlying assumptions employed in calculating the net value differentials for the sample carcasses are presented.

4.2 CALCULATING NET VALUE DIFFERENTIALS FOR THE SAMPLE CARCASSES

4.2.1 Gross Value

Approximately 52 percent of the weight of an average market hog is composed of primal cuts (see Figure 4.1), which are the main determinants of the gross value of an animal. By-products also contribute to the total gross value. Figure 4.1 illustrates that approximately 33 percent of an average market hog's weight is by-products (this figure includes fats used in rendering lard). It has been estimated that by-products add from 7 to 12 percent to the total value of a slaughter hog (when boning by-products are included).[51]

In this study, cutout data and prices were available for only a limited number of carcass by-products. Yields of sideribs, tenderloin, backribs, backfat, jowl, trim, tail, and hocks were observed for each sample carcass,[52] and were included in the carcass value calculations. Excluded from the valuation process were carcass by-products such as riblets, feet, head, tongue, kidneys, rind, neck bones, fin bones, and scraps. Slaughter by-products (such as blood, hair, heart, lungs, liver, and spleen) also were excluded. These excluded products are low in value ($/kg.) in comparison to the primal cuts, and it is reasonable to expect, therefore, that their contribution to the percentage differen-

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[51] R. Kennedy and M. Churches, Canada's Agricultural Systems, Dept. of Agricultural Economics, McGill University, Ste. Anne de Bellevue, Quebec, 1981, p. 13.25.

[52] Sideribs, tenderloin, backribs, jowl, and tail weights were directly observed for each carcass. Yields of the other by-products and miscellaneous cuts were obtained as follows: backfat was equal to rough weight of loin and butt minus commercial- trimmed weight of loin and butt (kidney fat also was included in the backfat category); weight of hocks was determined by subtracting commercial-trimmed picnic from rough picnic; trim was defined as the difference between commercial-trimmed and rough weight belly, less the weight of the sideribs.

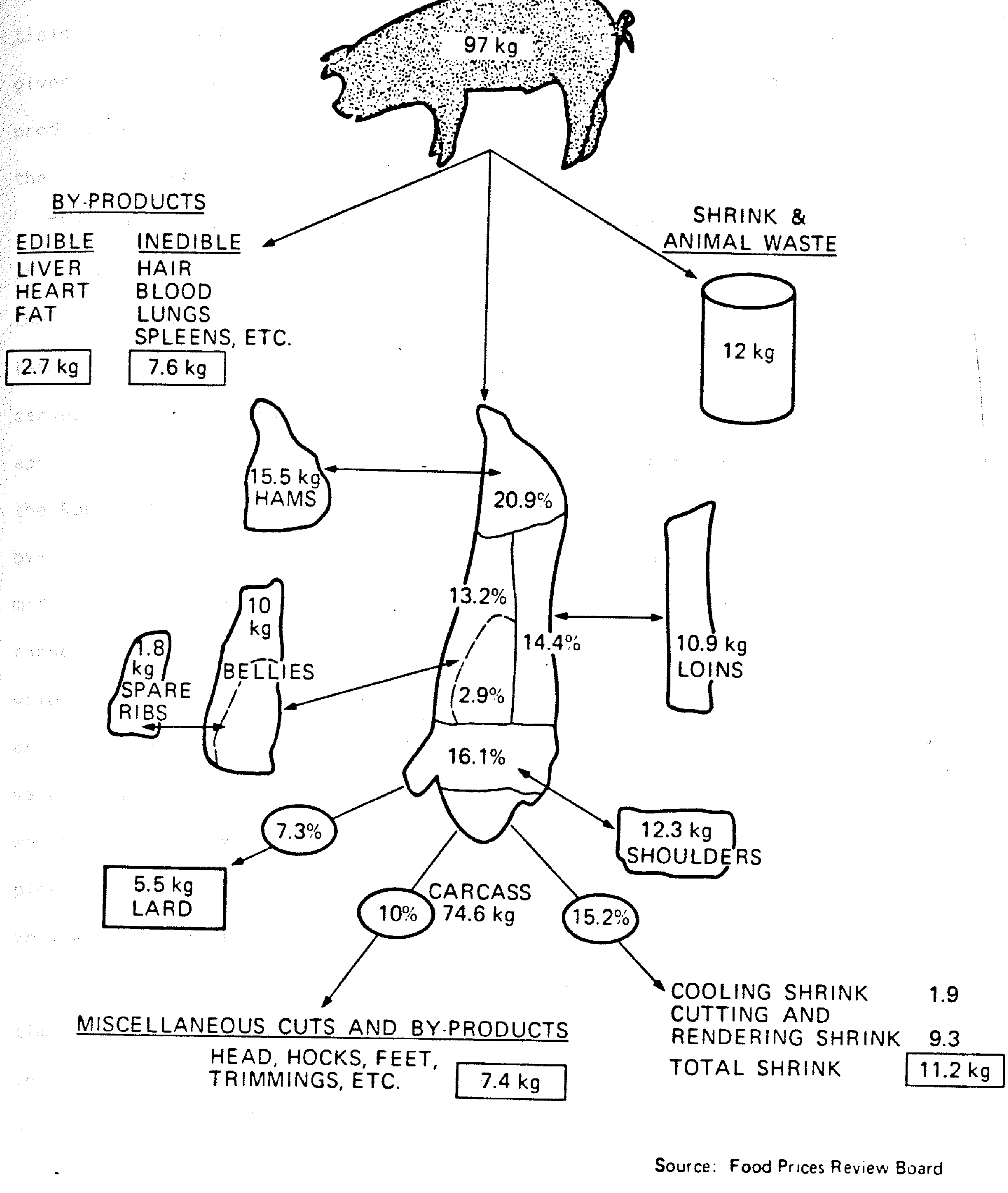

Figure 4.1: Approximate Disposition of a Market Hog

tials in net value between hogs would be minimal. This expectation is given further support when one considers that most of these excluded products are unlikely to differ greatly between animals in terms of their percentage yields.

The greatest part of carcass value is, of course, derived from the primal cuts (ham, loin, belly, and the shoulder, which is composed of the picnic and the butt). In this study, values of primal cuts were determined for each of the sample carcasses. For each time period observed, the commercial-trimmed weight of each cut was multiplied by an appropriate price. Primal cut prices were obtained from price sheets of the Ronald A. Chisolm Co. Ltd., as were the prices used in valuing the by-products and miscellaneous cuts.[53] The primal cut prices then were modified to reflect the intrinsic values associated with specific weight ranges within a given cut. Weight-based premiums and discounts were developed from the weight- range-specific price quotations for U.S. pork, as quoted in the National Provisioner "Yellow Sheets". Prices used in valuing primal cuts thus were dependent on both the type of cut, and its weight. Appendix C describes, by way of an example, the procedure employed in developing the weight-range-specific premiums and discounts applied in this study.

The gross value per 100 kg. for each carcass was determined for each time period by summing the products of the percentage carcass yields of the carcass components by their respective prices.

$$GV_{it} = P_{jt} Y_{ji}$$

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[53] Price quotes for pork trim were for trimmings of 35 percent lean content.

where:

GV_{it} = gross value per 100 kg. of carcass "i" in time period "t",

P_{jt} = price ($ per 100 kg.) for carcass component "j" in time period "t",

Y_{ji} = percentage yield of carcass component "j" from carcass "i".

This formula for calculating gross value is more fully described in Appendix C.

4.2.2 Processing Costs

Total processing costs per animal, as described in Chapter 3, were assumed to be constant across carcasses.[54] Processing costs per unit of carcass weight were therefore believed to decrease with increasing weight. Also, it was assumed that processing costs are not likely to change over short periods of time, since they depend upon factors such as wages and other input costs, and processing technology. These are expected to be fairly stable within a year, and so it was decided that yearly average processing cost data would be adequate for identifying changes in processing costs over time. Estimates of average processing costs per hog for an average-sized Canadian plant were provided by the Canada Meat Council. These estimates were: $7.50 (1980), $8.50 (1981), and $9.50 (1982).

For each carcass, processing costs per 100 kg. carcass weight were subtracted from gross value per 100 kg. to obtain the net value per 100 kg. carcass weight for each carcass in each time period.

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[54] No time and motion studies were found where processing time requirements were related to carcass physical characteristics, and therefore, the validity of this assumption could not be evaluated by referring to previous empirical studies.

$$NV_{it} = GV_{it} - C_{it}$$

where:

NV_{it} = net value per 100 kg. of carcass "i" in time period "t",

GV_{it} = gross value per 100 kg. of carcass "i" in time period "t",

C_{it} = processing costs per 100 kg. of carcass "i" in time period "t".

4.2.3 Net Value Percentage Differentials

In Chapter 3, it was defined that the quality of a carcass could be quantified by its "value index", i.e., "the difference (percent) in the net value of carcass "i" from the mean net value over all carcasses". If we denote this measure by Y , then

$$Y_{it} = ((NV_{it} - \overline{NV}_t)/\overline{NV}_t)100$$

where:

$\overline{NV}_t$ = mean net value per 100 kg. over all carcasses in time period "t".

Subsequent tests of the pricing efficiency achieved by various quality- pricing mechanisms were based on their ability to realistically model the relationship of value indices to carcass measurements such as backfat and weight, and their ability to predict value indices for any carcass in any time period.

4.3 PROCEDURE FOR COMPARING ALTERNATIVE MECHANISMS

An objective of this thesis is to compare alternative grade-pricing mechanisms in terms of grade-pricing performance. As described in Chapter 1, Section 1.3, grade-pricing mechanisms are the processes or techniques for achieving grade-pricing efficiency. In Chapter 3, it was concluded that grade-pricing efficiency is achieved when a grade-pricing mechanism assigns to pork carcasses value indices exactly equalling their actual value indices. In Chapter 2, a review of the relevant literature revealed that existing and proposed grade-pricing mechanisms in Canada and the U.S. differ with respect to i) the carcass measurements used to indicate carcass quality, and ii) the procedure used in determining the index discounts or premiums associated with the chosen carcass measurements. In this section, procedures are presented which will facilitate the comparison of alternative sets of carcass measurements and alternative grade-pricing procedures to determine their effect on the ability of a grade-pricing mechanism to assign appropriate value indices to pork carcasses.

4.3.1 Alternative Sets of Carcass Measurements

Six alternative sets of carcass measurements will be examined. The scope of the measurements is limited to those contained within the cutout data supplied by Agriculture Canada. Since the measurement of carcass weight is required to determine total payment for a carcass, warm carcass weight is included in each of the six combinations. The six combinations are described below (with the understanding that carcass weight is included in each).

1. The sum of maximum fat thickness at the shoulder and loin (measured in inches using a ruler). This was the measurement used in the Index 100 system prior to March, 1982.
2. A single measurement of maximum loin fat thickness (measured in inches using a ruler). This measurement currently is used in the Index 100 grade-index table.
3. A single fat measurement at the last rib, 70 millimeters (mm.) off the dorsal midline (measured in mm. using an electronic probe). The NPPC Pork Value Task Force used a last rib fat measurement in constructing their "Pork Value Guide" grade-index table.
4. A single fat measurement at the 3-4th last rib interface, 70 mm. off the dorsal midline (measured in mm. using an electronic probe). A recent Agriculture Canada study showed this measurement provided superior predictions of lean yield in comparison to last rib fat thickness.[55]
5. The last rib fat measurement described above, plus an accompanying measurement of muscle depth at the last rib (measured in mm. using an electronic probe).

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[55] A. Fortin, S.D.M. Jones, and C.R. Haworth, "Test of Electronic Probes for Grading Hog Carcasses", a report prepared for a Canadian Steering Committee on Electronic Hog Grading, Oct. 22, 1982.
This study also examined probe sites at the 4-5th and 5-6th last ribs, using the same electronic probe. When the same probe was used on the last rib, 3-4th, 4-5th, and 5-6th last rib sites, the 3-4th rib site was slightly superior in predicting commercial yield. For this reason, of the 3-4th, 4-5th, and 5-6th rib sites, only the 3-4th rib site was examined in the current study.

6. The 3-4th last rib fat measurement described above, plus an accompanying measurement of muscle depth at the 3-4th last rib (measured in mm. using an electronic probe).

Hereafter, these combinations are referred to as "trials" 1 through 6, respectively.

A recent study by Agriculture Canada animal scientists[56] showed 3-4th last rib fat and muscle thickness produced slightly higher R-square values in comparison to last rib fat and muscle thickness, when carcass yield was the dependent variable. Similarly, last rib fat and muscle thickness produced higher R-square values in comparison to 3-4th last rib fat thickness alone, which produced higher R-square values in comparison to last rib fat thickness alone. In a previous study,[57] a single (ultrasonic) fat measurement at the last rib was found to produce higher R-square values in comparison to a sum measurement of fat thickness at the loin and shoulder, which in turn produced a higher R-square than did a single fat thickness measurement at the loin (with carcass yield as the dependent variable).

From the above results, the six combinations of carcass measurements can be ranked according to their ability to predict carcass yield. In descending order, the ranking is: trial 6, trial 5, trial 4, trial 3, trial 1, and trial 2.

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[56] Ibid.

[57] A. Fortin, A.H. Martin, D.W. Sim, H.T. Fredeen, and G.M. Weiss, "Evaluation of Different Ruler and Ultrasonic Measurements as Indices of Commercial and Lean Yield of Hog Carcasses for Commercial Grading Purposes", Canadian Journal of Animal Science, vol. 61, Dec., (1981), p. 898.

It is plausible that a similar ranking would occur when the dependent variable is carcass quality as measured by carcass value indices. However, the relationship of carcass dollar value to carcass yield is dependent upon wholesale prices for pork cuts, making direct extrapolation from the carcass yield-carcass measurements relationship to the carcass value-carcass measurements relationship somewhat tenuous.

Using carcass value index as the dependent variable, the six combinations of carcass measurements examined in this study will be ranked according to their ability to explain the variation of the dependent variable (based on R-square values, and the standard errors of the estimated coefficients for these variables). In addition, practical measures of the degree to which the alternative combinations contribute to grade-pricing efficiency will be developed by observing how closely assigned value indices based on each of the six sets of carcass measurements match actual value indices.

Therefore, two hypotheses regarding the choice of carcass measurements in a grade-pricing mechanism will be addressed. These are:

1. Ranking carcass measurements according to their ability to explain carcass value will produce the same result as ranking carcass measurements according to their ability to explain carcass yield.
2. The choice of carcass measurements used in a grade-pricing mechanism has no significant effect on grade-pricing efficiency.

4.3.2 Alternative Grade-Pricing Procedures

From the review of the relevant literature presented in Chapter 2, and the historical background information presented in Appendix A, three general principles applied in the development of grade-pricing procedures can be identified. These three principles are described below, followed by a brief description of how these principles have been applied in the development of grade-pricing mechanisms for pork carcasses in North America.

1. The adjustment of the grade-index premiums and discounts associated with the chosen carcass measurements in response to short term (seasonal) fluctuations in the actual relationship of carcass value to carcass measurements.
2. The adjustment of the premiums and discounts in response to an underlying trend in the actual relationship of carcass value to carcass measurements.
3. Adjusting the pattern of the grade-index premiums or discounts associated with incremental differences in carcass measurements, depending upon the carcass weight range, and/or the carcass backfat thickness range.

Principle 1 -- A number of studies have recognized that seasonal fluctuations in the wholesale prices paid for pork cuts can result in seasonal fluctuations in the relationship of carcass value to carcass measurements. In a recent U.S. study, the NPPC noted the possible desireability of adjusting the grade-price premiums and discounts associated with carcass weight in response to seasonal fluctuations in the weight-based discounts for wholesale pork cuts.[58] Earlier, Ikerd and Cramer had proposed a system by which appropriate seasonal adjustments to the premiums and discounts are determined based on current wholesale pork prices.[59] These and other studies have indicated that seasonal adjustments to a grade-pricing system for pork carcasses may improve grade-pricing efficiency. This hypothesis will be addressed in this section as follows:

1. Adjustment of the grade-index premiums and discounts associated with the chosen carcass measurements in response to short term fluctuations in the carcass value-carcass measurements relationship has no significant effect on grade-pricing efficiency.

Principle 2 -- Appendix A describes how grade-pricing standards for pork carcasses in both Canada and the U.S. continually have been updated in response to trends in consumer preferences (which are reflected in wholesale pork prices) and in the physical traits of the hog population. However, these revisions have not occurred regularly. For example, the Canadian Index 100 grade-index table was revised in January, 1979, but then remained unchanged until March, 1982; a period in excess of two years.

It is unclear as to how often a grade-pricing system should be adjusted in response to trends in the relationship of carcass value to carcass measurements, if value indices assigned by the system are to

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[58] Pork Value Task Force Report - Technical Appendix, undated, primary authors M. Hayenga (Iowa State University), R. Kauffman and B. Grisdale (University of Wisconsin), pp. 13-16.

[59] J.E. Ikerd and C.L. Cramer, "A Practical Computer Method for Pricing Pork Carcasses and Hogs", American Journal of Agricultural Economics, vol. 52, 1970, pp. 242-246.

closely reflect the actual value indices of carcasses. In light of this uncertainty, the following hypothesis will be addressed:

2. Adjustment of the grade-price premiums and discounts associated with carcass measurements in response to underlying trends over time in the carcass value-carcass measurements relationship has no significant effect on grade-pricing efficiency.

Principle 3 -- The relationship of carcass value to carcass measurements also has been recognized as being unstable when observed over subsamples of specific carcass types. For example, in the Index 100 table of grade indices, the pattern of the discounts associated with incremental increases in backfat varies according to carcass weight range (see Figure 4.2b). Alternatively, the NPPC's Pork Value Guide grade-index table maintains a constant index-discount for increasing backfat for all carcass weight ranges (see Figure 4.2a). How much, if anything, does the NPPC guide give up in terms of grade-pricing efficiency by not applying the principle followed in the Index 100 system? In response to this question, the following hypothesis will be addressed:

3. Grade-pricing efficiency is not affected significantly by adjusting the grade index premiums or discounts associated with incremental differences in carcass measurements, depending upon carcass backfat or carcass weight range.

An evaluation of the merit of applying the above principles to the development of grade-pricing mechanisms for pork carcasses will be conducted in two stages. In the first stage, the sample data acquired for this study will be used to examine the structure of the relationship of

A) NPPC Pork Value Guide

Last rib fat thickness (inches)

Carcass Wt. (lb.)	0.7	0.8	0.9	1.0	1.1	1.2	1.3
i) 146-153	104	103	102	101	100	99	98
ii) 154-161	104	103	102	101	100	99	98
iii) 162-168	104	103	102	101	100	99	98
iv) 169-175	103	102	101	100	99	98	97
v) 176-182	102	101	100	99	98	97	96
vi) 183-190	101	100	99	98	97	96	95
vii) 191-197	100	99	98	97	96	95	94
viii) 198-204	99	98	97	96	95	94	93
ix) 205-212	98	97	96	95	94	93	92

B) Index 100

Loin Fat Thickness (inches)

Carcass Wt. (lb.)	< 0.8	0.8	0.9	1.0	1.1	1.2	1.3
i) 140-149	108	107	105	103	102	100	98
ii) 150-159	110	108	107	105	103	102	100
iii) 160-169	113	112	110	108	107	105	103
iv) 170-179	114	113	112	110	108	107	105
v) 180-189	113	112	110	108	107	105	103
vi) 190-199	112	110	108	107	105	103	102
vii) 200-299	90	90	90	90	90	90	90

Figure 4.2: Backfat Discounts -- NPPC Guide vs. Index 100

carcass value to carcass measurements.[60] That is, conclusions will be drawn (based on the sample data) as to whether the relationship of carcass value to carcass measurements exhibits seasonal fluctuation or an underlying trend in the response of carcass value to backfat and weight, or an instability in the response of carcass value to backfat and weight when observed over subsamples of specific carcass types. The three principles described above will be examined in light of these conclusions. Those principles conforming to the actual structure of the relationship of carcass value to carcass measurements then will be included in the second stage evaluation.

The second stage evaluation will measure the effect of the application of the three principles on grade-pricing efficiency. This will be accomplished in the following manner. Using the raw data (consisting of cutout data for a stratified sample of 247 carcasses, and 36 sets of monthly average wholesale pork prices spanning the period January, 1980, to December, 1982) value indices will be calculated for each of the sample carcasses for each of the sample months. Procedures then will be developed in which value indices are assigned to the sample carcasses, following each of the three grade-pricing principles. Comparing the value indices assigned by these procedures to the sample carcasses to the actual calculated value indices for the sample carcasses will provide a measure of the grade-pricing efficiency attained by these procedures. Similarly, procedures will be developed in which the three

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[60] The carcass measurements used in these tests were carcass weight and the sum of maximum loin and shoulder fat. This particular fat measurement was chosen for this portion of the analysis somewhat arbitrarily, mainly because of its familiarity to the Canadian hog/pork sector.

grade-pricing procedures are not applied. The grade-pricing performance of these procedures also will be measured. Then, by comparing the performance of procedures which do not apply a given principle to the performance of procedures which do apply the principle, one can gauge whether the application of the principle improves grade-pricing performance, and if so, to what extent.

4.3.3 Measures of Grade-Pricing Performance

As described above, the grade-pricing performance obtained by the various procedures tested will be evaluated by comparing value indices assigned by a given grade-pricing procedure to the actual calculated value indices. The two measures of pricing performance used are i) bias, and ii) precision. These measures,[61] and an interpretation of their meaning, follow.

4.3.3.1 Grade-Pricing Bias

Bias in the assigned value indices will be evaluated by regressing actual carcass value indices versus assigned indices. In the absence of bias, the estimated intercept of such a regression will equal zero, and the estimated coefficient will equal one. An example of bias is presented in Figure 4.3. From the example, one can see that bias measures whether the index premiums and discounts associated with varying values in the chosen carcass measurements accurately reflect the actual effect of incremental changes in the carcass measurements on carcass value. Thus, a measure is provided as to how closely the grade-price signal

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[61] Similar measures were used by J.E. Ikerd and C.L. Cramer, op. cit.

generated by a given grade-pricing mechanism reflects the actual relationship of carcass value to these measurements.

In the case of positive bias (as illustrated in Figure 4.3), value indices for carcasses of below-average value will be expected to be underestimated, while value indices for carcasses of above-average quality will be expected to be overestimated. Under such circumstances producers who consistently deliver hogs of above-average quality will tend to receive grade-price premiums larger than what is justified by the extra value realized from these hogs by packers. Conversely, below-average quality hogs will tend to receive grade-price discounts larger than what is justified by the lesser value realized from these hogs by packers. The opposite situation would exist in the case of negative bias.

4.3.3.2 Grade-Pricing Precision

Grade-pricing precision refers to the variation of predicted around actual value indices; i.e., the degree of confidence one has that the value index predicted for an individual carcass is within a certain range of its true value index. It was measured by calculating the standard deviation of the residual "actual carcass value index minus predicted index". Knowing the standard deviation of this residual value, one can calculate the overall probability that predicted value indices for individual carcasses will be within a given range of their actual value indices.[62] For each precision score calculated, accompanying fig-

[62] Note that precision refers to the <u>overall</u> probability that predicted value indices will be within a given range of actual value indices. If zero bias exists, then all grades of carcasses are equally likely to be assigned value indices within a given range of their true value indices. But if bias exists, then the probability that a carcass will be assigned a value index within a given range of its actual

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A_i = Actual carcass value index (difference from mean) for carcass "i"
P_i = Predicted (assigned) carcass value index (difference from mean) for carcass "i"
For any given time period, $\overline{A} = 0$
Any of the pricing models will produce values of P_i such that $\overline{P} = 0$

To test for bias, regress A_i on P_i, obtaining, for example,

$$\hat{A}_i = 0 + 0.8P_i \pm e$$

Bias is indicated since $0.8 \neq 1.0$. To indicate what this means, assume that carcass value indices are a function of backfat thickness (expressed as differences from the mean) alone, and that the relationship is as follows:

Backfat	-4	-3	-2	-1	0	1	2	4	4
A	4	3	2	1	0	-1	-2	-3	-4
P	5.00	3.75	2.50	1.25	0	-1.25	-2.50	-3.75	-5.00

If we judge the quality of carcasses of varying backfat thickness on the basis of predicted value indices, we would overestimate the impact of backfat on carcass quality. The size of the premiums and discounts would be too large. This will be referred to as positive bias. Alternatively, negative bias will refer to the underestimation of the impact of carcass traits on carcass quality (i.e., the size of the premiums and discounts are too small).

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Figure 4.3: Example of Bias in Quality-Pricing Accuracy

ures were calculated to indicate i) the probability of predicting within two index points of actual quality, and ii) the range ($\pm$ "n" index points of the actual value index) within which 80 percent of the predicted value indices for individual carcasses would be expected to fall.

4.3.4 Drawing Inferences About Alternative Grade-Pricing Mechanisms

The objective of the comparative analysis is to determine the influence of the choice of carcass measurements and the choice of grade-pricing procedure on the ability of a grade-pricing mechanism to assign correct value indices to carcasses. On an a priori basis, it is unclear whether the choice of grade-pricing procedure will affect the grade-pricing performance achieved by the alternative sets of carcass measurements. Likewise, it is unclear whether the choice of carcass measurements will affect the grade-pricing performance scores of the alternative grade- pricing procedures. Therefore, in order to draw valid inferences with respect to the relative grade-pricing performance of the alternative carcass measurements and grade-pricing procedures, i) the grade-pricing performance of any given grade-pricing procedure will be evaluated for different combinations of carcass measurements, and ii) the effect of the choice of carcass measurements on grade-pricing performance will be evaluated for different grade-pricing procedures.

This procedure will be more fully explained by working through an example. In Chapter 5, Section 5.1.2.1, the following hypothesis (in an abbreviated form) is addressed:

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value index decreases as actual value indices deviate from the average (100) index.

1. Using a seasonally adjusting grade-pricing procedure has no significant effect on i) grade-pricing bias, i) grade-pricing precision, or iii) the practical achievement of grade-pricing efficiency in the slaughter hog market.

This general hypothesis actually contains three separate hypotheses, each of which will be addressed separately, below.

<u>Hypothesis 1 -- Grade-Pricing Bias</u>

Since grade-pricing bias is evident when the "bias score" obtained by a procedure does not equal one, the hypothesis can be stated as:

1. The bias score obtained by a procedure which does not adjust seasonally will be equal to the bias score for a procedure which does adjust seasonally.

Two grade-pricing procedures, one which accounts for seasonality, and one which does not, will be used to predict (i.e., assign) value indices for each of the sample carcasses. These assigned value indices will be compared to the calculated value indices for these carcasses, using the "bias" measure of grade-pricing efficiency. This will be repeated for twelve months of price data (i.e., for twelve sets of assigned and calculated value indices). For each month, the bias score obtained for the procedure which does not account for seasonality will be tested to determine whether it differs significantly from the bias score for the procedure which does account for seasonality. Normally, in choosing a level of significance, a level of either 10, 5, or 1 percent is chosen. This limits the probability of making a Type 1 error. However, as the probability of making a Type 1 error is decreased, the probability of making a Type 2 error increases. For the above hypothesis, Type 1 and Type 2 error are as follows:

Type 1 error: Deciding that not accounting for seasonality has an effect on grade-pricing bias when actually it doesn't;

Type 2 error: Deciding that not accounting for seasonality has no effect on grade-pricing bias when actually it does.

In this case, there is a desire to avoid committing both Type 1 and Type 2 error.[63] Because of the strong desire to limit the probability of committing Type 2 error, a significance level of 20 percent is chosen.[64] In comparison to the the traditionally chosen significance level of 5 percent, this increases the probability of making a Type 1 error, but decreases the probability of making a Type 2 error. All subsequent tests performed in this study for the purpose of detecting the presence of significant grade-pricing bias use 20 percent as the critical level of significance.

<u>Hypothesis 2 -- Grade-Pricing Precision</u>

In comparing a seasonally adjusting grade-pricing procedure to one which does not adjust seasonally, the hypothesis with respect to grade-pricing precision is:

1. The precision score obtained by a procedure which does not adjust seasonally will not be inferior to (i.e., larger than) the precision score obtained by a procedure which does adjust seasonally.

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[63] That is, it is assumed that the hog/pork industry is averse to having "less than the best possible" grade-pricing performance, in addition to being averse to making a change to a grade-pricing system that produces no improvement in grade-pricing performance.

[64] Two-tailed t-tests will be used to test for significant differences in bias scores.

The carcass value indices assigned by two grade-pricing procedures (one which accounts for seasonality and one which doesn't) to the sample carcasses will be compared to calculated value indices for these carcasses. How closely assigned value indices match actual value indices are to be measured in terms of grade-pricing precision scores. As with the test for bias, there is a concern to avoid committing either Type 1 error or Type 2 error. Because of the strong desire to limit Type 2 error, the 20 percent level of significance is chosen as the critical level of significance for all subsequent tests regarding the significance of improvements in grade-pricing precision.[65]

Validation of Conclusions Reached for Hypotheses 1 and 2

As stated at the beginning of this section, it is unclear whether in testing alternative grade-pricing procedures, the results obtained will in some way be dependent upon the carcass measurements used in these procedures. Similarly, in comparing the grade-pricing performance of alternative sets of carcass measurements, it is unclear whether the results will be affected by the grade-pricing procedure in which the alternative measurements are applied. In response to this problem, each grade-pricing procedure will be tested using each of the six alternative sets of carcass measurements. Similarly, each set of carcass measurements will be tested using three different grade-pricing procedures; one which adjusts over time, one which adjusts over carcass types and time,

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[65] Since this test involves the comparison of two variances, an F-test is used. Because in an F-statistic the numerator always consists of the larger of the two variance measures being compared, and the denominator is the smaller measure, in using the F-test to compare precision scores the test measures whether the numerator is significantly larger than the denominator. Therefore, a one-tailed test is used.

and one which does not adjust over carcass type or time. Thus, each test of a given grade-pricing procedure will be conducted six times (once for each set of carcass measurements), and each test of a given set of carcass measurements will be conducted three times (using three different grade-pricing procedures). If the results for a given test are consistent across the various trials, this will indicate the validity of these test results.

Hypothesis 3 -- Practical Achievement of Grade-Pricing Efficiency

Comparing a seasonally adjusting grade-pricing system to one which does not adjust seasonally, the question of ultimate concern is whether or not the practical application of a seasonally adjusting system is worth pursuing. Thus, the hypothesis of interest is:

1. The application of a seasonally adjusting grade-pricing system would not produce a significant improvement in the practical achievement of grade-pricing efficiency.

To address this question, statistical tests of significance are not used. Rather, the probable benefits and costs asociated with the establishment of a seasonally adjusting system will be identified, and weighed against each other in a descriptive analysis.

Chapter V

RESULTS AND INTERPRETATION

The results of the analysis of alternative grade-pricing procedures first are presented. These include the results of tests on the sample data to determine the behavior of the relationship of carcass value to backfat thickness and carcass weight as observed over time and as observed over subsamples of specific carcass types. Subsequently, following the procedure outlined in Chapter 4, various grade-pricing procedures are examined to determine their effect on grade-pricing efficiency. The effect of the choice of carcass measurements on grade-pricing performance then is examined.

5.1 CHOICE OF GRADE-PRICING PROCEDURE

5.1.1 The Relationship of Carcass Value to Carcass Measurements

5.1.1.1 Behavior Over Time

Thirty six sets of actual carcass value indices were calculated for the sample carcasses, using the thirty six sets of monthly average wholesale pork prices. Ordinary Least Squares regressions of the dependent variable, "value index", on the independent variables "backfat" (the sum measurement of fat thickness at the shoulder and the loin measured in inches by a ruler) and "warm carcass weight" (kg.)[66] then

[66] The independent variables were expressed in difference from the mean form, as was the dependent variable, the percentage difference in the value of carcass "i" in time period "t" from the mean value of all carcasses in time period "t".

were performed. Each of the thirty six sets of value indices were regressed on the backfat and weight measurements for the sample carcasses. Thus, a time series of thirty six estimated regression coefficients for backfat and weight was produced.

Two non-parametric tests, one for trend (initially suggested by Mann,)[67] and one for cyclical movements (initially suggested by Wallis and Moore)[68] were applied to the above series of coefficients.[69] On the basis of these tests, it was concluded that the response of carcass value indices to backfat thickness exhibited a positive trend over the observed time span, but that periodic movement was absent. On the other hand, the response of value indices to carcass weight exhibited significant periodicity, but no significant trend.[70]

A visual inspection of Figures 5.1 and 5.2, showing plots of the estimated backfat (Figure 5.1) and weight (Figure 5.2) coefficients versus time, reveals patterns concurring with the above results. The positive trend in the backfat coefficients indicates that (for the carcass sample studied here) comparing 1980 to 1982, a deviation in the backfat thick-

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[67] H.B. Mann, "Non-Parametric Tests Against Trends," Econometrica, vol. 13, (1945), p. 246.

[68] W.A. Wallis and G.H. Moore, "A Significance Test for Time Series Analysis," Journal of the American Statistical Association, vol. 30, (1941), p. 401.

[69] These tests are presented in G. Tintner, Econometrics, (New York: John Wiley and Sons, Inc., 1952), pp. 211-215 (trend test) and pp. 234-238 (test for cyclical movements), and are described in Appendix D.1.

[70] This analysis and the subsequent analysis in this study assumes that the estimation of the quality-carcass measurements relationship is not adversely affected by violations of the assumptions of ordinary least squares regression. Appendix E presents tests which revealed that neither multicollinearity nor heteroscedasticity were present in this relationship to any serious degree.

ness of an individual carcass from the average backfat thickness has had a less severe impact upon carcass value indices. This may reflect an observed trend in wholesale pork prices; for the 36 month time span under study, the price difference between hams (the largest lean cut in a carcass) and bellies has exhibited a decreasing trend (see Figure 5.3). Since the percentage carcass yield of belly is positively related to backfat thickness,[71] a relative increase in the value of bellies in comparison to other cuts would result in a smaller "penalty" being associated with increasing backfat thickness.

An explanation for the observed cyclical movements in the weight coefficients can be found in the seasonal patterns in consumer demand for various pork cuts. In particular, the price difference between light and heavy hams follows a distinct seasonal pattern (see Figure 5.4). Comparing Figures 5.4 and 5.2, the troughs in the estimated weight coefficients directly coincide with the peaks in the price discount for heavy hams. For example, during the Easter and Christmas seasons, when whole hams are likely to be in high demand, the price difference between light and heavy hams increases dramatically. During these same seasons, the estimated weight coefficients take on their greatest negative values. Also, it should be noted that while the seasonal fluctuations in the magnitude of the weight coefficients may, in theory, reflect seasonal changes in the average weight of the slaughter hog population, this is unlikely since Canadian hogs generally are raised in confinement, resulting in relatively constant management practices

[71] See A.H. Martin, H.T. Fredeen, G.M. Weiss, A. Fortin, and D. Sim, "Yields of Trimmed Pork Product in Relation to Weight and Backfat Thickness of the Carcass," Canadian Journal of Animal Science, vol. 61, (1981), p. 306.

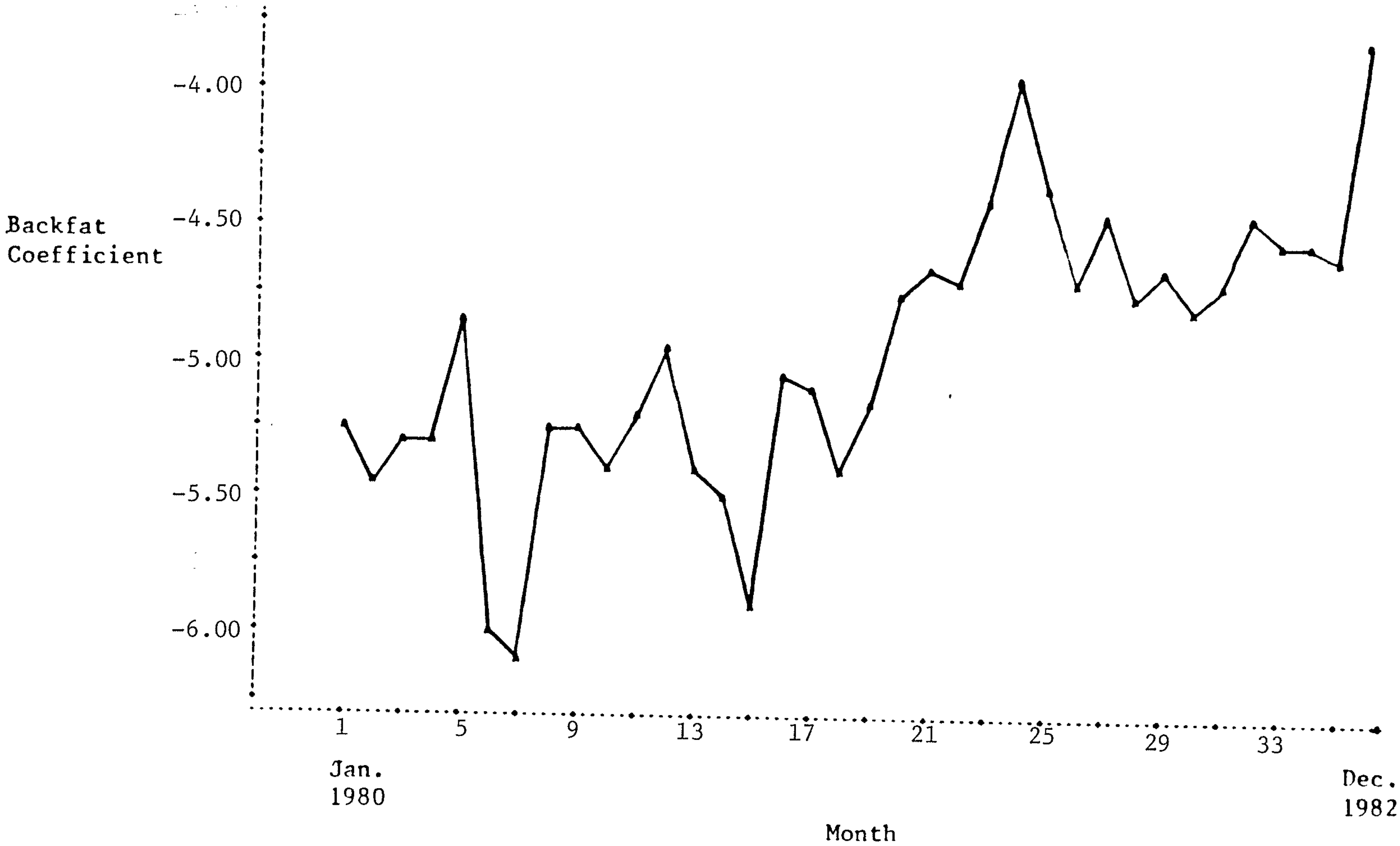

Figure 5.1: Plot of Estimated Backfat Coefficients Over Time

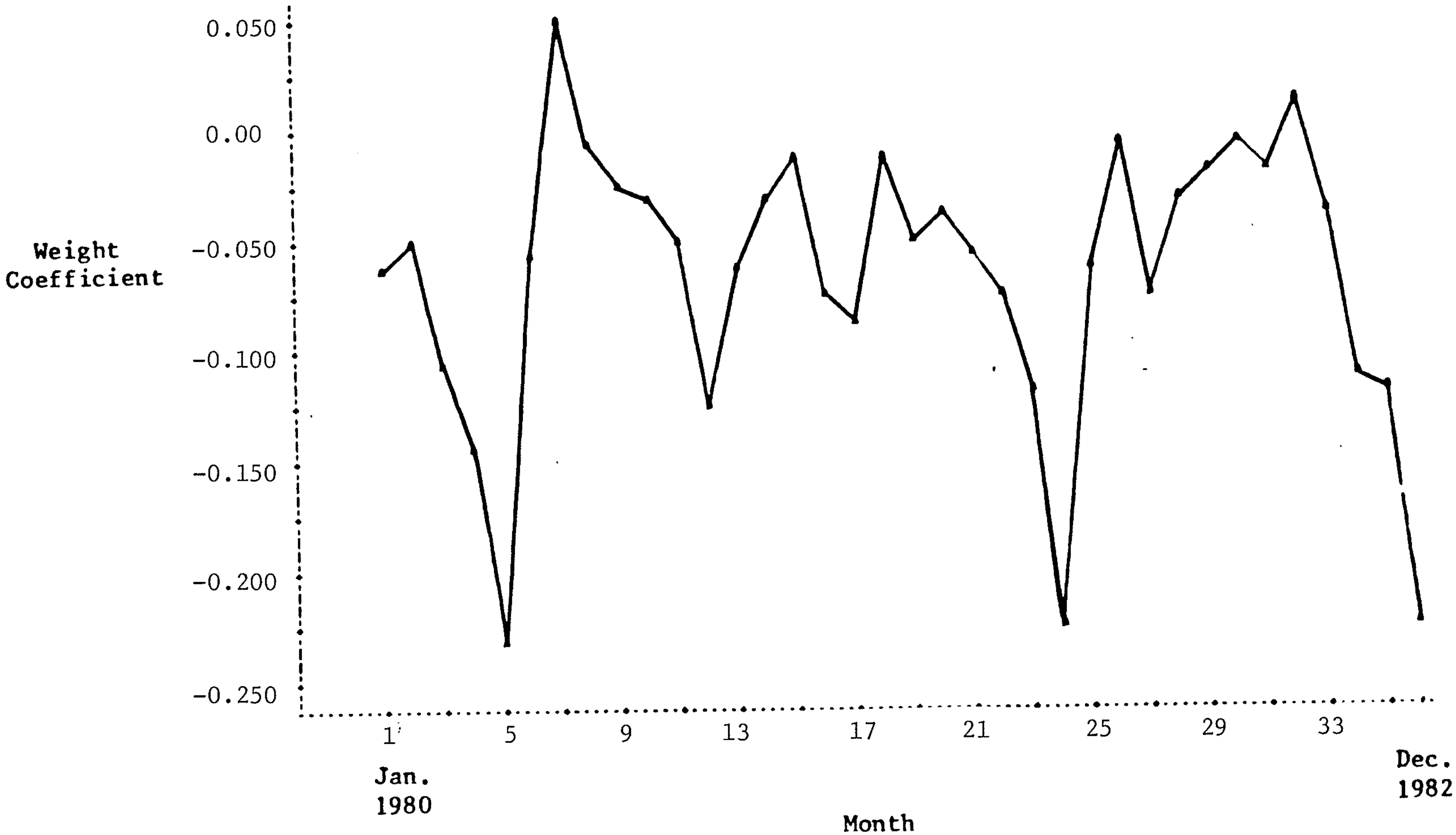

Figure 5.2: Estimated Weight Coefficients Over Time

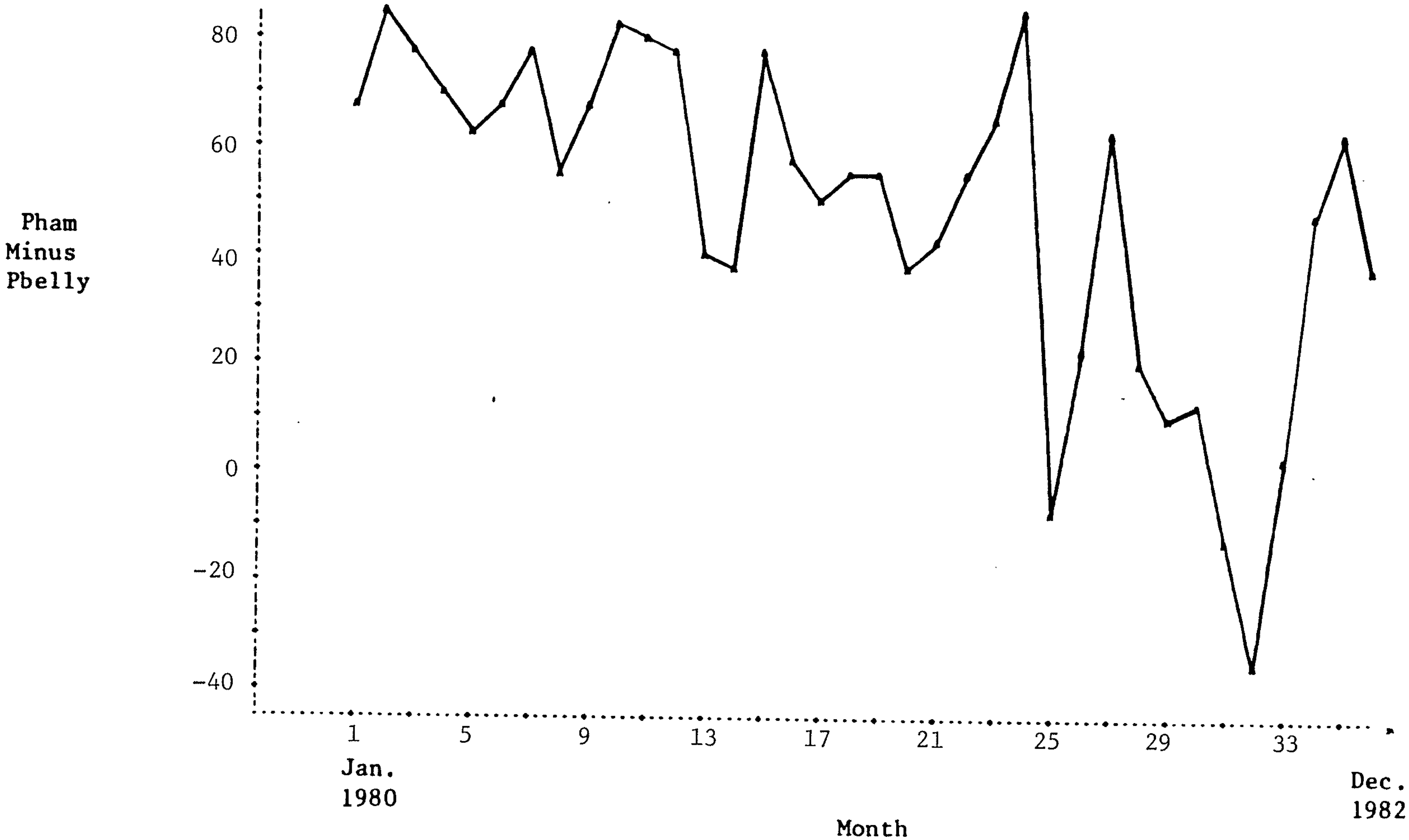

Figure 5.3: Price Difference Between Hams and Bellies Over Time

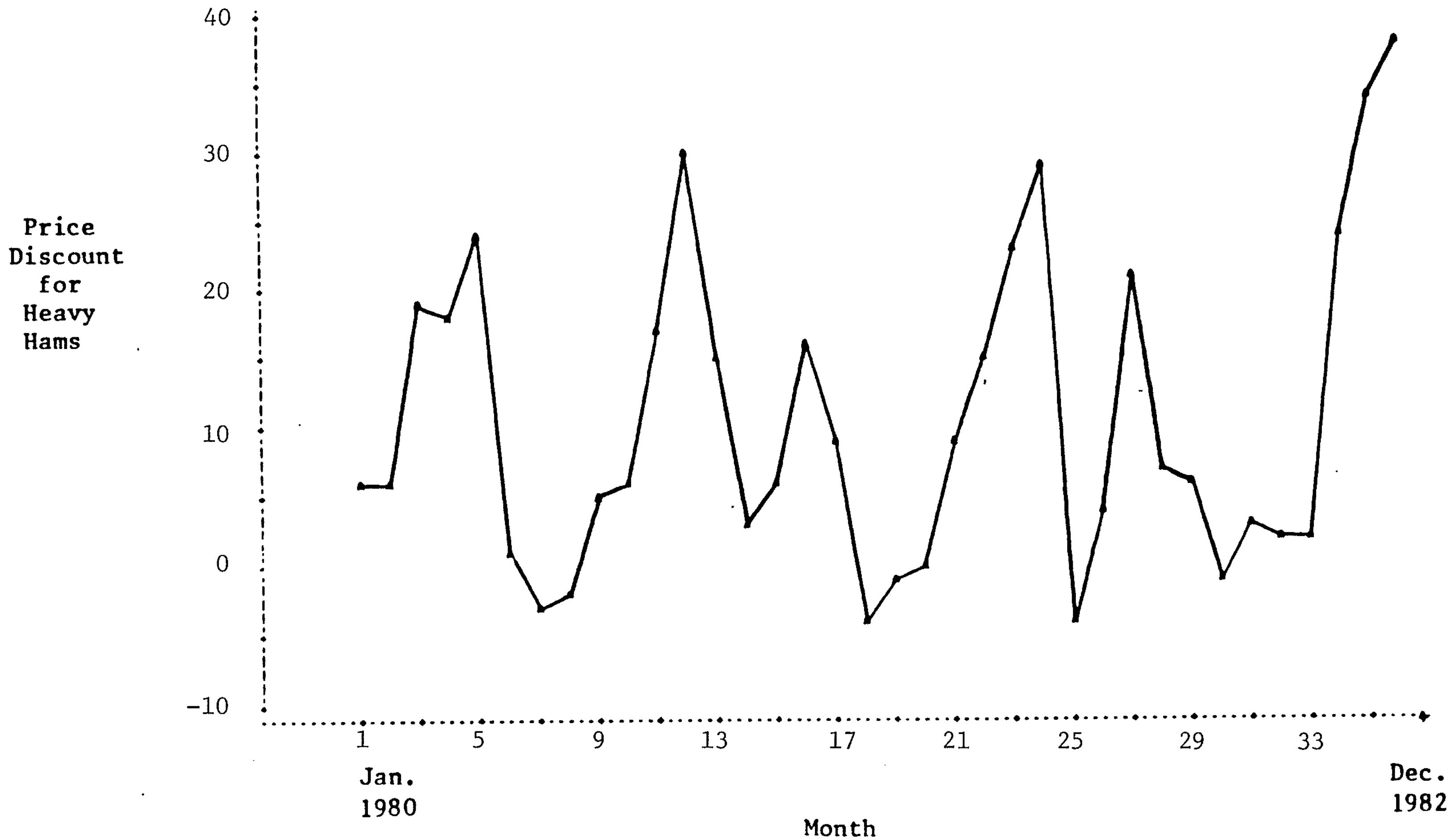

Figure 5.4: Price Discounts Between Light and Heavy Hams Over Time

throughout the year.[72] Hence, the physical traits of the pork carcass population are expected to be stable throughout the year.

5.1.1.2 Behavior Over Different Carcass Types

Classifying the sample carcasses according to carcass weight, the sample was divided into two subsamples; carcasses with warm carcass weight less than 72 kg., and those weighing in excess of 77 kg. Value indices were calculated for the carcasses within each subsample using wholesale pork prices averaged over 1982. For each of the two subsamples, an ordinary least squares regression of value indices on backfat and carcass weight was performed. A test suggested by Chow[73] then was used to determine whether the estimated regression coefficients differed between the two subsamples.

The same procedure was applied to a second set of two carcass subsamples, where carcasses were classified according to backfat thickness; carcasses with backfat (summed measure of maximum shoulder and loin fat) of less than 2.9 inches, and those with backfat in excess of 3.2 inches.

It was concluded (5 percent significance level) from the Chow tests (presented in Appendix D.2), that the relationship of carcass value to backfat and weight was unstable when compared between light and heavy weight carcasses. The major cause of this instability is believed to be

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[72] A perusal of 1980, 1981, and 1982 data in the Canadian Livestock and Meat Trade Report indicated the grade distribution of the Canadian slaughter hog population to be unaffected by season. This illustrates the constancy of the physical traits of the hog population, regardless of the time of year.

[73] G.C. Chow, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," Econometrica, vol. 28, (1960), pp. 591-605.

packers' general preference for small and medium sized pork cuts.[74] Individual cuts that are considered too large to be desireable for sale in whole form in the wholesale market generally are subjected to substantial trimming, or are used in the production of processed meat products. Once a carcass is considered "too large", additional increases in size are less detrimental (and may be desireable) to the net value (per kg.) of a carcass. In addition, price discounts associated with increasing backfat thickness would be expected to be smaller for heavier carcasses. If wholesale cuts obtained from heavy carcasses undergo substantial trimming in order to decrease their size, or are directed for use in processed products, there will be less concern over whether an excess fat cover is present on these cuts.

Comparing the estimated coefficients obtained for the lean and fat carcass subsamples, no significant difference in the relationship of carcass value to carcass measurements was exhibited between these two subsamples. While a previous U.S. study had found the coefficients for various lean-prediction formulas to vary between lean, medium, and fat carcasses,[75] a similar result was not necessarily expected for the quality-predicting formula examined here. The Canadian slaughter hog population is more homogeneous (in terms of both weight and fat) in comparison to that in the U.S., making extrapolations from studies of U.S. carcasses to Canadian carcasses somewhat tenuous. The negative results

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[74] In the carcass valuation process, wholesale pork cuts of non-optimal weight were discounted according to the procedure outlined in Appendix B.

[75] R.L. Edwards, G.C. Smith, H.R. Cross, and Z.L. Carpenter, "Estimating Lean in Pork Carcasses Differing in Backfat Thickness," Journal of Animal Science, vol. 52, (1981), pp. 703-709.

here obtained for the Chow test for lean and fat carcass subsamples therefore were not seen as being in conflict with a priori expectations, and were accepted as reflecting the true characteristics of the Canadian slaughter hog population.

5.1.2 Comparison of Grade-Pricing Procedures

From the analysis in the preceeding section, it was concluded that the relationship of carcass value to carcass measurements of backfat and weight exhibited (for the sample data) i) short term (i.e., seasonal) instability, especially in the estimated coefficients for carcass weight, apparently resulting from seasonal fluctuations in the weight-based wholesale price discounts associated with heavy wholesale pork cuts; ii) long term (trend) instability, especially in the estimated coefficients for backfat, apparently resulting from a decreasing trend in the price difference between wholesale "lean cuts" (particularly ham) and belly, and iii) instability over carcass weight ranges.

Therefore, it was decided that the following principles merit examination to determine if their application in a grade-pricing mechanism for pork carcasses can improve grade-pricing performance.

1. The adjustment of the grade-index premiums and discounts associated with the chosen carcass measurements in response to seasonal fluctuations in wholesale pork prices;
2. The adjustment of the premiums and discounts in response to underlying trends in wholesale pork prices;
3. Adjusting the pattern of the grade-index discount associated with incremental differences in carcass measurements, depending upon carcass weight range.

5.1.2.1 Adjusting for Seasonal Fluctuation

The hypothesis addressed in this section of the analysis is:

Ho: Adjustment of the grade-index premiums and discounts associated with the chosen carcass measurements in response to short term (seasonal) fluctuations in the carcass value-carcass measurements relationship has no significant effect on i) grade-pricing bias, ii) grade-pricing precision, or iii) the practical achievement of grade-pricing efficiency in the slaughter hog market.

Two procedures were developed by which value indices were assigned to the sample carcasses. The indices assigned to the sample carcasses by these two procedures were compared to the actual value indices of these carcasses as calculated for each month in 1980.

Procedure 1a -- No Adjustment for Seasonal Fluctuation

In procedure 1a, a set of actual value indices for the sample carcasses first was calculated using wholesale pork prices averaged for 1980. These indices then were regressed on the chosen carcass measurements. The resulting estimated regression thus reflected the average structure of the carcass value-carcass measurements relationship for 1980. A set of assigned value indices was generated using this estimated relationship. These indices then were compared to the actual indices for each individual month to determine the extent to which the carcass value-carcass measurements relationship deviates, in individual months, from the average relationship for the year.

The above procedure was applied six times; once for each of the six combinations of carcass measurements (as were all the grade-pricing procedures tested in this study). Its resulting grade-pricing performance, measured in terms of bias and precision, is described below.

Effect on Grade-Pricing Bias -- As was described in Chapter 4, bias was determined by regressing actual on assigned indices, then noting whether the estimated intercept differred significantly from zero, and whether the estimated response coefficient differred significantly from one. For all of the tests performed in this study, a regression of actual on predicted value indices produced estimated intercepts with t-statistics essentially equal to zero, so that the probability of the intercept being equal to zero was, in every case, equal to 1.0000. The estimated response coefficients were, however, always significant at the 0.01 percent level. Therefore, bias was evaluated on the basis of the value of the estimated response coefficient alone.

Procedure 1a indicated that short term (i.e., monthly) fluctuations in wholesale pork prices occasionally can be of sufficient magnitude as to render the grade-price signal generated by a yearly average estimate of the carcass value-carcass measurements relationship to be significantly (20 percent level) biased. From Table 5.1, for all six combinations of carcass measurements (i.e., the six trials) applied in procedure 1a, the greatest positive bias, occurring in August, tended to be approximately 0.90. The greatest negative bias, occurring in May, tended to be approximately 1.10. Translating these "bias scores" into practical terms, a positive bias of 0.90 means that carcasses with actual value indices within 4 index points of 100 would be expected to be graded accurately (assuming that predicted value indices are rounded to the nearest one index point).[76] Carcasses with actual value indices

[76] That is, if all carcasses with an actual index value of (for example) 104 were graded using a grade-pricing system where a positive bias of 0.90 existed, the mean of the predicted value indices for these carcasses (rounded to the nearest 1 index point) would be expected to

within 4 to 13 (-4 to -13) index points of 100 would be expected to be graded one index point too high (low). A negative bias of 1.10 means that carcasses with actual value indices within 5 index points of 100 would be expected to be graded accurately. Carcasses with actual value indices within 5 to 16 (-5 to -16) index points of 100 would be expected to be graded one index point too low (high).

Grade-Pricing Precision -- Recall from Chapter 4 that grade-pricing precision is measured by the standard deviation of the residual "actual value index less assigned value index". "Precision scores" were calculated for procedure 1a for each month of the 1980 price data. The highest (worst) and lowest (best) of these precision scores are presented in Figure 5.2.[77] Over all six trials, the best precision scores were obtained for July. Using procedure 1a, the probability of an individual carcass being assigned a value index falling within 2 index points of its actual (calculated) value index for this month was approximately 41 percent. Put another way, producers would have 80 percent confidence that an individual carcass would be assigned a value index within approximately 4.8 index points of its actual value index (see Table 5.2). The corresponding figures for the month with the lowest precision scores (December) were 47 percent and 4.0 index points.

Procedure 1b -- Adjustment for Seasonal Fluctuation

In procedure 1b, an ordinary least squares regression of carcass value (i.e., calculated carcass value indices) on the chosen carcass measurements was performed for each separate month. Each estimated regres-

equal 104.

[77] Precision scores were not presented for all twelve months, in order to limit the volume of numerical results presented.

TABLE 5.1

Procedure la Bias Scores -- 1980 Data

Month	Estimated Coefficient Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
January	0.969	0.970	0.969	0.971	0.973	0.973
February	0.986	0.982	0.989	0.989	0.993	0.993
March	1.023	1.034	1.019	1.028	1.019	1.026
April	1.087	1.098	1.077	1.089	1.074	1.086
May	1.124*	1.144*	1.106	1.127*	1.097	1.117*
June	1.095	1.078	1.089	1.088	1.091	1.092
July	0.972	0.952	0.978	0.967	0.984	0.975
August	0.900	0.889	0.914	0.899*	0.915	0.902*
September	0.926	0.923	0.937	0.929	0.938	0.929
October	0.958	0.954	0.962	0.956	0.964	0.958
November	0.951	0.955	0.957	0.953	0.956	0.951
December	1.008	1.021	1.004	1.004	0.996	0.999
Mean	1.000	1.000	1.000	1.000	1.000	1.000

*Indicates values of estimated coefficients (from the regression of assigned carcass value indices on actual indices) significantly different from 1 at the 20 percent level of significance.

TABLE 5.2

Procedures 1a and 1b Precision Scores -- 1980 Data

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Procedure 1a						
Lowest Std. Dev. Res. (Dec.)	3.244	3.270	3.134	3.120	3.066	3.072
80% C.I. (index points)	±4.15	±4.19	±4.01	±4.00	±3.93	±3.93
P($\hat{Y}$ = Y±2 index points)	46%	46%	48%	48%	48%	48%
Highest Std. Dev. Res. (July)	3.796	3.871	3.691	3.704	3.606	3.637
80% C.I. (index points)	±4.86	±4.96	±4.73	±4.74	±4.62	±4.66
P($\hat{Y}$ = Y±2 index points)	40%	39%	41%	41%	42%	42%
Procedure 1b						
Lowest Std. Dev. Res. (Dec.)	3.224	3.252	3.114	3.100	3.044	3.051
80% C.I. (index points)	±4.13	±4.16	±3.99	±3.97	±3.90	±3.91
P($\hat{Y}$ = Y±2 index points)	47%	46%	48%	48%	49%	49%
Highest Std. Dev. Res. (July)	3.728	3.807	3.621	3.637	3.534	3.569
80% C.I. (index points)	±4.77	±4.87	±4.64	±4.66	±4.53	±4.57
P($\hat{Y}$ = Y±2 index points)	41%	40%	42%	42%	43%	43%
F-Ratio*						
December	1.012	1.011	1.013	1.013	1.015	1.014
July	1.037	1.034	1.039	1.037	1.041	1.038

*Critical F value for the 0.20 level is 1.11.

sion then was used to generate a set of assigned value indices for the sample carcasses. In this way, the assigned value index for any given carcass was adjusted for each month in 1980 to reflect seasonal fluctuations in the structure of the relationship of carcass value to the carcass measurements resulting from seasonal fluctuations in wholesale pork prices.

Grade-Pricing Bias -- Since procedure 1b produced assigned value indices which were adjusted monthly, this procedure did not exhibit any bias resulting from seasonal instability in the relationship of carcass value to carcass measurements. Therefore, when value indices assigned using this procedure were regressed on actual calculated value indices, the estimated coefficient always equalled 1.0. An observation worth noting is that, using procedure 1b, bias was not exhibited for any of the six different trials. This result indicated that bias is caused only when a grade-pricing mechanism does not adjust to instability in the carcass value-carcass measurements relationship over time; it is not affected by the choice of carcass measurements used to indicate carcass value.

Grade-Pricing Precision -- Since grade-pricing procedure 1b produced no seasonal grade-pricing bias, one might expect that the value indices it assigns to carcasses would exhibit greater precision than those assigned by procedure 1a. Table 5.2 presented the precision scores obtained by procedures 1a and 1b for December (in which the best precision scores were obtained) and July (in which the worst precision scores were obtained) data. For all six trials, for each of the twelve months of price data,[78] precision scores obtained by procedure 1b consistently were superior to those of procedure 1a. However, the magnitude of the improvement in grade-pricing precision for the seasonally-adjusting procedure was very small. Table 5.2 indicates that the probability of a value index assigned by procedure 1b being within 2 index points of the actual value index for a given carcass tended to be only about 1 percent higher than that for procedure 1a. In Table 5.2, an F-test comparison of corresponding precision scores obtained by procedures 1a and 1b indicated that the improvements in grade-pricing precision offerred by the seasonally-adjusting procedure were not statistically significant at the 20 percent level.

Interpretation

It was determined that applying the principle of accounting for seasonal fluctuations in wholesale pork prices as opposed to not applying this principle did not produce any statistically significant (20 percent level) improvement in grade-pricing precision. That is, the uncertainty accompanying the grade-price signal was not reduced significantly. By adjusting the price signal monthly, grade-pricing bias was, of course, eliminated. That is, adjusting the grade-pricing system to monthly fluctuations in wholesale pork prices ensures that the grade-price signal is "correct" in relation to packers' preferences for carcasses of different physical type, for any given month.

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[78] Only the precision scores for December and July of 1980 were included in Table 5.2 in order to limit the volume of numerical results presented.

Having determined the consequence of not applying the principle of accounting for seasonal fluctuations to be the presence of statistically significant grade-pricing bias for certain months, the folowing question now is addressed. What are the practical implications of seasonal grade-pricing bias? As long as a grade-pricing system is able to reflect without bias the general preferences of packers for hogs of different physical type, producers will continue to receive a grade-price signal which is, in general, correct. That is, producers will be encouraged to market hogs whose physical characteristics generally are in line with what packers want.

In terms of the equity of the grade-pricing system, the presence of seasonal bias is not likely to be of concern to packers or producers in aggregate. In Section 5.1.1.1, it was noted that the grade distribution of the Canadian slaughter hog population appears to be unaffected by season. Regardless of the bias present for an individual season, as long as the 100 index grade continues to accurately identify pork carcasses of average value, the total dollar effects of bias for a given month will be equal but opposite for carcasses of above and below average quality. For positive seasonal bias, the total dollar amount paid out in overly-large grade-price premiums will be balanced by the total dollar amount not paid out due to overly-large grade-price discounts. Thus, (assuming a normal grade distribution about the mean, 100 index) under positive bias, producers of above average quality hogs benefit at the expense of packers, while packers benefit to an offsetting amount at the expense of producers of hogs of below average quality. Similarly, under conditions of negative bias, producers of below average quality hogs benefit at the expense of packers, while packers benefit to an offsetting degree at the expense of producers of hogs of above average quality. As long as the occurrences of positive and negative seasonal bias balance out over the year (i.e., if the grade-pricing mechanism is unbiased, on average, for the year), then on balance, there is no aggregate gain or loss over the course of the year.

One possible benefit to be gained from the application of a seasonally adjusting grade-pricing mechanism is in packers' technical efficiency. If a seasonally adjusting system were established, and if, as a result of its application, producers tended to deliver more heavy hogs in the summer[79] and fewer heavy carcasses prior to Christmas,[80] packers may be able to reduce their overall cutting, trimming, and processing costs. While this argument seems plausible, further research is required to determine whether such gains actually could be achieved.

Based on the above discussion, a definite acceptance or rejection of the hypothesis that a seasonally adjusting system would not affect the practical achievement of grade-pricing efficiency cannot be made. Use of a non-seasonally adjusting system does not appear to produce any major detrimental effects. Over the span of a year, equity between producers and packers is maintained, and the grade-price signal generally reflects packers preferences for different grades of hogs. However, the

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[79] Figure 5.2 illustrated that excess weight is less detrimental to carcass value in July, August, and September. This is probably because consumers demand fewer roasts and whole hams during this period, and more processed meats.

[80] Figure 5.2 illustrated that excess weight is most detrimental to carcass value prior to the Christmas-New Year season. This is probably because consumers demand more whole hams and roasts during this period, and fewer processed meats.

use of a seasonally adjusting system may be able to facilitate an increase in packers' technical efficiency.

5.1.2.2 Adjusting for Underlying Trends Over Time

The hypothesis addressed in this section is:

Ho: Adjustment of the grade-index premiums and discounts associated with the chosen carcass measurements in response to underlying trends over time in the carcass value-carcass measurements relationship has no significant effect on i) grade-pricing bias, ii) grade-pricing precision, or iii) the practical achievement of grade-pricing efficiency in the slaughter hog market.

Two procedures were developed by which value indices were assigned to the sample carcasses. The indices assigned by these procedures then were compared to the actual value indices of the sample carcasses as calculated using the data for each month in 1981 and 1982.

<u>Procedure 2a -- No Adjustment for Trend</u>

In procedure 2a, an estimated regression reflecting the average structure of the carcass value-carcass measurements relationship for 1980 was used to generate a set of assigned value indices for the sample carcasses. These indices then were compared to the actual indices for these carcasses, as calculated for each monthly price data set for 1981 and 1982. In this way, an indication was obtained of the ability of the carcass value-carcass measurements relationship for 1980 to reflect the average relationship for 1981 and 1982, and of the combined effects of seasonality and trend on grade-pricing performance.

Grade-Pricing Bias -- Table 5.3 indicates that the value indices assigned according to the average 1980 carcass value-carcass measurements relationship tended to be significantly (20 percent level) biased for 4 out of 12 months when compared to actual value indices for 1981.[81] The greatest positive bias, occurring in August, tended to be approximately 0.86. The greatest negative bias, occurring in March, tended to be approximately 1.01. The average of the 12 bias scores for 1981 was (for all six trials) approximately 0.94, indicating that the assigned "average 1980 carcass value indices" tended to overestimate the response of carcass value to carcass measurements for the 1981 data. The magnitude of this overestimation can be measured in practical terms; a positive bias of 0.94 means that carcasses with actual value indices of 108 or higher (92 or lower) would be expected to be assigned a value index 1 index point higher (lower) than their actual value index.

For the 1982 data, Table 5.3 indicates that the 1980 value indices tended to be significantly (20 percent level) biased for 9 out of 12 months. The average of the 12 bias scores for 1982 was (for all six trials) approximately 0.85, indicating a further tendency for the average 1980 relationship to overestimate the response of carcass value to carcass measurements. In practical terms, a positive bias of 0.85 means that only those carcasses with actual indices within 2 index points of 100 would be expected to be graded accurately. Carcasses with actual indices within 3 to 8 (-3 to -8) index points of 100 would be expected to be graded 1 index point too high (low). Carcasses with actual indi-

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[81] Only the maximum negative and maximum positive bias scores for the years 1981 and 1982 were included in Table 5.3 in order to limit the volume of numerical results presented.

TABLE 5.3

Procedure 2a Bias Scores -- 1981 and 1982 Data

	Estimated Coefficient					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
1981 Max. Neg. Bias (March)	1.019	1.009	1.018	1.010	1.022	1.014
Max. Pos. Bias (Aug.)	0.855	0.850	0.877	0.868	0.872	0.867
Avg. Bias Measure	0.941	0.942	0.949	0.946	0.945	0.943
#Bias Measures ≠1 (80% level)	4	2	4	4	4	4
1982 Max Neg. Bias	-	-	-	-	-	-
Max. Pos. Bias (Aug.)	0.746	0.739	0.770	0.758	0.768	0.754
Avg. Bias Measure	0.847	0.849	0.861	0.858	0.856	0.853
#Bias Measures ≠1 (80% level)	9	9	9	9	10	9

ces within 9 to 14 (-9 to -14) index points of 100 would be expected to be graded 2 index points too high (low).

From the above analysis, it is indicated that trends over time in the carcass value-carcass measurements relationship can produce statistically significant bias in grade-pricing, if these trends are not accounted for in the grade-pricing system.

Procedure 2b -- Adjustment for Trend

Procedure 2b was exactly similar to procedure 1b in the previous section, with assigned value indices for a given month being generated by an estimated regression of carcass value indices (as calculated for that month) on the chosen carcass measurements. Thus, in procedure 2a, separate regressions were estimated for each month in 1981 and 1982. This assured that the assigned value index for any given carcass was adjusted to reflect any trend, as well as any seasonality in the carcass value-carcass measurements relationship. As a result, when value indices assigned using this procedure were regressed on actual calculated value indices, the estimated coefficient always equalled 1.0 (i.e., there was no grade-pricing bias).

Grade-Pricing Precision -- Procedure 2b produced assigned value indices which were unbiased, while the indices assigned by procedure 2a were biased for individual months in 1981 and 1982 due to the effects of seasonality and trend in the carcass value-carcass measurements relationship. As a result, one might expect the value indices assigned by procedure 2b to exhibit greater precision than those of procedure 2a. In Table 5.4 precision scores are presented for procedures 2a and 2b for 1981 and 1982. Comparing precision scores for a given month and trial, procedure 2b consistently produced superior (i.e., smaller) precision scores. However, the magnitude of the difference in precision scores between the two procedures was small. The probability of a value index assigned by procedure 2b being within 2 index points of the actual index for an individual carcass tended to be about 1 percent higher than that for procedure 2a. As shown in Table 5.4, an F-test comparing corresponding precision scores obtained by the two procedures indicated none of the pairs of precision scores were significantly different at the 20 percent level. Thus, the use of a grade-pricing procedure which accounted for the instability in the carcass value-carcass measurements relationship over time did not produce statistically significant improvement in grade-pricing precision.

While applying the principle of accounting for the underlying trend over time in the carcass value-carcass measurements relationship did not produce any statistically significant improvement in grade-pricing precision, it did, of course, ensure that the grade-price signal was accurate for the year in general (i.e., yearly grade-pricing bias was eliminated).

Interpretation

Comparing the index premiums and discounts assigned by the estimated carcass value-carcass measurements relationship for 1980 to the calculated carcass values using 1981 and 1982 price data, increasing positive yearly bias was evident. The practical implications of such bias are as follows.

In regards to the grade-price signal being communicated to producers, a greater emphasis is put on the production of higher quality (particu-

TABLE 5.4

Procedures 2a and 2b Precision Scores -- 1981 and 1982 Data

1981	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Procedure 2a						
Lowest Std. Dev. Res. (Nov.)	3.137	3.157	3.024	3.014	2.980	2.982
80% C.I. (index points)	±4.02	±4.04	±3.87	±3.86	±3.82	±3.82
P($\hat{Y}$ = Y±2 index points)	48%	47%	49%	49%	50%	50%
Highest Std. Dev. Res. (March)	3.488	3.555	3.377	3.383	3.284	3.316
80% C.I. (index points)	±4.47	±4.55	±4.32	±4.33	±4.20	±4.25
P($\hat{Y}$ = Y±2 index points)	43%	43%	45%	45%	46%	45%
Procedure 2b						
Lowest Std. Dev. Res. (Dec.)	(Nov.) 3.107	3.129	3.004	2.982	(Nov) 2.945	2.946
80% C.I. (index points)	±3.98	±4.01	±3.85	±3.82	±3.77	±3.77
P($\hat{Y}$ = Y±2 index points)	48%	48%	50%	50%	50%	50%
Highest Std. Dev. Res. (March)	3.470	3.538	3.359	3.367	3.265	3.299
80% C.I. (index points)	±4.44	±4.53	±4.30	±4.31	±4.18	±4.22
P($\hat{Y}$ = Y±2 index points)	44%	43%	45%	45%	46%	46%
1982						
Procedure 2a						
Lowest Std. Dev. Res. (Nov.)	3.074	3.099	2.966	2.950	2.915	2.914
80% C.I. (index points)	±3.94	±3.97	±3.80	±3.78	±3.73	±3.73
P($\hat{Y}$ = Y±2 index points)	48%	48%	50%	50%	51%	51%
Highest Std. Dev. Res. (Jan.)	3.308	3.339	3.195	3.186	3.143	3.156
80% C.I. (index points)	±4.24	±4.28	±4.09	±4.08	±4.02	±4.04
P($\hat{Y}$ = Y±2 index points)	45%	45%	47%	47%	48%	47%

TABLE 5.4 (Continued)

Procedures 2a and 2b Precision Scores -- 1981 and 1982 Data

1982	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Procedure 2b						
Lowest Std. Dev. Res. (Dec.)	2.979	2.999	2.877	2.861	2.841	2.832
80% C.I. (index points	±3.81	±3.84	±3.68	±3.66	±3.64	±3.63
$P(\hat{Y} = Y \pm 2$ index points)	50%	50%	51%	52%	52%	52%
Highest Std. Dev. Res. (Jan.)	3.276	3.309	3.165	3.156	3.109	3.122
80% C.I. (index points)	±4.20	±4.24	±4.05	±4.04	±3.98	±4.00
$P(\hat{Y} = Y \pm 2$ index points)	46%	45%	47%	47%	48%	48%
F-ratio*						
1981 - Lowest Std. Dev. Resid.	1.019	1.018	1.013	1.022	1.024	1.025
Highest Std. Dev. Resid.	1.010	1.010	1.011	1.010	1.012	1.010
1982 - Lowest Std. Dev. Resid.	1.065	1.068	1.063	1.063	1.053	1.059
Highest Std. Dev. Resid.	1.020	1.018	1.019	1.019	1.022	1.023

*Critical F value for the 0.20 level is 1.11.

larly leaner) carcasses than is warranted by the actual response of carcass value to differences in carcass measurements (particularly backfat) between carcasses.

In regards to the equity of the grade-pricing system, the presence of increasing positive yearly bias implies that carcasses of above average quality will tend to receive premiums in excess of what is warranted by their actual value differentials, while below average quality carcasses will tend to receive price discounts which are larger than warranted. As a consequence, producers of high quality pork carcasses will benefit at the expense of packers, while packers will benefit at the expense of producers of lower quality carcasses.

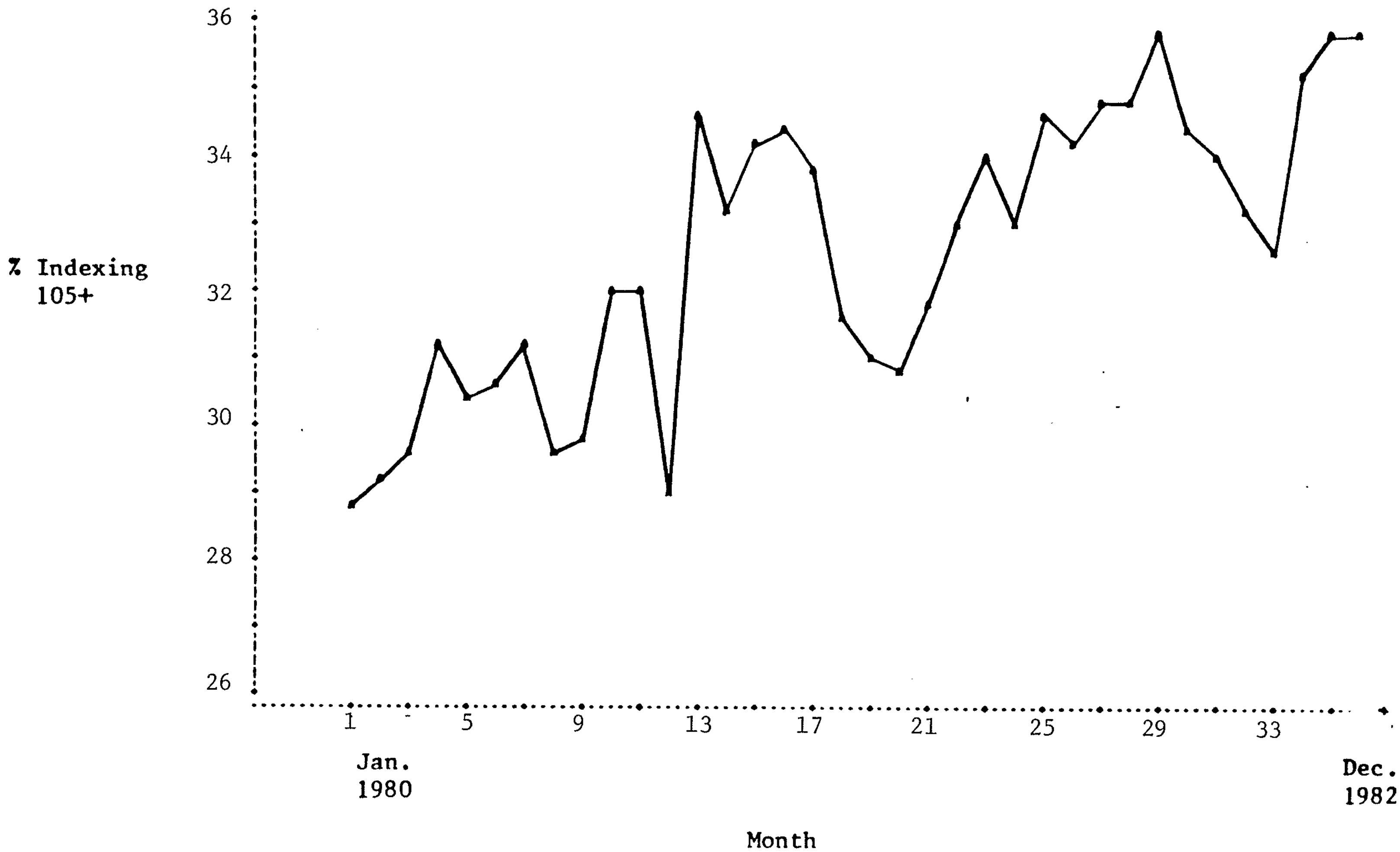
In Section 5.1.3.2 it was indicated that the observed decreasing trend in the response of carcass value indices to backfat thickness may be due, at least in part, to a decreasing trend in the wholesale price difference between hams (the largest lean cut in a carcass) and bellies (whose percentage carcass yield is positively related to backfat thickness). If we assume that a change in the relative structure of wholesale pork prices is the only trend which occurs, (so that the grade distribution of pork carcasses remains normal about the mean index, 100) then neither packers nor producers as a whole would be affected by the presence of positive yearly bias -- i.e., neither packers nor producers would benefit at the expense of the other. (Although producers of high quality carcasses would benefit at the expense of producers of low quality carcasses). However, in the case of the Canadian slaughter hog industry, the average physical traits of the Canadian slaughter hog population also have been changing. Figure 5.5 reveals that a higher percentage of the slaughter hog population graded at an index of 105 or higher in 1980 and 1981, as compared to 1979. Figure 5.6 indicates that a lower percentage of the slaughter hog population graded at an index of between 85 to 95 in 1980 and 1981. Thus, during this period, it appears the 100 index grade no longer identified carcasses of average value. Rather, a 100 index carcass would be expected to be of slightly lower than average value. At the same time, the grade-price differentials being assigned by the 1979 Index 100 table (in effect from January of 1979 to March of 1982) were likely increasingly positively biased over 1980, 1981, and early 1982. Since more carcasses received above average grade indices, and the premiums and discounts of the 1979 Index 100 Table were likely positively biased for 1980 and 1981, then the total dollar amount of grade-price overpayment for carcasses indexing above 100 presumeably exceeded the total dollar amount of grade-price underpayment for carcasses indexing below 100. However, this does not mean that producers as a whole benefitted at the expense of packers. Since packers determine their base price bids for pork carcasses according to the average net value realized from their operations for all carcasses, they cannot unwittingly, through the fault of the grade-pricing system, be put in a position where they end up paying more for carcasses, on average, than the average net value realized from these carcasses would dictate. If, for example, a trend occurs in the hog population such that the Index 100 grade identifies a carcass of less than average net value, packers will simply adjust their base price bids accordingly downward. The likely result of the maintenance of the same Index 100 grade index table from 1979 to early 1982, therefore, was that producers of hogs of above average quality benefitted from grade-price premiums which increasingly became larger than warranted, while producers of below average quality hogs received grade-price discounts which also became increasingly larger than warranted.

Based on the above discussion, the hypothesis that the adjustment of a grade-pricing system in response to underlying trends over time in the carcass value-carcass measurements relationship has no effect on the practical achievement of pricing efficiency, can be rejected. The practice of not adjusting a grade-pricing system yearly would (as indicated for the sample data) result in a tendency to assign grade-price premiums and discounts which are larger than warranted, magnifying packers preferences for higher quality (particularly leaner) carcasses. While this distorts the communication of packers' preferences to producers, the effects of such positive bias on the average physical characteristics of the slaughter hog population may be seen as being desireable. An overemphasis on carcass quality may be essential to expanding export markets for Canadian hogs and pork. With regards to the equitable treatment of all market participants, positive bias will tend to make producers of higher quality hogs better off, and producers of lower quality hogs worse off, than they would be under a grade-pricing system that was adjusted yearly. Hog producers may find this condition objectionable.

5.1.2.3 Adjusting Premiums and Discounts Over Carcass Weight Ranges

The hypothesis addressed in this section is:

Ho: Adjusting the pattern of the grade-price premiums and discounts associated with incremental differences in carcass measurements between



Based on data from the Canadian Livestock and Meat Trade Report, 1979-1981

Figure 5.5: Percent of Canadian Hog Population Indexing 105+ Over Time

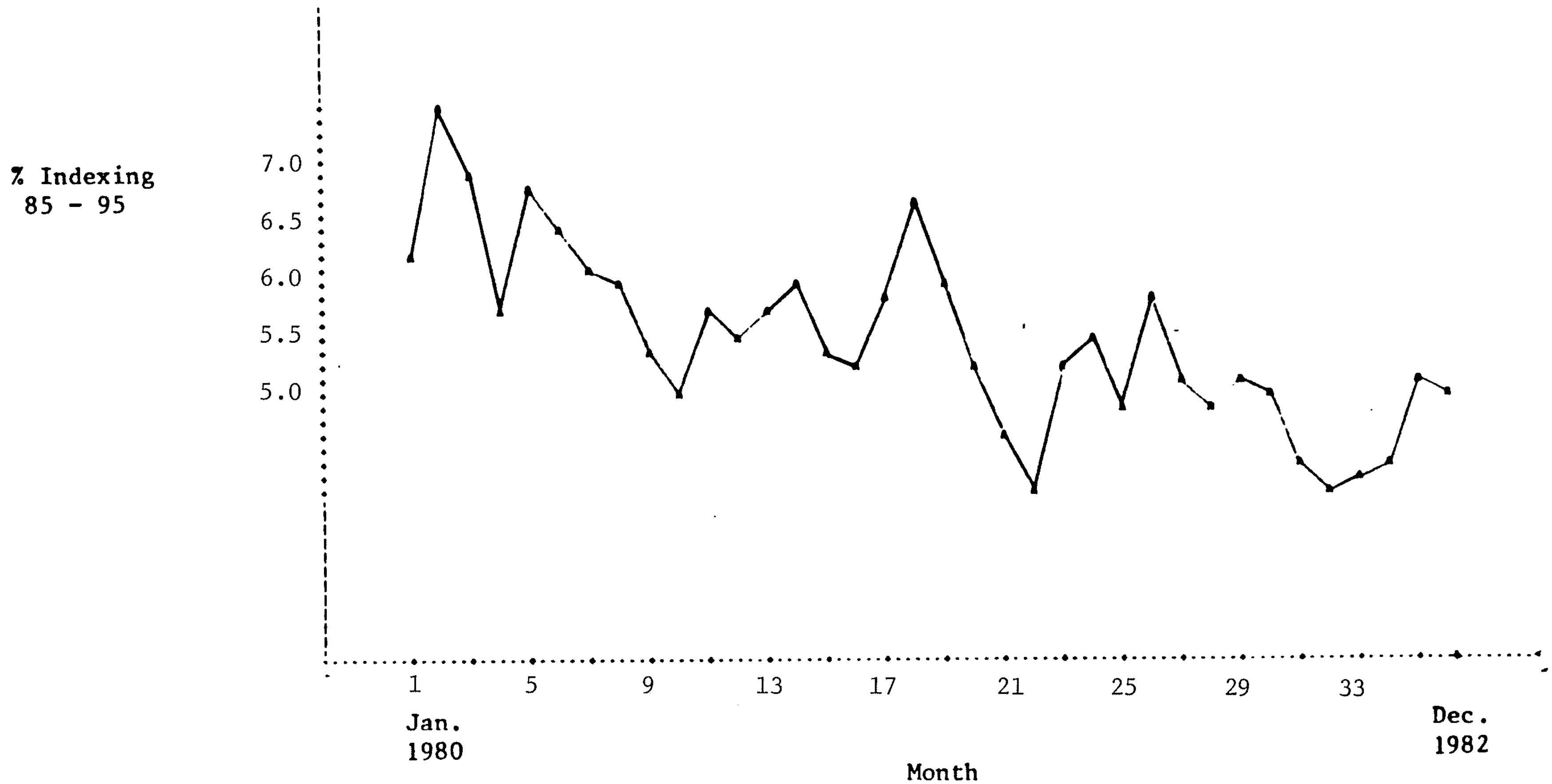


Figure 5.6: Percent of Canadian Hog Population Indexing 85-95, Over Time

carcasses of different weight ranges has no significant effect on i) grade-pricing precision, or ii) the practical achievement of grade-pricing efficiency in the slaughter hog market.

Two grade-pricing procedures were developed for the purpose of illustrating the effect on grade-pricing performance when the grade index premiums and discounts associated with the chosen carcass measurements are adjusted according to the weight range of the carcasses being graded. Both procedures accounted for the seasonality and trend in the carcass value-carcass measurements relationship by assigning value indices for a given month according to an estimate of the carcass value-carcass measurements reationship for that specific month. Therefore, neither procedure exhibited any grade-pricing bias. The difference between the two procedures was that while procedure 3a used one regression (using the entire carcass sample) for each month, procedure 3b used three estimated regressions[82] for each month (one for each of three different weight ranges of carcasses).

Comparison of Procedures 3a and 3b

It has been demonstrated in Sections 5.1.2.1 and 5.1.2.2 that grade-pricing bias results when a grade-pricing system does not adjust for changes in the carcass value-carcass measurements relationship which occur over time. Within the sections mentioned above, it also has been demonstrated that grade-pricing bias is eliminated for a given time period if the grade-pricing system is adjusted to reflect the carcass

[82] For each month, a regression of carcass value on the chosen carcass measurements was performed for i) a subsample of carcasses weighing less than 72.4 kg., ii) a subsample of carcasses weighing between 72.4 and 81.5 kg., and iii) a subsample of carcasses weighing in excess of 81.5 kg.

value-carcass measurements relationship for that time period. Grade-pricing bias therefore is not affected by whether or not the grade-pricing system is adjusted over carcass weight ranges, or by the choice of carcass measurements used in the system.

Grade-Pricing Precision -- Table 5.5 presents the precision scores obtained by procedures 3a and 3b when they were applied to the 1980 data.[83] Comparing precision scores for a given month and trial, Table 5.5 shows procedure 3b consistently produced precision scores superior to those of procedure 3a. Further analysis of Table 5.5 indicates that, across the 12 months and 6 trials, the improvement in grade- pricing precision obtained by using procedure 3b in comparison to 3a tended to be statistically significant at the 20 percent level.

However, while a statistically significant improvement is indicated, the magnitude of the improvement, in terms of market participants' confidence in the ability of the system to assign correct value indices to individual carcasses, is small. The probability of a value index assigned by procedure 3b being within 2 index points of the actual index for a carcass tended to be about 2 or 3 percent higher than that for procedure 3a.

Interpretation

The practical implications of grade-pricing precision do not include the ability of a grade-pricing system to effect change in the physical characteristics of the slaughter hog population. For example, a grade-pricing system which assigns index premiums for hogs with large ears,

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[83] Results were presented for 2 of the 12 months (i.e., the highest and lowest precision scores obtained for the year) only, in order to limit the volume of numerical results presented.

TABLE 5.5

Procedures 3a and 3b Precision Scores -- 1980 Data

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Procedure 3a						
Lowest Std. Dev. Resid.	3.224	3.252	3.114	3.100	3.044	3.051
80% C.I. (index points)	±4.13	±4.16	±3.99	±3.97	±3.90	±3.91
P($\hat{Y}$ = Y±2 index points)	47%	46%	48%	48%	49%	49%
Highest Std. Dev. Resid.	3.728	3.807	3.621	3.637	3.534	3.569
80% C.I. (index points)	±4.77	±4.87	±4.64	±4.66	±4.53	±4.57
P($\hat{Y}$ = Y±2 index points)	41%	40%	42%	42%	43%	43%
Procedure 3b						
Lowest Std. Dev. Resid.	3.108	3.136	2.924	2.809	2.840	2.851
80% C.I. (index points)	±3.98	±4.02	±3.74	±3.60	±3.64	±3.65
P($\hat{Y}$ = Y±2 index points)	48%	48%	51%	52%	52%	52%
Highest Std. Dev. Resid.	3.544	3.630	3.336	3.340	3.228	3.236
80% C.I. (index points)	±4.54	±4.65	±4.27	±4.28	±4.13	±4.14
P($\hat{Y}$ = Y±2 index points)	43%	42%	45%	45%	46%	46%
F - Ratio*						
Lowest Std. Dev. Resid.	1.076	1.075	1.134	1.174	1.149	1.145
Highest Std. Dev. Resid.	1.107	1.100	1.178	1.186	1.199	1.216

*Critical F value for the 0.20 level is 1.11.

and discounts hogs with small ears likely would exhibit very low grade-pricing precision if the value indices assigned by this system were compared to the actual value indices for these hogs. However, there is little doubt that farmers would respond to this system by producing more hogs with large ears, and fewer hogs with small ears. Neither does grade-pricing precision affect the overall ability of the system to ensure equity for all market participants; greater or lesser grade-pricing precision does not increase packers' welfare at the expense of producers' welfare, or vice versa. Rather, the practical implications of grade-pricing precision lie in whether market participants believe the grade-pricing system is serving a meaningful purpose in terms of encouraging the production of hogs of the physical type truly desired by packers.

For the sample data, the adjustment of a grade-pricing system according to the weight range of carcasses being graded tended to provide a statistically significant (20 percent level) improvement in grade-pricing precision. However, the practical benefits of this improvement, in terms of market participants' confidence that the actual value index of a carcass will be correctly identified by the value index that it is assigned by the grade-pricing system, seem small. The probability that the value index assigned to an individual carcass would be within 2 index points of its actual value index tended to be between 40 to 50 percent (see Table 5.5). For the sample data, for grade-pricing procedure 3b, (which adjusted for carcass weight range), the above probability ranged from 1 to 4 percent higher than that for the precision score for the corresponding trial in procedure 3a (which did not adjust for carcass weight range) (see Table 5.5). Therefore, it appears that the improvement in grade-pricing precision gained by employing a grade-pricing procedure which adjusts over carcass weight ranges, while statistically significant, is insignificant in a practical sense. That is, it appears there would be only a small improvement in market participants' confidence in the ability of the grade-pricing system to correctly identify the net value potential of carcasses.[84]

5.2 CHOICE OF CARCASS MEASUREMENTS

The six alternative combinations of carcass measurements[85] (described in Chapter 4) were examined with two objectives in mind. The first was to rank the sets of carcass measurements with respect to their ability to reflect carcass value. Of interest was whether a rank ordering of these carcass measurements' ability to reflect carcass yield would be the same as a rank ordering of their ability to reflect carcass value. The second objective was to measure the differences in grade-pricing performance one could expect to result from the use of different sets of carcass measurements for the grade-pricing of pork carcasses. Of interest was whether the choice of carcass measurements used in a grade-pric-

[84] The validity of this conclusion may be affected by the carcass sample used in this study; a stratified sample, chosen to include repesentation in extreme backfat and weight categories. This likely resulted in overall poorer precision scores than would be expected in a practical carcass grading situation, where the distribution of physical types of carcasses would be expected to be closer to a random normal distribution.

[85] It is not practical to obtain fat or muscle thickness measurements 7 cm. off the carcass midline using a ruler. The last rib and 3-4th last rib measurements therefore were obtained using an electronic probe, as they most probably would be in actual grading practice. The shoulder and loin fat and muscle measurements were obtained using a ruler, the technique currently used in the Index 100 system.

ing mechanism would have a statistically significant effect on grade-pricing efficiency, and whether this effect would be of practical significance to the slaughter hog industry.

5.2.1 Ranking the Carcass Measurements

Here, the hypothesis of interest was:

Ho: Ranking carcass measurements according to their ability to explain carcass value will produce the same result as ranking carcass measurements according to their ability to explain carcass yield.

Value indices were calculated for the sample carcasses using average wholesale pork prices for 1980. Six regressions then were estimated using these value indices as the dependent variable; one regression for each of the six sets of carcass measurements. In all six regressions, all estimated coefficients had their expected signs (positive for muscle thickness, and negative for carcass weight and backfat thickness). The estimated intercept was, in all six regressions, equal to zero (.0001 level).[86] The estimated coefficients for carcass weight ranged from -0.07 to -0.11, indicating that carcass value index tends to decrease at a rate of about one index point for every ten kilogram increase in carcass weight. This compares reasonably with the index discounts associated with overly-large carcasses, as reflected in the Index 100 grade-index table. The magnitude of the estimated coefficients for fat thickness also were reasonable in comparison to the Index 100 table discounts associated with increasing backfat (though the Index 100 backfat

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[86] Because the dependent and independent variables all were expressed in difference from the mean form, the expected value of the intercept was, in all cases, zero.

discounts tended to be more severe). The Index 100 Table associates a discount of roughly 15 (0.6) index points for a one inch (millimeter) increase in backfat thickness, while the coefficients in Table 5.6 suggest approximately a 10 (0.5) index point discount for every additional inch (millimeter) of backfat. Therefore, the estimated coefficients obtained for the various carcass measurements all compared reasonably with theoretical expectations.

None of the six trials exhibited signs of serious multicollinearity, or significant (10 percent level) heteroscedasticity, as is evidenced by the results of tests presented in Appendix E. These results indicated that none of the carcass measurements used here as independent variables produced any of the common problems encountered in regression analysis.

Given that there was basically nothing to choose between the six trials in terms of the "theoretical" and "econometric" properties of the estimated regressions, the trials were ranked on the basis of the "statistical" properties of the estimated regressions. That is, ranking was determined on the basis of R-square , with the condition that every estimated coefficient in a given regression be significant at the 10 percent level or better.

The six estimated regressions are presented in Table 5.6. All estimated coefficients were significant at the 10 percent level or higher, so the six combinations of carcass measurements were ranked on the basis of R-square alone. Based on the R-square values presented in Table 5.6, the trials can be ranked, in descending order, as follows:

1. warm carcass weight, last rib fat and muscle thickness (trial 5);

2. warm carcass weight, 3-4th last rib fat and muscle thickness (trial 6);
3. warm carcass weight, 3-4th last rib fat thickness (trial 4);
4. warm carcass weight, last rib fat thickness (trial 3);
5. warm carcass weight, sum of loin and shoulder fat thickness (trial 1);
6. warm carcass weight, loin fat thickness (trial 2).

Note, from Table 5.6, that the difference in R-square between trials 5 and 6 was very small, indicating virtually no difference in the ability of the last rib fat and muscle thickness measurements to explain variations in carcass value, as compared to the 3-4th last rib measurement site. A similar observation is true in comparing the last rib and 3-4th last rib sites when muscle thickness measurements are excluded. Based on these observations, a more valid ranking of the six trials would be, beginning with the best ability to explain carcass value:

1 and 2. trial 5 or trial 6;

3 and 4. trial 4 or trial 3;

5. trial 1;

6. trial 2.

The above ranking is essentially similar to the ranking of these same carcass measurements on the basis of their ability to explain carcass yield. On the basis of this simple comparison, justification is provided for the currently common practice of examining the suitability of alternative carcass measurements as standards for carcass quality, based on their ability to predict physical measures of carcass yield. When quality is defined in terms of carcass value, as in this study, those

TABLE 5.6

Alternative Carcass Measurements: Estimated Regressions -- Avg. 1980 Data

	Intercept	FSUM	RLOINF	FMLR7F	FM34R7F	FMLR7M	FM34R7M	WCW	R^2
Trial 1									
Estimate	2.3614^{-8}	-5.3479						-0.0699	.3641
Standard Error	0.2163	0.5255						0.358	
Prob. >ltl	1.0000	0.0001						0.0519	
Trial 2									
Estimate	3.6065^{-8}		-9.4081					-0.0858	.3455
Standard Error	0.2194		0.9719					0.0359	
Prob. >ltl	1.0000		0.0001					0.0175	
Trial 3									
Estimate	2.5250^{-9}			-0.5319				-0.0705	.4054
Standard Error	0.2091			0.0471				0.0341	
Prob. >ltl	1.0000			0.0001				0.0267	
Trial 4									
Estimate	1.2929^{-9}				-0.4917			-0.0945	.4094
Standard Error	0.2084				0.0431			0.0335	
Prob. >ltl	1.0000				0.0001			0.0052	
Trial 5									
Estimate	2.1569^{-9}			-0.4832		0.0955		-0.1102	.4354
Standard Error	0.2042			0.0479		0.0266		0.0346	
Prob. >ltl	1.0000			0.0001		0.0004		0.0017	
Trial 6									
Estimate	1.6671^{-9}				-0.4648		0.0793	-0.1160	.4310
Standard Error	0.2050				0.0433		0.0262	0.0337	
Prob. >ltl	1.0000				0.0001		0.0027	0.0007	

Note* F- statistics for all six regressions were significant at the .0001 level.

TABLE 5.6 - (Continued)

Alternative Carcass Measurements: Estimated Regressions -- Avg. 1980 Data

FSUM	= sum of loin and shoulder fat measurements (inches; ruler measurement)
RLOINF	= loin fat thickness measurement (inches; ruler measurement)
FMLR7F	= last rib fat thickness measurement (millimeters; fat-o-meater probe)
FM34R7F	= 3-4th last rib fat thickness measurement (millimeters; fat-o-meater probe)
FMLR7M	= last rib muscle thickness measurement (millimeters; fat-o-meater probe)
FM34R7M	= 3-4th rib fat thickness measurement (millimeters; fat-o-meater probe)
WCW	= warm carcass weight (Kilograms)

measurements which best explain variations in carcass yield generally can be expected to best explain variations in carcass value.

5.2.2 Effect on Grade-Pricing Precision

It already has been established that bias in the assigned value indices occured strictly as a result of the instability of the carcass value-carcass measurements relationship over time. Therefore, the choice of carcass measurements does not increase or decrease grade-pricing bias. In examining the effect of the choice of carcass measurements on grade-pricing performance, the hypothesis of interest thus is as follows:

Ho: The choice of carcass measurements used in a grade-pricing system has no significant effect on i) grade-pricing precision, or ii) the practical achievement of grade-pricing efficiency in the slaughter hog market.

To evaluate the effect of the choice of carcass measurements on grade-pricing precision, the six combinations of carcass measurements were used to assign value indices to the sample carcasses for each month in 1980, using three different grade-pricing procedures. In this way, if the choice of grade-pricing procedure used had an effect on the relative precision scores for the alternative trials, this would become apparent. Two of the procedures already were described in Section 5.1.3.1. Recall that procedure 1b used a separate regression of carcass value indices on the chosen carcass measurements for each month to assign value indices for each month. Thus, procedure 1b accounted for any seasonality and trend in the carcass value-carcass measurements relationship for 1980, but did not account for any variation in the relationship over carcasses of different weight ranges. Procedure 1a used a regression of carcass value indices (average for 1980) on the chosen carcass measurements to assign average 1980 value indices to the sample carcasses. These assigned indices then were compared to the calculated value indices for each month. Thus procedure 1a did not account for seasonality or trend in the carcass value-carcass measurements relationship, or for variation in this relationship over carcass weight ranges. Finally, procedure 3b accounted for all three types of instability in the relationship by assigning value indices for each month based on separate regressions for light, medium, and heavy weights of carcasses, re-estimated for each of the twelve months.

Table 5.7 presents the simple yearly average of the 12 precision scores obtained by each of the above procedures when applied to 1980 wholesale pork price data. In the Table, the trials are presented, from left to right, in order from least precision to greatest precision. Precision scores for the trials in Table 5.7 were compared by an F-ratio. No significant improvement in grade-pricing precision was exhibited between adjacent trials (with one exception; procedure 3a, trials 1 vs. 3). Comparing the best trial to the worst (trial 5 vs. trial 2) indicated statistically significant (20 percent level) differences in grade-pricing precision. These results were consistent for all three grade-pricing procedures. In addition, regardless of the grade-pricing procedure used, the last rib and 3-4th last rib sites consistently produced smaller (superior) precision scores compared to the loin site. For procedures 1a and 1b, the improvement in precision was just short of being significant at the 20 percent level. The improvement was significant at the 20 percent level using procedure 3b. The inclusion of muscle thickness measurements at either of the 3-4th last rib or last rib sites did not produce significant (20 percent level) improvement in grade-pricing precision.

Measured in practical terms, the probability of the carcass measurements in trial 5 (last rib fat and muscle thickness, carcass weight) assigning a value index to a carcass falling within 2 index points of its actual value was anywhere from 2 percent (procedure 1b) to 5 percent (procedure 3b) higher in comparison to trial 2 (loin fat, carcass weight).

Given that the precision scores for the alternative trials within each of the three procedures all were within a range such that the above probability ranged from 43 to 50 percent, a 5 percent increase in this probability does not suggest a very significant improvement in market participants' confidence in the ability of the grade-pricing system to correctly identify value indices for individual carcasses. However, as with the conclusion regarding the practical benefits in grade-pricing precision discussed in Section 5.1.2.3, the validity of the above conclusion may be affected by the fact that a stratified carcass sample was used in this study. All precision scores therefore were likely to be larger than one would expect if a random sample (which would more closely represent conditions in a practical grading situation) were used.

TABLE 5.7

Alternative Carcass Measurements: Grade-Pricing Precision -- 1980 Data

	Trial 2	Trial 1	Trial 3	Trial 4	Trial 6	Trial 5
Procedure 1a	Assigned indices not adjusted for month or carcass weight range					
Avg. Std. Dev. Resid.	3.500	3.452	3.342	3.332	3.273	3.261
80% C.I. (index points)	±4.48	±4.42	±4.28	±4.27	±4.19	±4.18
P($\hat{Y}$ = Y±2 index points)	43%	44%	45%	45%	46%	46%
F - ratio*	1.028	1.067	1.006	1.036	1.007	Trial 5 vs. 2: 1.152
		1.097		1.043	1.044	
Procedure 1b	Assigned indices adjusted for each month					
Avg. Std. Dev. Resid.	3.473	3.424	3.314	3.303	3.244	3.231
80% C.I. (index points)	±4.45	±4.38	±4.24	±4.23	±4.15	±4.14
P($\hat{Y}$ = Y±2 index points)	44%	44%	45%	46%	46%	46%
F - ratio*	1.029	1.067	1.007	1.037	1.008	Trial 5 vs. 2: 1.155
		1.098		1.043	1.045	
Procedure 3b	Assigned indices adjusted for light, medium and heavy weight carcasses, for each month					
Avg. Std. Dev. Resid.	3.335	3.283	3.090	3.090	3.010	2.995
80% C.I. (index points)	±4.27	±4.20	±3.96	±3.96	±3.85	±3.83
P($\hat{Y}$ = Y±2 index points)	45%	46%	48%	48%	49%	50%
F - ratio*	1.032	1.129	1.000	1.054	1.010	Trial 5 vs. 2: 1.240
		1.165		1.054	1.064	

*Critical F value for the 0.20 level is 1.11

5.3 IMPLICATIONS FOR THE GRADE-PRICING OF HOGS IN CANADA

Chapter 5 has focused on the second objective of this thesis as stated in Chapter 1; that of comparing the ability of various grade-pricing mechanisms to contribute to grade-pricing efficiency. In this section, the empirical results, and the interpretation of these results, will be applied to the third and fourth objectives of this thesis; determining whether the pricing efficiency of the Canadian Index 100 system can be improved, and commenting on the practical feasibility of attaining any such improvements.

5.3.1 Choice of Carcass Measurements

The use of carcass weight and either fat thickness at the last rib or the 3-4th last rib could improve the precision scores obtained by the single measurement of loin fat thickness and carcass weight currently used in the Index 100 system. Results indicated the practical benefits of the improvement may be small in relation to the general level of grade-pricing precision obtained by any of the grade-pricing procedures here tested. However, due to the nature of the carcass cutout data used in this study, the results obtained likely underestimate the actual grade-pricing precision that would be obtained in a practical grading situation.

Though the increase in grade-pricing precision may be small, there would appear to be little practical difficulty associated with the use of either the last rib or the 3-4th last rib fat measurements in place of the loin fat measurement used currently, particularly if electronic probes are used by graders.

The addition of an accompanying measurement of muscle thickness at the last rib or 3-4th last rib could provide additional improvement to grade-pricing precision, though this improvement likely would not be of statistical or practical significance. Physically obtaining and recording an accompanying muscle depth measurement likely would not be a problem if an electronic probe is used. However, the Index 100 grade-index table currently used is designed to accomodate the use of only two carcass measurements. The introduction of a third carcass measurement would require that a new format be developed for expressing the grade-indices associated with varying levels of backfat, weight, and muscle thickness. An alternative format might be the use of the actual estimated regressions of carcass value on these carcass measurements, with separate regressions for different carcass weight ranges.

Because the results in this study were not based on a random sample of pork carcasses, an accurate assessment of the practical benefits of improved grade-pricing precision to be gained from the use of alternative carcass measurements could not be claimed. However, since there would be little difficulty in changing from the loin fat measurement to either a last rib or 3-4th last rib fat measurement, there appears to be little reason not to change. Since the addition of muscle thickness measurements would require the establishment of a new format to replace the current grade-differential table format, one would have to weigh the practical benefits to be gained from the inclusion of the muscle depth measurements against the difficulties involved in introducing a new format for a three-measurement grade-pricing system. Based on the results obtained in this study, the inclusion of muscle thickness measurements is not thought to be justified, since the improvement in grade-pricing precision attributable to muscle thickness measurements was minimal.

5.3.2 Accounting for Seasonal Fluctuations

Results of tests performed in this chapter indicated that the use of a grade-pricing system which does not account for seasonal fluctuations in wholesale prices for pork cuts can result in statistically significant seasonal grade-pricing bias for individual months. It was suggested that such seasonal bias has no practical implications as regards producer and packer equity. Also, it has no detrimental effect in terms of the general promotion of the production of slaughter hogs of the physical type most desired by packers. However, it was suggested that if a seasonally adjusting grade-pricing system were introduced, and if it were to encourage the production of more heavy carcasses for the summer months, and fewer heavy carcasses during the pre-Christmas period, packers might be able to realize a decrease in their overall cutting, trimming, and processing costs. Further research is required to determine whether such a gain in packers' technical efficiency actually could be achieved. If the packing industry could be shown to benefit from the application of a seasonally adjusting system, the magnitude of this benefit would need to be compared to the costs of developing and maintaining such a system. An evaluation of these costs would include the dollar costs of administering such a system. Additionally, it would require an analysis of whether a seasonally adjusting grade-price signal would be seen by industry members as a means for more closely communicating packers' preferences to producers, or if it would simply serve to confuse both packers and producers.

Finally, even if a benefit-cost analysis of the kind described above were to produce positive results, the effect of such a system on the desireability of Canadian pork carcasses in export markets also would need to be considered. The introduction of seasonal variability in the average weight of Canadian pork carcasses may adversely affect Canada's reputation among pork importing countries for the production of slaughter hogs of uniform physical type.

5.3.3 Accounting for Long Term (Trend) Behavior

Based on the results obtained in this study, one can infer that if the Index 100 Table remains unchanged for a period in excess of one year, grade-price premiums and discounts assigned by the Table will tend (over the course of a year) to be larger than warranted by the true relationship of quality to carcass measurements. Carcasses of above average quality will tend to receive price premiums in excess of what is warranted by their actual value differentials, while below average quality carcasses will tend to receive price discounts which are larger than warranted. As a consequence, producers of above average quality pork carcasses tend to benefit at the expense of packers, while packers will tend to benefit at the expense of producers of hogs of below average quality. Further research is required to determine the actual dollar value impacts of trend-bias for producers. Also, the hog/pork industry must consider whether the effects of such bias in fact are considered to be undesireable. Overemphasizing the importance of producing high quality pork carcasses may produce a Canadian slaughter hog population which is sufficiently differentiated in terms of quality as to facilitate the expansion of export markets for Canadian hogs and pork. If, however, such trend-bias is viewed as being undesireable, (because of its implications for individual producers) it can be reduced by a policy of yearly updating the grade index table. Such updates could be based on observed trends in the relationship of carcass value indices to carcass measurements in previous years, and possibly on expected trends for the current year.

Chapter VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSIONS

Differences in the development of grade-pricing systems for slaughter hogs and/or pork carcasses in Canada and the U.S. can be found in the grade-pricing policies and mechanisms currently employed or proposed in the two countries. While the choice of grade-pricing policies is determined mostly by the objectives (e.g., the establishment of a uniform hog population for export purposes) of a hog/pork sector and/or its philosophy towards government regulation, the choice of a grade-pricing mechanism (whether for an entire sector, or for individual packers) depends on the grade-pricing performance of the mechanism as balanced against the practical difficulties in its application.

The focus of this thesis was on mechanisms (i.e., the processes or techniques) for the grade-pricing of pork carcasses. There is a wide diversity in existing and proposed mechanisms in Canada and the U.S., both in regards to the carcass measurements used to indicate carcass quality, and as to the procedure by which the relationship of carcass quality to the chosen carcass measurements is modelled. It was felt that by applying a number of alternative grade-pricing mechanisms to a common data set, the ability of these mechanisms to contribute to pricing efficiency (with respect to quality) could be determined. From this, it was hoped that possibilities for improving the performance of the Canadian Index 100 grade-pricing system could be identified.

In Chapter 2, various studies were cited for their contributions in the areas of i) determining the "best" choice of carcass measurements for indicating carcass quality, and ii) predicting carcass quality, as defined by a measure of the dollar value of the carcass, using carcass measurements. In addition, Appendix A presented a description of the historical development of slaughter hog grading practices in Canada and the U.S.

In Chapter 3, a framework for examining the relationship between carcass quality (as defined by dollar value) and price within the context of pricing efficiency was developed. It was shown that for any given point in time, the quality-price (i.e., the premium or discount associated with the grade) for a carcass should equal the difference of its net value from the average net value of all carcasses in that time period. It also was shown that an appropriate measure of the quality of an individual carcass is its "value index" (i.e., the percentage difference in the net value/kg. of carcass "i" from the mean net value of all carcasses).

Chapter 4 described the procedure by which alternative grade-pricing mechanisms were compared. The primary intent of these comparisons was to determine the effect of i) the choice of carcass measurements, and ii) the choice of the procedure for modelling the relationship of quality to the chosen carcass measurements, on grade-pricing performance (as defined by the "precision" and "accuracy" of predictions, and the practical achievement of grade-pricing efficiency in the slaughter hog market).

In Chapter 5, the results of tests determining the nature of the carcass quality-carcass measurements relationship (i.e., its behavior over time and over carcass types) were presented. In Section 5.1.1.1, results indicated that (for the sample data) the above relationship does exhibit significant (5 percent level) periodicity in terms of the response of carcass value to incremental differences in weight between carcasses. This periodicity appeared to result from short term fluctuations in the price discounts assigned to heavy pork cuts in the wholesale pork market. (Specifically, the net value of carcasses is affected more severely by increases in carcass weight during the pre-Christmas season, and is affected less severely by carcass weight during the summer months of July, August, and September).

In Section 5.1.2.1, it was determined that if a yearly average estimate of the carcass value-carcass measurements relationship is used to assign grade-prices to pork carcasses throughout that year, the grade-price signal generated can be significantly (20 percent level) biased for individual months. That is, the size of the premiums or discounts associated with incremental differences in carcass measurements can be too large for some months, and too small for others, compared to the actual effect that differences in these carcass measurements have on the net value of carcasses.

An interpretation of the above results revealed that such seasonal bias does not produce serious effects in the slaughter hog market. Producers still are encouraged to market hogs whose physical characteristics generally are in line with what packers want. In addition, if the occurrences of positive bias (i.e., the premiums and discounts are too large) and negative bias (i.e., the premiums and discounts are too small) balance out over the year, then over the course of a year, neither packers nor producers are able to benefit at the expense of the other. It was suggested, however, that the use of a seasonally adjusting system might facilitate an improvement in packers' technical efficiency. If it could encourage the production of more heavy carcasses during the summer, and fewer heavy carcasses prior to the Christmas season, packers may be able to realize a reduction in their overall cutting, trimming, and processing costs. Further research is required to evaluate the potential for a seasonally adjusting grade-pricing system to effect seasonal variations in the physical characteristics of the Canadian slaughter hog population (particularly in average carcass weight), and the implications of such variations in regards to packers' technical efficiency, as well as Canada's reputation as an exporter of high quality pork.

In Section 5.1.1.1, tests on the sample data indicated the carcass value-carcass measurements relationship exhibits significant (5 percent level) trend over time in terms of the response of carcass value to incremental differences in backfat thickness between carcasses. It was suggested this trend may reflect a decreasing trend in the price difference between wholesale "lean" cuts and bellies.

Results in Section 5.1.2.2 indicated that the carcass value-carcass measurements relationship for 1980 was positively biased in comparison to the 1981 relationship; even more so in comparison to the 1982 relationship. That is, the premiums and discounts established by the estimated relationship for 1980 were larger than required to reflect the carcass value-carcass measurements relationship for 1981 and 1982. The presence of such positive yearly bias was shown to tend to make producers of above average quality hogs better off, and make producers of below average quality hogs worse off, than they would be under a grade-pricing system that was updated every year. This is likely the case which has been occurring in Canada, since the Index 100 table of grade index differentials has not been updated since March of 1982, and the last update prior to that was in January, 1979. Further research is recommended to determine the dollar value of the described implications for producer welfare, and whether the presence of such yearly positive bias in Canada has produced desireable effects in terms of the rate at which the average quality of Canadian pork carcasses has increased.

Tests on the sample data in Section 5.1.1.2 revealed that the carcass value-carcass measurements relationship exhibits significant (1 percent level) instability when compared between subsamples of light (less than 72 kg.) and heavy (greater than 77 kg.) carcasses. Subsequent results in Section 5.1.2.3 indicated that a grade-pricing system which accounts for this instability in the carcass value-carcass measurements relationship will tend to exhibit greater grade-pricing precision (i.e., the probability that the value index assigned to an individual carcass will be within a given range of its actual value index will be higher) in comparison to a grade-pricing system which assumes this relationship to be stable across carcass weight ranges. The results indicated that this improvement was, from a practical viewpoint, insignificant, because a high degree of imprecision in grade-pricing still would remain. However, all "precision scores" obtained in this study were obtained using a stratified carcass sample. The general magnitude of the precision scores obtained in this study therefore were probably larger than would be obtained in a practical grading situation. Analysis of the kind performed in this study should be performed on a random carcass sample, in order to more closely represent a practical grading situation.

In Chapter 4, it was indicated that animal scientists generally focus on the prediction of carcass yield as a criterion for deciding which carcass measurements to include in a grade-pricing system. To determine whether this practice would tend also to indicate the ability of various carcass measurements to reflect the net value of carcasses, six alternative sets of carcass measurements[87] were ranked on the basis of their yield prediction ability (as determined by previous research by various animal scientists). A similar ranking was obtained using carcass net value as the dependent variable. Essentially, the rankings were similar, and were as follows (in descending order):

1 and 2. There was essentially no difference between last rib fat and muscle thickness, carcass weight; or 3-4th last rib fat and muscle thickness, carcass weight;

3 and 4. There was essentially no difference between last rib fat thickness, carcass weight; or 3-4th last rib fat thickness, carcass weight;

5. Sum of maximum backfat thickness at the loin and shoulder, carcass weight;

6. A single measurement of maximum backfat thickness at the loin, carcass weight.

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[87] These measurements are described in Chapter 4, Section 4.4.1.

Results in Section 5.2.2 indicated that a statistically significant (20 percent level) improvement in grade-pricing precision could be obtained by using either the last rib or 3-4th last rib measurement sites in comparison to the use of the loin site alone (as is used currently in the Index 100 system). Also, it was found that the addition of muscle thickness measurements at these sites consistently tended to produce small improvements to grade-pricing precision, compared to the use of the fat measurements alone (with carcass weight). The magnitude of this improvement was, however, not significant at the 20 percent level. Given that the current Index 100 system is designed to accomodate only two carcass measurements, the introduction of a third measurement, muscle thickness, did not appear to be justified. Further research is recommended, using a random carcass sample, to determine the practical implications for the Canadian slaughter hog industry if either the last rib or 3-4th last rib sites were adopted in the Index 100 system.

6.2 RECOMMENDATIONS

In Chapter 1, it was stated that the pupose of this study was to suggest possible means for improving the grade-pricing performance of the Canadian Index 100 grading/settlement system. The results of this study have indicated the following in this regard.

1) The use of a last rib or 3-4th last rib backfat measurement in place of the loin fat measurement currently used could improve the grade-pricing precision of the system. Further research is recommended, using a random carcass sample, to more clearly determine the practical significance of this improvement in terms of market participants' confi-

dence in the system's ability to establish grade-price differentials which meaningfully reflect the net value differentials between carcasses.

2) The inclusion of muscle thickness measurements at either the last rib or 3-4th last rib measurement sites appears to be unjustified. This practice would require the establishment of a new format for the Index 100 system (to replace the backfat-weight table currently used), but its potential to improve grade-pricing precision appeared to be minimal. However, a clearer indication of the effect of this practice in a practical grading situation could be obtained through further research, employing a random carcass sample.

3) In the continuing search to determine which carcass measurements provide the best indications of carcass quality, the relative ability of alternative carcass measurements to predict carcass yield generally can be expected to reflect the relative ability of the measurements to predict carcass value.

4) The relationship of carcass value to carcass measurements can exhibit instability within a year. The fact that the Index 100 sytem does not adjust seasonally in response to this instability has no deleterious effects on the ability of the system to encourage production of carcasses of the physical type generally desired by packers, nor does it, in itself, result in any one group of market participants achieving a net increase in welfare over the course of a year, at the expense of another group; that is, equity is maintained.

5) Introduction of seasonal adjustments to the grade-indices potentially may facilitate an improvement in packers' technical efficiency.

Further research is required to evaluate this potential, and determine if seasonal variations in the average weight of the Canadian slaughter hog population would deleteriously affect Canada'a reputation for quality in pork export markets.

6) The relationship of carcass value to carcass measurements exhibited a significant decreasing trend (over 1980, 1981, and 1982) in the impact of backfat thickness upon carcass value. On the basis of this result, it was suggested that a grade-pricing system which is not updated regularly (i.e., at least yearly) will tend to significantly overestimate the true relationship of carcass value to carcass measurements. Producers of high quality hogs will tend to receive grade-price premiums larger than warranted by the net value differentials of their pork carcasses, while lower quality hogs will tend to be discounted to a greater degree than warranted. If the Canadian hog/pork industry wishes to avoid the occurrence of such bias, yearly updates to the Index 100 grade index table should be considered.

7) The relationship of carcass value to carcass measurements exhibited significant instability between subsamples of light and heavy carcasses. Accounting for this instability in determining the premiums and discounts associated with incremental differences in backfat and weight (as is done in the Index 100 system) improved grade-pricing precision. Further research employing a random carcass sample would determine whether the extent of this improvement is sufficient to influence market participants' confidence in the system.

BIBLIOGRAPHY

Agriculture Canada, Food Systems Branch. The Canadian Pork System. 1976.

Bache, D.H. "Alternative Methods of Pricing Slaughter Hogs". Ph.D. dissertation. Purdue University, 1969.

Bowland, J.P. "Relationship of Grade to Carcass Cut-out in Pigs". Feeders' Day Report. Dept. of Animal Science, University of Alberta. June 1, 1963.

Canadian Swine Council; Meat Packers Council of Canada; and Canada Dept. of Agriculture. Canada's New Hog Carcass Valuation System. Joint publication. Oct., 1968.

Chow, G.C. "Tests of Equality Between Sets of Coefficients in Two Linear Regressions". Econometrica. Vol. 28, 1960. pp.591-605.

Clifton, E.S.; Jessen, R.J.; and Jacobs,E.M. "Marketing Hogs on the Chicago Market". Journal of Farm Economics. Vol. 31, Feb., 1949. pp. 343-361.

Couvillion, W.C., Sr. "Pricing Efficiency, Physical Characteristics, and Wholesale Values of Slaughter Hogs". Ph.D. dissertation. University of Tennessee, 1971.

Cross,H.R.; Smith,G.C.; and Carpenter, Z.L. "Pork Carcass Cutability Equations Incorporating Some New Indices of Muscling and Fatness". Journal of Animal Science. Vol. 37, 1973. pp. 423-429.

Cross,H.R.; Smith,G.C.; Carpenter, Z.L.; and Kotula,A.W. "Relationship of Carcass Scores and Measurements to Five Endpoints for Lean Cut Yields in Barrow and Gilt Carcasses". Journal of Animal Science. Vol. 41, 1975. pp. 1318-1326.

Dowell, A.A. and Engelman, G. "Research Into the Problems Involved in Marketing Slaughter Livestock by Carcass Weight and Grade". Journal of Farm Economics. Vol. 31, Feb., 1949. pp. 343-361.

Edwards, R.L.; Smith, G.C.; and Carpenter, Z.L. "Estimating Lean in Pork Carcasses Differing in Backfat Thickness". Journal of Animal Science. Vol. 52, April, 1981. pp. 703-709.

Engelman,G.; Dowell, A.A.; Ferris, E.; and Anderson, P. Marketing Slaughter Hogs by Carcass Weight and Grade. Minnesota Agricultural Experiment Station Technical Bulletin 187. April, 1950.

Engelman, G.; Dowell, A.A.; and Olson, R.E. Relative Accuracy of Pricing Butcher Hogs on Foot and by Carcass Weight and Grade. Minnesota Agricultural Experiment Station Technical Bulletin 208. June, 1953.

Engelman, G. and Gaarder, R.O. Marketing Meat Type Hogs. USDA Marketing Research Report 227. April, 1958.

Erdman, H.E. "Problems in Establishing Grades for Farm Products". Journal of Farm Economics. Vol. 32, 1950. pp. 15-29.

Fahey, T.J.; Schaefer, D.M.; Kauffman, R.G.; Epley, R.J.; Gould, P.F.; Romans,J.R.; Smith, G.C.; and Topel, D.G. "A Comparison of Practical Methods to Estimate Pork Carcass Composition". Journal of Animal Science Vol. 44, 1977. pp. 8-17.

Fortin, A. "Carcass Composition of Yorkshire Barrows and Gilts Slaughtered Between 85 and 112 Kg Body Weight". Canadian Journal of Animal Science. Vol. 62, Mar., 1982. pp. 69-76.

Fortin, A., Research Scientist. Research Branch, Agriculture Canada Animal Research Centre, Ottawa, Ontario. Personal letter. March, 1983.

Fortin, A.; Martin, A.H.; Sim,D.W.; Fredeen, H.T.; and Weiss, G.M. "Evaluation of Different Ruler and Ultrasonic Backfat Measurements as Indices of Commercial and Lean Yield of Hog Carcasses for Commercial Grading Purposes". Canadian Journal of Animal Science. Vol. 61, Dec., 1981. pp. 893-905.

Fredeen, H.T. "Recent Trends in Carcass Performance of the Commercial Hog Population in Canada". Journal of Animal Science. Vol. 42, 1976. pp. 342-351.

Fredeen, H.T.; Berg, R.T.; Bowland, J.P.; and Doornenbal, H. "Prediction of Yield and Value of Hog Carcasses". Canadian Journal of Animal Science. Vol. 44, 1964. pp. 334-336.

Fredeen, H.T. and Bowman, G.H. "Backfat Thickness and Carcass Weight as Predictors of the Yield of Hams and Loins in Pig Carcasses". Canadian Journal of Animal Science. Vol. 48, 1968. pp. 117-129.

Fredeen, H.T. and Bowman, G.H. "Commercial Grades of Pigs in Canada". Canadian Journal of Animal Science. Vol. 48, 1968. pp. 109-116.

Fredeen, H.T.; Martin, A.H.; Harbison, D.S.; and McAndrews, J.G. "Criteria of Belly Bacon Desirability. I. Fat-Lean Ratio of the Pork Belly in Relation to Backfat, Carcass Weight and Specific Gravity". Canadian Journal of Animal Science. Vol. 55, Dec., 1975. pp. 641-648.

Fredeen, H.T. and Weiss, G.M. "Comparison of Techniques for Evaluating Lean Content of Hog Carcasses". Canadian Journal of Animal Science. Vol. 61, June, 1981. pp. 319-333.

Freebairn, J.W. "The Value of Information Provided by a Uniform Grading System". Australian Journal of Agricultural Economics. Vol. 17, Aug., 1973. pp. 127-139.

Gaarder, R.O. "Relationships Between Physical Characteristics and Value of Live Hogs and Hog Carcasses". Ph.D. dissertation. Iowa State University of Science and Technology, 1962.

Griffith, G.R. and Giles, L.R. "Pig Carcass Pricing Models: A Preliminary Investigation". Review of Marketing and Agricultural Economics. Vol. 45, Dec., 1977. pp. 146-157.

Hawkins, M.H. "Alternative Methods of Marketing Livestock". Canadian Journal of Agricultural Economics. Vol. 17. pp. 104-110.

Hayenga, M.L. An Evaluation of Hog Pricing and Grading Methods. Michigan State University, Agricultural Economics Report 192. May, 1971.

Hayenga, M.L. "Hog Pricing and Evaluation Methods -- Their Accuracy and Equity". American Journal of Agricultural Economics. Aug., 1971. pp. 507-509.

Hayenga, M.; Kauffman, R.; and Grisdale, B. "Technical Appendix 1, Pork Value Task Force Report". Undated. Received from the National Pork Producers Council.

Ikerd, J.E. and Cramer, C.L. "A Practical Computer Method for Pricing Pork Carcasses and Hogs". American Journal of Agricultural Economics. Vol. 52, May, 1970. pp. 242-246.

Ikerd, J.E. and Cramer, C.L. "Price Signal Refraction in Pork Processing". American Journal of Agricultural Economics. Vol. 50, May, 1968. pp. 225-231.

Judge, G.; Griffith, W.; Carter Hill, R.; and Tsoung-Chao Lee. The Theory and Practice of Econometrics. New York: John Wiley and Sons, Inc., 1980.

Kennedy, R. and Churches, M. Canada's Agricultural Systems. Dept. of Agricultural Economics, McGill University, Ste Anne de Bellevue, Quebec. 1981.

Koutsoyiannis, A. Theory of Econometrics. London: The Macmillan Press Ltd. 1977.

Lancaster, K.J. Consumer Demand. A New Approach. New York: Columbia University Press. 1971.

Mann, H.B. "Non-Parametric Tests Against Trends". Econometrica. Vol. 13, 1945. p.246.

McCoy, J.H. Livestock and Meat Marketing. Second edition. Westport, Conneticut: Avi Publishing Co. Inc. 1979.

Martin, A.H.; Fredeen, H.T.; L'Hirondelle, P.J.; Murray, A.C.; and Weiss, G.M. "Pork Quality Attributes: Their Estimation and Their Relationships With Carcass Composition in Commercial Pigs". Canadian Journal of Animal Science. Vol. 61, June, 1981. pp. 289-298.

Martin, A.H.; Fredeen, H.T.; Weiss, G.M.; Fortin, A.; and Sim, D. "Yield of Trimmed Pork Product in Relation to Weight and Backfat Thickness of the Carcass". Canadian Journal of Animal Science. Vol. 61, June, 1968. pp. 299-310.

Martin, M.B. "An Economic Analysis of Quality and Grading in Corn Marketing". Ph.D. dissertation. Iowa State University, 1974.

Meat Packers Council of Canada. "Review of Hog Carcass Indices". Nov., 1974.

Mehren, G.L. "The Function of Grades in an Affluent, Standardized-Quality Economy". Journal of Farm Economics. Vol. 43, 1961. pp. 1377-1383.

Meyer, A.L. "Obstacles to Carcass Grade and Weight Marketing of Livestock". Ph.D. dissertation. Purdue University, 1980.

National Pork Producers Council. "The Pork Value Approach". Brochure. P.O. Box 10383, Des Moines, Iowa, 50306.

National Provisioner Daily Market and News Service. The Daily Yellow Sheet. 15 W. Huron St., Chicago, Illinois, 60610.

North Central Livestock Marketing Research Committee. Objective Carcass Grade Standards for Slaughter Hogs. Minnesota Agricultural Experiment Station Bulletin 414. North Central Regional Publication 30. 1952.

Pearson, A.M.; Hayenga, M.L.; Heifner, R.G.; Bratzler, L.J.; and Markel, R.A. "Influence of Various Traits Upon Live and Carcass Value for Hogs". Journal of Animal Science. Vol. 31, Aug., 1970. pp. 318-322.

Price, M.A. "Meat Carcass Grading in the Future". Canadian Journal of Animal Science. Vol. 63, Mar., 1982. pp. 3-13.

Purcell, W.D. Agricultural Marketing Systems: Systems, Coordination, Cash, and Futures Prices. Reston, Virginia: Reston Publishing Co., Inc. 1979.

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

Rawls, E.L., Jr. "A Theoretical and Procedural Approach to Estimating the Differential Value of Pork Carcasses and Live Hogs". Ph.D. dissertation. Virginia Polytechnic Institute, 1969.

Report of the Select Committee of the Legislative Assembly of Manitoba. Livestock Marketing in Manitoba. Feb., 1964.

Rhodes, V.J. and Kiehl, E.R. "On Consumer Grades for Food". Journal of Farm Economics. Vol. 38, Feb., 1956. pp. 44-61.

Ronald A. Chisolm Ltd., Two Bloor Street West, Suite 2501, Toronto, Ontario, M4W 3K3. Packing house products price reports, Jan., 1980 to Dec., 1982.

Rosendale, V.M. "Relationships Between Carcass Traits and the Value of Live Hogs and Hog Carcasses". M.S. thesis. University of Illinois, 1964.

Shepherd, G.; Beard, F.; and Erikson, A. Could Hogs Be Sold by Carcass Weight and Grade in the U.S.? Iowa Experiment Station Research Bulletin 270. Jan., 1940.

Shepherd, G.S.; Futrell, G.A.; and Strain, J.R. Marketing Farm Products. Sixth edition. Ames, Iowa: Iowa State Press, 1976.

Simmons, P. "Determination of Grade Prices for Wool". Review of Marketing and Agricultural Economics. Vol. 48, April, 1980. pp. 37-46.

Skelley, G.C.; Handlin, D.L.; and Bonnette, T.E. "Pork Acceptability and Its Relationship to Carcass Quality". Journal of Animal Science. Vol. 36, 1973. pp. 488-492.

Smith, G.C. and Carpenter, Z.L. "Evaluation of Factors Associated With the Composition of Pork Carcasses". Journal of Animal Science. Vol. 36, 1973. pp. 493-499.

Tintner, G. Econometrics. New York: John Wiley and Sons, Inc. 1952.

Tomek, W.G. and Robinson, K.L. Agricultural Product Prices. Second edition. London, England: Cornell University Press. 1981.

USDA, Consumer Marketing Service. "Official United States Standards for Grades of Pork Carcasses". Service and Regulatory Announcement 171. Sept., 1952.

USDA, Consumer Marketing Service. "Official United States Standards for Grades of Slaughter Swine". Service and Regulatory Announcement 172. Sept., 1952.

USDA. Packers and Stockyards Resume. Packers and Stockyards Administration. Vol. 15, Dec., 1977.

Wallis, W.A. and Moore, G.H. "A Significance Test for Time Series Analysis". Journal of the American Statistical Association. Vol. 30, 1941. p.401.

Warrack, A.A. "A Conceptual Framework for Analysis of Market Efficiency". Canadian Journal of Agricultural Economics. Vol. 20, pp. 9-22.

Waugh, F.V. "Quality as a Determinant of Vegetable Prices". Columbia University, New York. 1929.

Weisberger, P. Canada's Competitive Position in the North American Hog Industry. USDA. Economic Research Service, Washington, D.C. 20250. Staff report no. AGES811216. Dec., 1981.

Wiley, J.R.; Paarlberg, D.; and Jones, R.C. Objective Carcass Factors Related to Slaughter Hog Values. Purdue University Agricultural Experiment Station Bulletin 567. Dec., 1951.

Zusman, P. "A Theoretical Basis for Determination of Grading and Sorting Schemes". Journal of Farm Economics. Vol. 49., 1967. pp. 89-106.

Appendix A

HISTORICAL BACKGROUND

This Appendix describes the historical development of hog grading and pricing practices in both the U.S. and Canada. This historical description is included to acquaint the reader with the initial reasons for official grades, and the circumstances which have guided their modification over time. While a historical background is not essential to the achievement of the major objective of this study, it is hoped that the reader will gain an improved understanding of the problem addressed in this thesis, and the motivation for this study.

A.1 HISTORICAL BACKGROUND

A.1.1 Development of Official Grade Standards

The development of grading standards and/or the payment of equitable price differentials for animals of varying physical characteristics has been a concern of the North American livestock industry since the nineteenth century.[88]

In the U.S., the initial attempts to classify livestock were undertaken by private publishers of market price reports in response to the growth of the large terminal markets. Early grade names within markets

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[88] This section is based largely on J.H. McCoy, op. cit., pp.286-287, G. Engelman, A. Dowell, E. Ferris, and P. Anderson, Marketing Slaughter Hogs by Carcass Weight and Grade, Minn. Agr. Exp. Sta. Tech. Bul. 187, April, 1950, pp. 3-6, and The Report of the Select Committee of the Legislative Assembly of Manitoba, Livestock Marketing in Manitoba, Feb., 1964, pp. 190-191.

were, however, typically vague, and had limited meaning between markets, since grade terminology and specifications often differed between markets. Meaningful and useful price reporting required the use of a common grade classification system for all markets.

The USDA began work in developing grade standards in 1915, and by 1918 tentative, unpublished USDA grades for live barrows and gilts were formulated for market reporting purposes. These were revised and published as tentative standards in 1931. Tentative USDA pork carcass standards were initially published in 1924. These early carcass and live standards reflected the existing strong demand for lard, and encouraged the production of heavy, "lard-type" (low lean-to-fat ratio) hogs.

Thus, by the late 1930's, the U.S. pork industry long had recognized the need for official slaughter hog standards to facilitate market price reporting, and was making use of government-developed live animal standards for this purpose. There was, however, very slow acceptance of both the tentative live and carcass standards as aids in pricing slaughter hogs because the U.S. pork industry believed these standards did not accurately reflect the actual cut-out value of hogs.[89] Furthermore, the standards were subjective in their descriptions of the physical qualities required for a given grade.

In Canada, hog grading standards evolved in response to a need different to that in the U.S. Canada had developed a lucrative British market for Wiltshire sides during World War I. After the war, superior and more consistent quality Danish bacon began to compete for the Brit-

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[89] G. Engelman, et al., 1950, ibid., p. 5.

ish market. Canada had been producing mainly lard type hogs to this time. These hogs were purchased on a "flat basis" with little regard for physical differences between hogs. This method of purchase offered no monetary incentive to produce the superior quality hogs required for the British market. In response to this situation, an official live grading system, aimed at encouraging the production of long, lean hogs for the Wiltshire side trade, was established in 1922 under the Federal Livestock and Livestock Products Act. By 1932, it was compulsory to buy and sell hogs on the basis of these official live grades.

A.1.2 Rail Grading With Objective Grade Standards

Before the advent of pricing according to grade, the most common pricing procedure used by both Canadian and U.S. packers was that of pricing according to live weight alone. This method was found to be inaccurate since prices generated by this method did not reflect the value of the animals.[90] Figure A.1 illustrates the difference in pricing accuracy of live weight versus carcass weight and grade pricing of a sample of slaughter hogs. In Figure A.1, the calculated values of the hogs (based on prices obtained for pork products), on the horizontal axis, are compared to the predictions of value produced by the two pricing systems. Pricing on the basis of live weight and the existing USDA live grades also had been shown to produce a considerable degree of pricing error, relative to carcass grading.[91]

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[90] Ibid., p. 3.

[91] Ibid., pp. 5-6.

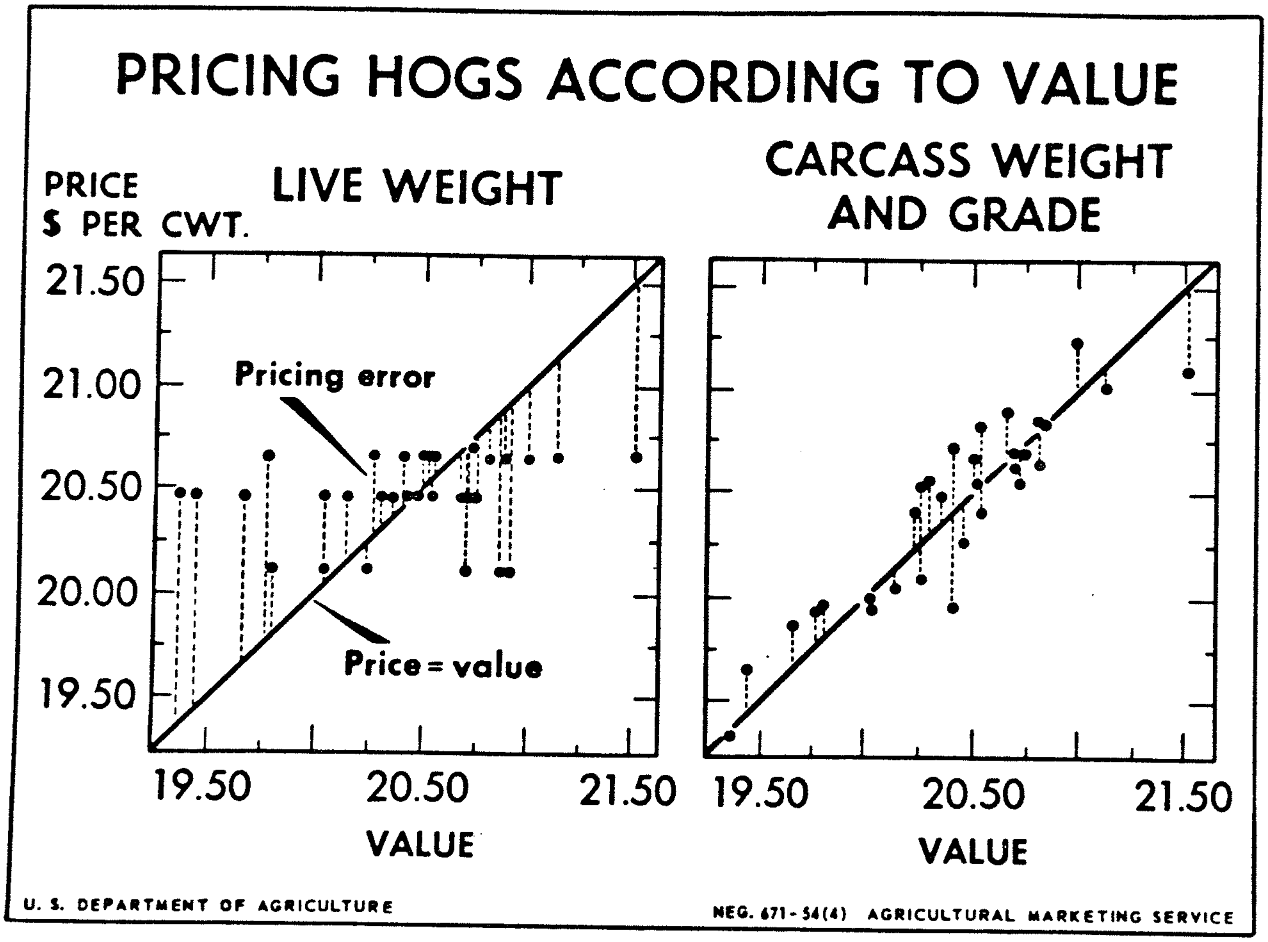

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Figure A.1: Live Weight versus Carcass-Based Pricing (1950)

In an effort to reduce the degree of pricing error, and to further improve the quality of Canadian hogs via appropriate price incentives to producers, Canada introduced carcass grading on a voluntary basis in 1934. These carcass grades were based on measurements of weight, back-fat, and length. By 1940, it was made the sole official grading system for hogs in Canada. In contrast, during the 1940's in the U.S., even live grading was being used only for market price reporting purposes; neither the USDA live nor carcass standards found significant use by packers for quality-pricing purposes.

In 1940, Shepherd et al. examined the pros and cons of carcass weight and grade selling.[92] The prevalent method of sale in the U.S. at that time (by live weight alone) tended to price all hogs of the same class and weight range at about the same price per hundredweight. After comparing cut-out values for lots of hogs with prices paid, it was concluded that "prices paid for different lots of hogs do not closely represent their actual cut-out values"[93] when purchases were based on live weight alone. Hogs of similar weight were found to vary considerably in dressing percentage. It was determined that differences in the dressing percentage and "make-up" (i.e., cutability) of carcasses, were responsible for the differences in value for hogs of similar weight range. While favoring the use of carcass grades over live, the Shepherd study also indicated that objective grade specifications reflecting the cutability of hog carcasses were needed. The subjective "finish", "con-

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[92] G. Shepherd, F. Beard, and A. Erikson, Could Hogs Be Sold By Carcass Weight and Grade in the U.S.?, Iowa Exp. Sta. Res. Bul. 270, Jan., 1940.

[93] Ibid., p. 475.

formation", and "quality" specifications in the U.S. standards were inadequate in identifying cutability differences among hogs. It was believed that objective specifications would aid the grader in achieving accuracy and consistency in grading, and would eliminate disagreements over the grade designated for any particular hog. The authors stated that "the problem of determining proper price differentials for different grades waits upon the setting up of the grade specifications".[94]

By 1950, Canada had been grading slaughter hogs on the rail (i.e., on a carcass grade basis) for almost twenty years. In the U.S., packers continued to purchase hogs primarily on the basis of live weight alone. Engelman et al., in 1950, examined the possibility of grading U.S. hogs on the rail.[95] A set of carcass standards based on the relationship between average backfat thickness and carcass weight to percentage yield of lean was developed, and the value differentials between hogs falling in the different grade categories were determined. Three main sources of variations in live hog values were identified; 1) variations in weight (since heavier weights of wholesale cuts from heavier carcasses normally sold at a discount to lighter cuts), 2) variations in dressing percentage, and 3) variations in carcass types (cutability). A comparison of the relative abilities of live versus rail grading to explain carcass value showed the rail grading method to be superior. In spite of these findings, only about ten percent of U.S. hogs currently are purchased "on the rail".[96] Meyer (1980) determined that the reasons U.S.

[94] Ibid., p. 450.

[95] G. Engelman, et al., op. cit.

[96] USDA, Packers and Stockyards Resume, Packers and Stockyards Administration, vol. 15, Dec., 1977.

packers did not purchase on this basis were that they either graded no livestock or procured most of their livestock through a non-direct channel.[97] Livestock not sold directly to the packers are seldom traded on a carcass basis. Producers, on the other hand, were found to have difficulty in comparing prices quoted on a carcass grade basis. They also lacked confidence that their livestock would be graded without bias, and disliked the fact that their livestock must be committed to a particular packing plant before the final grade and price settlement is achieved.

A variety of methods are used in evaluating hogs purchased on a live basis. Often, the hogs are weighed, although estimated weight also may be used. The expected yield often is estimated by a visual inspection of the conformation and finish of the animals. Both this weight and yield data may be based either on evaluations of individual hogs, or lots of hogs. The lots may be either unsorted, or sorted according to class, weight range, or grade.

Attempts at developing objective carcass grade standards continued in the U.S., and in the early 1950's, the North Central Livestock Marketing Research Committee organized a joint study including six state agricultural experiment stations. Their proposed standards were published in 1952.[98] Later in the same year, " Official United States Standards for Grades of Pork Carcasses" and complementary "Standards for Grades of Slaughter Swine" were established.[99] The carcass standards were based

[97] A.L. Meyer, "Obstacles to Carcass Grade and Weight Marketing of Livestock", (unpublished Ph.D. dissertation, Purdue University, 1980).

[98] North Central Livestock Marketing Research Committee, Objective Carcass Grade Standards For Slaughter Hogs, Minn. Agr. Exp. Sta. Bul. 414, North Central Regional Publication 30, 1952.

[99] USDA, Consumer Marketing Service, "Official United States Standards

primarily on backfat thickness and either one of carcass weight or length. Borderline cases could have their final grade determined by a subjective appraisal of conformation.

Given these newly promulgated objective USDA standards, Engelman et al. (1953) compared the relative accuracy of pricing hogs on foot and by carcass weight and grade.[100] The authors stated that "one of the principal tests of the desirability of any method of marketing hogs is the relative accuracy of pricing in relation to the actual value of the hog to the packer".[101] In comparing numerous live grade-pricing systems with rail grade purchasing, it was found that the carcass weight and grade method was the most accurate.

In spite of the efforts to develop grade standards which could improve the accuracy of hog pricing, the majority of slaughter hogs in the U.S. continued to be sold on a live basis. Clifton et al. (1954) compared the prices actually paid for different grade classes of hogs in the Chicago market to their value.[102] It was shown that price differentials paid did not accurately reflect the wholesale value differences between grades. This meant that in spite of the efforts of the U.S. hog industry, American slaughter hog producers still were not receiving pay-

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for Grades of Pork Carcasses", and "Official United States Standards for Grades of Slaughter Swine", Service and Regulatory Announcements 171 and 172, respectively, issued Sept., 1952.

[100] G. Engelman, A.A. Dowell, and R.E. Olson, Relative Accuracy of Pricing Butcher Hogs on Foot and by Carcass Weight and Grade, Minnesota Agricultural Experiment Station Technical Bulletin No. 208, June, 1953. op. cit.

[101] Ibid., p. 4.

[102] E.S. Clifton, R.J. Jessen, and E.M. Jacobs, "Marketing Hogs on the Chicago Market", Journal of Farm Economics, vol. 36, No. 4, (1954), pp. 611-619.

ment in relation to the value of the individual hogs they produced.

To summarize this section briefly, research efforts from 1940 to 1953 had recognized the superior accuracy of a grading system based on objective carcass measurements. By the mid-1950's, Canadian packers had nearly two decades of experience in rail grade pricing of hogs. In comparison, the majority of U.S. packers still were conducting purchases based on live weight alone. Research in 1954 subsequently showed that American producers were not receiving prices reflective of the value of their slaughter hogs.

A.1.3 Response to Changes in Consumer Preferences

Prior to World War I, both Canadian and U.S. hogs primarily were of the lard type. The hog/pork sectors in both countries found it necessary, however, to shift production towards leaner animals as consumers exhibited a shift in preferences away from lard.[103]

In the U.S., wholesale prices for lard had, since 1910, progressively declined relative to prices for lean cuts. In response to this trend, the tentative U.S. grade standards of 1949 were revised and deemed "official" in 1952. The revision consisted of a lowering of the backfat specifications for each weight category in each grade. Further revisions took place in 1955, and again in 1968, with each revision reflecting increased preference for lean pork through successive decreases in minimum backfat requirements.

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[103] This section is based largely on G. Engelman and R.O. Gaarder, Marketing Meat Type Hogs, USDA Marketing Research Report No. 227, April, 1958.

As was described earlier, Canada's reliance on the British export market provided the initial stimulus towards development of a leaner slaughter hog. As noted earlier, live grade standards which encouraged the production of leaner "bacon type" hogs were established in 1922. The Canadian grades for live hogs initially consisted of only two basic categories; 1) a "thick smooth grade" for lard type hogs, and 2) a "select bacon grade" for those hogs which were expected to produce carcasses suitable for the British export market. In 1929, the lard type category was divided into a "butcher grade" which identified those hogs with an excessive degree of finish, and a "bacon grade" for animals with less finish. These grades were replaced by letter-grade (i.e., "A", "B", "C") categories in the 1930's.

The price differentials paid between these live grades over the length of their use (until 1940) encouraged a significant increase in the overall quality of Canadian hogs. Over the years 1934 to 1940, when both live and carcass pricing methods were in use, the grade distribution of Canadian hogs marketed remained relatively stable (about 30 percent graded as "A", and about 50 percent graded "B") while their average live weight increased by nearly twenty pounds. Overall, larger, leaner hogs were being produced by Canadian farmers. The superiority of Canadian hog quality in relation to American hogs was illustrated in a 1957 sample which showed that 71 percent of Canadian barrows and gilts would have graded U.S. No. 1. In comparison, only an estimated 15 to 30 percent of U.S. barrows and gilts graded No. 1 in that year.[104]

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[104] Ibid., pp. 24-25.

Engelman, et al. attributed the superior quality of Canadian hogs relative to those in the U.S. to various factors. For example, the Canadian standards were more discriminating than their U.S. counterparts. In the 1957 sample mentioned above, of the Canadian hogs sampled, only 42 percent graded as Canada grade "A". Also, the introduction of carcass grading in Canada encouraged continued improvement in quality. As noted earlier, rail grading was compulsory by 1940. In contrast, it was estimated in 1957 that a maximum of only 8 to 10 percent of U.S. hogs were even sorted according to grade before being sold.[105] In addition, Canadian producers received a greater monetary incentive to produce Grade A hogs, when compared to U.S. producers. Price differentials between grades generally were much greater for Canadian hogs, due to two reasons; a government bonus payment for grades A and B1 hogs, and the tendency for Canadian packers to establish larger price differentials than those in the U.S. Canadian hog carcasses generally were trimmed to a greater extent than those in the U.S., making the difference in yield of lean cuts between individual hogs of relatively greater significance to Canadian packers. Engelman et al. showed the yield (as a percentage of carcass weight) difference between a grade "A" and "C" carcass to be 5.2 percent using a "regular" (i.e., U.S. packer method) trim, and 8.4 percent using the deboned, close-trimmed method of Canadian packers.[106]

In summary, following World War I, Canadian slaughter hogs exhibited a greater overall improvement in quality in comparison to their American counterparts. This appeared to be due to the fact that: 1) Canadian

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[105] Ibid., pp. 11-12.

[106] Ibid., pp. 28-29.

standards, designed to promote the production of lean animals, were promulgated in 1922, whereas the first official U.S. grades were not published until 1952; and 2) Canadian grading and pricing practices appeared to provide a clearer transmission of consumer preferences for lean pork to Canadian producers (via grade-price differentials for slaughter hogs), in comparison to practices in the U.S.

A.1.4 Accurate Pricing of Individual Hogs

By the 1950's, it was recognized that objective carcass grading procedures resulted in improved pricing accuracy over live grading procedures. Research in the late 1950's and 1960's showed that the existing grade standards in Canada and the U.S. were able to sort carcasses such that the average high-grade animal was of greater value than the average carcass of lower grade. However, it also was shown that the existing standards were unable to distinguish the value differentials between individual hogs.

In the U.S., in 1951, Wiley, et al. examined the relationship between various carcass measurements and carcass cutout value.[107] Pricing on a carcass basis was found to result in improved pricing accuracy over live weight and grade pricing. However, the improvement resulted mainly from the inclusion of the carcass weight measurement due to the fact that the existing carcass grade standards were not significant in their contribution to pricing accuracy.

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[107] J.R. Wiley, D. Paarlberg, and R.C. Jones, Objective Carcass Factors Related to Slaughter Hog Values, Purdue Univ. Agr. Exp. Sta. Bul. 567, Dec., 1951.

The continued inadequacy of pricing systems used in the U.S. was noted later by Bache in 1969.[108] Live market grade-price differentials were compared with wholesale carcass value differentials, and it was concluded that value differences associated with physical differences between animals were not being passed from the wholesale to the live market. In an attempt to improve their usefulness, the USDA standards for barrows and gilts were revised in 1968. These revisions stressed the importance of lean yield. The minimum backfat requirement for the old No.1 grade was eliminated, and a new No.1 grade was established to reflect the development of an improved quality of hog in the U.S. These USDA grades have remained basically unchanged since 1968.[109] The currently existing standards for pork carcasses also were established in 1968, and correspond to the live standards. Carcasses with quality deficiencies such as soft or oily fat, an unacceptable quality of lean, or thinness in the belly are graded as "U.S. Utility". Those carcasses not delegated to the "Utility" grade receive a "U.S. No. 1, 2, 3, or 4" grade, depending solely upon the backfat and weight criteria. The carcass grading of sows is similar, except that the sow carcass yield grade is determined by backfat measure alone, and the grades are designated as "U.S. No. 1, 2, or 3", "Medium", or "Cull".

If a packer wishes to purchase U.S. hogs on the basis of grade standards other than those provided by the USDA, written specifications of the grades must be made available to both the buyer and seller. This is

[108] H. Bache, "Alternative Methods of Pricing Slaughter Hogs", (unpublished Ph.D. dissertation, Purdue University, 1969).

[109] Pork carcass standards as presented in the 1981 U.S. Federal Register No. 7, pp. 47-54 are identical to those published in 1968 by the USDA Consumer Marketing Service.

a common practice in the U.S. Federal grades are practically unused by packers, as most employ their own private grading system. A factor contributing to the lack of practical acceptance of the USDA grades is that the number of grade categories still is too small to facilitate accurate pricing. Hayenga (1971) reported that, compared to pricing according to weight and backfat measurements directly,

> "the pricing error would be greater in the live weight and (USDA) grade system which requires the very same measures or estimates. This is primarily due to the fact that backfat thickness is an important factor affecting carcass value; lumping together as much as .3 inches of backfat (within a grade) is like discarding valuable information which could better pinpoint the value of each animal".[110]

In Canada, in 1963, a report by Bowland examined the range of cut-out measures and values within Canadian A,B, and C grades.[111] He reported a significant degree of overlapping of cut-out measurements and value between grades, and noted that while the existing grading system led to higher prices "on average" for the higher grade carcasses, it did not accurately reflect cut-out values of individual hogs.

In 1963, Fredeen et al. proposed that the existing Canadian grade structure was too limited in scope to recognize differences in individual carcass merit.[112] It was reported that more refined grading procedures could not effectively be used unless 1) a greater number of grade

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[110] M.L. Hayenga, "Hog Pricing and Evaluation Methods - Their Accuracy and Equity", American Journal of Agricultural Economics, vol. 53, (1971), p. 508.

[111] J.P. Bowland, "Relationship of Grade to Carcass Cut-out in Pigs", Feeders' Day Report, Dept. of Animal Science, Univ. of Alberta, June 1, 1963, pp. 14-16.

[112] H.T. Fredeen, R.T. Berg, J.P. Bowland, and H. Doornenbal, "Prediction of Yield and Value of Hog Carcasses", Canadian Journal of Animal Science, vol. 44, (1964), pp. 334-336.

classifications was provided, or 2) predicted yield itself was made the basis for commercial settlement. The Federal Department of Agriculture in cooperation with the Meat Packers Council of Canada (a national association of packers and processors) responded with a series of studies through 1965 to 1967.[113] Based on this research, a new "Index 100" grading system, established in 1968, classified carcasses according to 14 backfat categories, and nine weight categories (Figure 2.2). An estimated relationship of backfat thickness and carass weight to value was used as a basis for establishing a table of grade indices. The main advantage of this system was the creation of a much larger number of grade categories. This allowed a more precise means of identifying quality differentials for individual hogs. The Canada Department of Agriculture and the Canada Pork Council hoped the introduction of the new grading/settlement system would have a twofold effect. First, it would facilitate price incentives to encourage the production of top quality hogs. Second, the system also would provide a clear identification of the physical traits to "aim for" in the production of slaughter and feeder hogs. Producers would be able to adjust their feeding, management, and breeding practices in accordance with those index specifications providing the best monetary return.

In April, 1978, the first revisions to the index system took place. The number of backfat categories and weight range categories increased to 17 and 11, respectively. The range of index values for hogs falling within these specified categories also increased, from a range of 24

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[113] See Canadian Swine Council, Meat Packers Council of Canada, and Canada Dept. of Agriculture, Canada's New Hog Carcass Valuation System, joint publication, Oct., 1968, pp. 2-5, for a brief discussion of these studies.

Weight of Carcass

Backfat in tenths of inches	90 to 124 lb.	125 to 129 lb	130 to 139 lb.	140 to 149 lb	150 to 159 lb	160 to 169 lb	170 to 180 lb	181 to 195 lb	196 lb and Over
— 1.9	87	105	109	110	112	112	112	91	85
2.0-2.1	87	103	107	109	110	112	112	91	85
2.2-2.3	87	102	105	107	109	110	110	91	85
2.4-2.5	87	100	103	105	107	109	109	91	85
2.6-2.7	87	98	102	103	105	107	107	91	85
2.8-2.9	87	97	100	102	103	105	105	91	85
3.0-3.1	87	95	98	100	102	103	103	91	85
3.2-3.3	87	92	97	98	100	102	102	91	85
3.4-3.5	87	88	95	97	98	100	100	91	85
3.6-3.7	87	88	92	95	97	98	98	91	85
3.8-3.9	87	88	88	92	95	97	97	91	85
4.0-4.1	87	88	88	88	92	95	95	87	82
4.2-4.3	87	88	88	88	88	92	92	87	82
4.4—	87	88	88	88	88	88	88	87	82

Source: Canada Agricultural Products Standards Act Hog Carcass Grading Regulations, Consolidated Regulations of Canada, 1978, vol. II, chap. 286, p. 1490.

Figure A.2: Index 100 Table as of 1968

points (from 88 to 112) to one of 34 points (from 80 to 114). According to the 1968 standards, the 160-169 and 170-199 pound classes received the highest index value, while the 180-189 and 190-199 pound classes received the highest index under the 1978 standards (Figure 2.3). The revised standards encouraged the production of significantly heavier hogs, while maintaining the emphasis on leanness. This change proved unacceptable to the packers, as they feared a proliferation of heavy hogs would result in a glut of heavy primal cuts at the wholesale level. In January of 1979, the standards again were revised, with the highest average index weight class becoming that of 170-179 pounds (Figure 2.4). In March of 1982 a third revision took place, altering the backfat standards[114] in order to accommodate the use of a single backfat measurement (Figure 2.5). Fortin, et al. in a comparison of various backfat measurements as yield predictors, had found that a single measurement over the lumbar region resulted in accuracy of lean prediction comparable to that obtained by using two fat measurement sites.[115]

In current practice, the grade index table is used to reflect the yield and value of barrow and gilt carcasses only. Sows and stags are graded separately. Ridglings are automatically assigned an index grade of 67. Also, provisions are made for the application of index demerits due to type (i.e., thin belly, or physical injury of farm origin), or

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[114] Note that while the backfat standards in the Index 100 Table are described as "backfat in tenths of inches", the standards actually are in inches of backfat, with one tenth inch increments.

[115] A. Fortin, A.H. Martin, D.W. Sim, H.T. Fredeen, and G.M. Weiss, "Evaluation of Different Ruler and Ultrasonic Measurements as Indices of Commercial and Lean Yield of Hog Carcasses for Commercial Grading Purposes", Canadian Journal of Animal Science, vol. 61, Dec., (1981), pp. 893-905.

quality (i.e., abnormally soft or oily fat). A carcass of average weight (155 lbs) and backfat (3.2 inches of loin plus shoulder fat, or 1.5 inches loin fat alone) is given an index grade of 100. Superior yielding hogs of acceptable quality receive an index grade ranging from 101 to 114, while hogs likely to be of inferior yield receive an index grade ranging from 80 to 99. Price negotiations between producers (or producer selling organizations) and packers determine the price for an "Index 100" hog. Actual prices paid for individual hogs are determined by multiplying the assigned index grade by the negotiated Index 100 price. In this way, producers of superior quality hogs receive a price premium for their product. Inferior hogs warrant an appropriate price discount. All slaughter hogs sold in Canada to the packing industry are sold according to this system. To ensure equitable grade determination for both producers and packers, impartial government graders are used.

Weight of Carcass

Backfat in tenths of inches	90 to 124 lbs	125 to 129 lbs	130 to 139 lbs	140 to 149 lbs	150 to 159 lbs	160 to 169 lbs	170 to 179 lbs	180 to 189 lbs	190 to 199 lbs	200 to 209 lbs	210 and over
	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index
—1.9	87	105	107	108	110	112	113	114	114	90	80
2.0—2.1	87	103	105	107	108	110	112	113	113	90	80
2.2—2.3	87	102	103	105	107	108	110	112	112	90	80
2.4—2.5	87	100	102	103	105	107	108	110	110	90	80
2.6—2.7	87	98	100	102	103	105	107	108	108	90	80
2.8—2.9	87	97	98	100	102	103	105	107	107	90	80
3.0—3.1	87	95	97	98	100	102	103	105	105	90	80
3.2—3.3	87	93	95	97	98	100	102	103	103	90	80
3.4—3.5	87	92	93	95	97	98	100	102	102	90	80
3.6—3.7	87	90	92	93	95	97	98	100	100	90	80
3.8—3.9	87	88	90	92	93	95	97	98	98	90	80
4.0—4.1	87	87	88	90	92	93	95	97	97	80	80
4.2—4.3	85	85	87	88	90	92	93	95	95	80	80
4.4—4.5	83	83	85	87	88	90	90	90	90	80	80
4.6—4.7	82	82	83	85	87	88	88	88	88	80	80
4.8—4.9	80	80	82	83	85	87	87	87	87	80	80
5.0— —	80	80	80	80	80	80	80	80	80	80	80

Source: Canada Agricultural Products Standards Act Hog Carcass Grading Regulations, Canada Gazette, Part II, vol. 112, No. 8, p. 1432.

Figure A.3: Index 100 Table as of 1978

Backfat in tenths of inches	90 to 124 lbs	125 to 129 lbs	130 to 139 lbs	140 to 149 lbs	150 to 159 lbs	160 to 169 lbs	170 to 179 lbs	180 to 189 lbs	190 to 199 lbs	200 to 209 lbs	210 and over
	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index
—1.9	87	105	107	108	110	113	114	113	112	90	80
2.0—2.1	87	103	105	107	108	112	113	112	110	90	80
2.2—2.3	87	102	103	105	107	110	112	110	108	90	80
2.4—2.5	87	100	102	103	105	108	110	108	107	90	80
2.6—2.7	87	98	100	102	103	107	108	107	105	90	80
2.8—2.9	87	97	98	100	102	105	107	105	103	90	80
3.0—3.1	87	95	97	98	100	103	105	103	102	90	80
3.2—3.3	87	93	95	97	98	102	103	102	100	90	80
3.4—3.5	87	92	93	95	97	100	102	100	98	90	80
3.6—3.7	87	90	92	93	95	98	100	98	97	90	80
3.8—3.9	87	88	90	92	93	97	98	97	95	90	80
4.0—4.1	87	87	88	90	92	95	97	95	93	80	80
4.2—4.3	85	85	87	88	90	93	95	93	92	80	80
4.4—4.5	83	83	85	87	88	90	90	90	90	80	80
4.6—4.7	82	82	83	85	87	88	88	88	88	80	80
4.8—4.9	80	80	82	83	85	87	87	87	87	80	80
5.0—	80	80	80	80	80	80	80	80	80	80	80

Source: Canada Agricultural Products Standards Act Hog Carcass Grading Regulations, Canada Gazette, Part II, vol. 113, No.3, p. 486.

Figure A.4: Index 100 Table as of 1979

Backfat in tenths of inches	90 to 124 lbs.	125 to 129 lbs.	130 to 139 lbs.	140 to 149 lbs	150 to 159 lbs	160 to 169 lbs	170 to 179 lbs.	180 to 189 lbs.	190 to 199 lbs	200 to 209 lbs	210 and over
	Index No.	Index No.	Index No.	Index No	Index No.	Index No	Index No	Index No	Index No	Index No.	Index No
<0.8	87	105	107	108	110	113	114	113	112	90	80
0.8	87	103	105	107	108	112	113	112	110	90	80
0.9	87	102	103	105	107	110	112	110	108	90	80
1.0	87	100	102	103	105	108	110	108	107	90	80
1.1	87	98	100	102	103	107	108	107	105	90	80
1.2	87	97	98	100	102	105	107	105	103	90	80
1.3	87	95	97	98	100	103	105	103	102	90	80
1.4	87	93	95	97	98	102	103	102	100	90	80
1.5	87	92	93	95	97	100	102	100	98	90	80
1.6	87	90	92	93	95	98	100	98	97	90	80
1.7	87	88	90	92	93	97	98	97	95	90	80
1.8	87	87	88	90	92	95	97	95	93	80	80
1.9	85	85	87	88	90	93	95	93	92	80	80
2.0	83	83	85	87	88	90	90	90	90	80	80
2.1	82	82	83	85	87	88	88	88	88	80	80
2.2	80	80	82	83	85	87	87	87	87	80	80
2.3	80	80	80	80	80	80	80	80	80	80	80

Source: Canada Agricultural Products Standards Act Hog Carcass Grading Regulations, Canada Gazette, Part II, vol. 116, No.7, p. 1257.

Figure A.5: Index 100 Table as of 1982

A.2 SUMMARY

In the early 1900's, both the Canadian and U.S. hog/pork sectors recognized a need for the development of official grade standards for slaughter hogs, although each country's need arose from different circumstances. Early grade standards were somewhat subjective, relying on factors such as the conformation and muscling of the live animal, and interest soon arose in the incorporation of objective measurements taken from the dressed carcass. Since their initial development, both live animal and carcass grades have undergone numerous modifications in response to the trend in consumer preferences away from pork fat and lard. Other modifications to the standards have resulted from an attempt (particularly in the Canadian grading system) to develop methods accurately identifying the value of individual hogs. The end result of these research efforts has been the development in Canada of a compulsory grading/settlement system based on a table of carcass grade indices. In the U.S., packers still use their own grade-pricing systems. The reluctance in the U.S. to establish a single, official grade-pricing system is likely due to a wish to adhere to a strictly free-enterprise philosophy, which allows individual packers the freedom to grade hogs according to their own individual preferences. The official USDA grades presently see very limited use in grade-pricing but recent efforts by the NPPC have produced a voluntary guideline table of grade indices to assist in grade-pricing.

Appendix B

CARCASS CUTOUT DATA

Data were obtained from a cutout test performed on a total sample of 247 pork carcasses. The test was conducted at the University of Guelph in the spring and summer of 1982, following cutout standards and specifications described by Martin[116]et.al. A stratified sample of carcasses was chosen to achieve a uniform distribution across carcass weight and backfat cells. Some extreme cells (i.e., cells containing carcasses of low weight, but heavy fat cover, or heavy weight but thin fat cover) contained fewer carcasses. However, all carcasses in all cells were included in the present analysis since the intent was to produce results valid for the entire spectrum of carcass types in the Canadian slaughter hog population. The characteristics of the sample carcasses were judged to compare favorably with those of an extensive Agriculture Canada survey in 1981,[117] therefore the sample was believed to be representative of the Canadian slaughter hog population.

Summary statistics for the carcass sample are presented in Table B.1.

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[116] A.H. Martin, H.T. Fredeen, G.M. Weiss, A. Fortin, and D. Sim, "Yield of Trimmed Pork Product in Relation to Weight and Backfat Thickness of the Carcass", Canadian Journal of Animal Science, vol. 61, 1981, pp. 299-310.

[117] A. Fortin, S.D.M. Jones, and C.R. Haworth, op. cit., p.2.

TABLE B.1

Cutout Data -- Summary Statistics

VARIABLE	MEAN	STD.DEV.	MIN.VALUE	MAX.VALUE	STD.ERROR OF MEAN	COV.
WCW	75.897	6.492	57.000	94.500	0.413	8.554
RLOINF	1.294	0.240	0.500	2.100	0.153	18.518
RSHOULF	1.733	0.235	1.000	2.800	0.015	13.550
FMLR7F	21.709	4.706	13.000	38.000	0.299	21.676
FM34R7F	22.825	5.056	12.000	44.000	0.322	22.152
FMLR7M	50.792	8.202	32.000	84.000	0.524	16.148
FM34R7M	48.339	8.154	23.000	77.000	0.521	16.869
HAM	15.777	1.611	12.080	21.000	0.102	10.209
BELLY	9.279	1.289	5.160	13.400	0.082	13.892
PICNIC	6.928	0.902	4.920	15.480	0.057	13.016
BUTT	6.773	0.728	4.240	8.600	0.046	10.752
BACK	14.025	1.479	8.880	19.640	0.094	10.543
TNLOIN	0.760	0.117	0.520	1.160	0.007	15.410
BKRIBS	0.985	0.159	0.560	1.480	0.010	16.179
SDRIBS	19.521	1.760	15.480	25.500	0.112	9.015
BAKFAT	7.565	2.239	2.840	18.680	0.142	29.599
TRIMS	1.045	0.311	0.280	2.640	0.198	28.738
TAILS	0.514	0.116	0.200	0.800	0.007	22.610
JOWLS	1.42	0.303	0.560	2.360	0.193	21.341

WCW = warm carcass weight
RLOINF = ruler fat measurement at loin (inches)
RSHOULF = ruler fat measurement at shoulder (inches)
FMLR7F = electronic (Fat-O-Meater) fat measurement at last rib, 7cm off the dorsal midline (millimeters)
FMLR7M = electronic (Fat-O-Meater) muscle depth measurement at last rib, 7cm off the dorsal midline (millimeters)
FM34R7F = electronic (Fat-O-Meater) fat measurement at last rib, 7cm off the dorsal midline (millimeters)
FM34R7M = electronic (Fat-O-Meater) muscle depth measurement at last rib , 7cm off the dorsal midline (millimeters)
HAM = yield of commercial-trimmed ham (kg.)
BELLY = yield of commercial-trimmed belly (kg.)
PICNIC = yield of commercial-trimmed picnic (kg.)
BUTT = yield of commercial-trimmed butt (kg.)
BACK = yield of externally-defatted, boneless back (kg.)
TNLOIN = yield of tenderloin (kg.)
BKRIBS = yield of backribs (kg.)
SDRIBS = yield of sideribs (kg.)
BAKFAT = yield of backfat, including kidney fat (kg.)
TRIMS = yield of trimmings (kg.)
TAILS = yield of tail (kg.)
JOWLS = yield of jowl (kg.)

Appendix C

WHOLESALE PORK PRICE DATA

In calculating carcass values, weight-range-specific prices were developed for hams, bellies, butts, and shoulders. Ideally, loins also would have been priced in this manner, but this was not possible due to inconsistencies between the definition of a loin as it is priced in the Ronald A. Chisolm price reports for Canadian wholesale meats (where loins are defined as boneless backs) and in the National Provisioner prices for U.S. wholesale meats (where prices are quoted for entire loins). Consequently, the weight-range-specific price premiums and discounts for U.S. loins were not applied to the Canadian price data, though this was achieved for the other primal cuts.

The procedure used to develop weight-range-specific prices for Canadian primal cuts is described below, using the example of hams for the time period of October, 1981 (Table C.1). For this time period, monthly average U.S. prices for four weight ranges were obtained. These prices were converted to price ratios by dividing the price for each weight range by the price quoted for the "optimal" weight range. In the case of hams, the optimal weight range was that of 14 to 17 pounds.[118] The

[118] An optimal weight range was defined as that weight range that consistently receives the highest price. Weight ranges observed for the various cuts were as follows (* denotes the optimal weight range for a cut).

Hams - *14 to 17, 17 to 20, 20 to 26, 26 to 30

Bellies - 10 to 12, 12 to 14, *14 to 16, 16 to 18, 18 to 20, 20 to

Canadian price for ham, averaged for October, 1981 then was multiplied by each of the computed price ratios to obtain a series of Canadian prices for ham, adjusted for weight-range preferences. A similar procedure was carried out for hams, bellies, butts, and picnics, for each observed time period.

These prices then were applied in the following valuation formula, used to calculate the gross value per 100 kg. for each carcass in each time period.

$$
\begin{aligned}
GV_{it} = \; & ((PHAM_{kt})(HAM_i) + (PBELLY_{kt})(BELLY_i) + (PPICNIC_{kt})(PICNIC_i) \\
& + (PBUTT_{kt})(BUTT_i) + (PBACK_t)(BACK_i) + (PTAIL_t)(TAIL_i) \\
& + (PBACKFAT_t)(BACKFAT_i) + (PJOWL_t)(JOWL_i) + (PTRIM_t)(TRIM_i) \\
& + (PHOCK_t)(HOCK_i) + (PTENDERLOIN_t)(TENDERLOIN_i) \\
& + (PBACKRIBS_t)(BACKRIBS_i) + (PSIDERIBS_t)(SIDERIBS_i))/WCW_i
\end{aligned}
$$

where:

i refers to carcass "i",

t refers to time period "t",

k refers to weight range "k",

P "carcass component" refers to price ($ per 100 kg.) for the carcass component named,

carcass component "i" refers to the yield (kg.) of the carcass component named obtained from carcass "i",

WCW refers to warm carcass weight,

GV refers to gross value ($ per 100 kg.).

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Picnics - *4 to 8, 8 and up

Butts - *4 to 8, 8 and up

TABLE C.1

Developing Weight-Range-Specific Canadian Prices -- Hams

Weight Range (lbs)	14 - 17	17 - 20	20 - 26	26 - 30
U.S. Price ($/cwt)	84.450	80.750	78.875	76.200
Price Ratio	1.000	0.956	0.934	0.902
Canadian Price ($/100 kg.)		225.972		
Adjusted Canadian Price ($/100 kg.)	225.972	216.029	211.058	203.827

Appendix D

NATURE OF THE QUALITY-CARCASS MEASUREMENTS RELATIONSHIP

The following tests were performed for the purpose of determining the behavior of the relationship of carcass value indices to carcass measurements over time and over individuals. A 5 percent significance level was chosen as the minimum acceptable significance level for these tests, because there was a strong desire to limit the possibility of concluding that the above relationship did exhibit a particular behavior when in fact it did not.

D.1 BEHAVIOR OF THE RELATIONSHIP OVER TIME

D.1.1 Test for Trend

To test for trend, the relationship of carcass value to carcass backfat and weight was estimated using each of the 36 sets of monthly wholesale pork prices. A set of 36 estimated coefficients thus were obtained for backfat and for weight[119] (see Table D.1). A rank correlation coefficient was calculated to indicate the degree of randomness in the series of estimated coefficients.[120] This coefficient is defined as

$$\mathcal{T} = 2S/N(N-1)$$

where

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[119] Backfat thickness was a summed measure of maximum shoulder and loin backfat, measured in inches using a ruler. Warm carcass weight was measured in kilograms.

[120] The test was applied as described in G. Tintner, Econometrics, (New York: John Wiley and Sons, Inc., 1952), pp. 211-215.

$$S = 2P - .5(N)(N-1)$$

and where N=36

P=the sum of the "positive scores" of the individual observations.[121]

"τ" can assume any value from -1 to 1. A value of 1 indicates a perfect positive trend, a value of 0 indicates a complete absence of trend, and a value of -1 indicates a perfect negative trend.

In addition to determining the degree of trend as indicated by τ, the significance of the calculated value of "S" also is tested. For N larger than 10, the distribution of S is approximately normal with mean zero and variance $N(N-1)(2N+5)/18$. A two-tailed Z-test is used to determine whether S is significantly different from zero.[122]

Testing the estimated backfat coefficients for trend, the results were:

$$P=491 \quad S=352 \quad \tau=0.559 \quad varS=5390.$$

The value obtained for indicated a fairly strong positive trend, and the value obtained for S was significant at the 1 percent level. Given these results, it was concluded that the series of estimated backfat coefficients did exhibit a significant positive trend.

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[121] To obtain the positive score for an individual observation, the observations first are ranked. To determine the positive score for each of the "t" observations, count the number of observations "t+1, t+2....N" which have a higher rank than that of the "t"th observation.

[122] Because S is not a continuous variable, a correction for continuity is made in applying the Z-test, consisting of subtracting 1 from S if S is positive, or adding 1 to S if S is negative.

TABLE D.1

Series of Estimated Fat and Weight Coefficients -- 1980-1982

Month		Backfat Coefficient	Weight Coefficient
Jan., 1980	1	-5.226	-0.062
	2	-5.435	-0.048
	3	-5.185	-0.109
	4	-5.325	-0.141
	5	-4.842	-0.233
	6	-6.020	-0.055
	7	-6.080	0.048
	8	-5.262	-0.004
	9	-5.249	-0.026
	10	-5.380	-0.033
	11	-5.217	-0.049
	12	-4.952	-0.128
Jan., 1981	13	-5.383	-0.063
	14	-5.500	-0.033
	15	-5.882	-0.014
	16	-5.069	-0.778
	17	-5.090	-0.089
	18	-5.424	-0.012
	19	-5.173	-0.049
	20	-4.752	-0.036
	21	-4.668	-0.054
	22	-4.676	-0.076
	23	-4.376	-0.120
	24	-3.943	-0.227
Jan., 1982	25	-4.339	-0.065
	26	-4.682	-0.009
	27	-4.472	-0.078
	28	-4.726	-0.031
	29	-4.656	-0.017
	30	-4.815	-0.004
	31	-4.679	-0.017
	32	-4.465	0.011
	33	-4.574	-0.039
	34	-4.557	-0.112
	35	-4.601	-0.121
Dec., 1982	36	-3.798	-0.223

Testing the estimated weight coefficients for trend, the results were:

$$P=318 \quad S=6 \quad \tau=0.010 \quad varS=5390.$$

The value obtained for τ provided only very slight evidence of a positive trend, and the value obtained for S did not test significantly different from zero even at the 10 percent level. Given these results, it was concluded that the series of estimated weight coefficients did not exhibit any significant trend.

D.1.2 Test for Periodicity

To test for seasonal variation, a non-parametric test based upon the observed number of turning points and phases (where a phase is a run of like signs in the first differences of successive observations) in the series was applied. "In a series of N independent random observations the expected number of completed runs of length 'd' of the signs of first differences (d 'positive' or d 'negative' signs) is:

$$2(d+3d+1)(N-d-2)/(d+3)!$$ "[123]

The expected frequencies of runs of length 1, 2, and greater than 2, referred to as U1, U2, and U, respectively)[124] were compared to the observed frequencies (u1, u2, and u) by use of the criterion:

$$\chi^2_p=(u1-U1)/U1+(u2-U2)/U2+(u-U)/U$$

Testing the estimated backfat coefficients for periodicity, the results were:

$$u1=13 \quad u2=5 \quad u=3 \quad U1=13.75 \quad U2=5.87 \quad U=2.05 \quad \chi^2_p=0.610$$

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[123] Ibid., p. 234.

[124] $U1=5(N-3)/12 \quad U2=11(N-4)/60 \quad U=4N-21/60$; from Tintner, op. cit.

The value for χ^2_p was not significant at the 5 percent level. Also, a comparison of the observed total number of phases (22) to the expected number of phases for a random series of N=36 observations (21.67) revealed no significant difference between the two, even at the 10 percent level of significance. Given these results, it was concluded that the series of estimated backfat coefficients did not exhibit any significant seasonal movement.

Testing the estimated weight coefficients for periodicity, the results were:

$$u1=7 \quad u2=3 \quad u=6 \quad U1=13.75 \quad U2=5.87 \quad U=2.05 \quad \chi^2_p=12.328$$

The calculated value of χ^2_p was significant at the 1 percent level, and the observed number of phases (16) was significantly different from the expected number for a random series of observations (21.67) at the 2.5 percent level of significance, but not at the 1 percent level. Given these results, it was concluded that the series of estimated weight coefficients did exhibit a significant periodicity.

D.2 BEHAVIOR OF THE RELATIONSHIP OVER CARCASS TYPES

A Chow test was applied to subsamples of "light" and "heavy" carcasses. The value indices of these carcasses were determined using average 1982 wholesale pork prices, and were regressed on the independent variables backfat thickness and warm carcass weight. As Table D.2 indicates, the calculated values for the F-statistic exceeded the critical value at the 1 percent level, and so it was concluded that the estimated coefficients did differ significantly between these two subsamples.

TABLE D.2

Chow Test Results -- 1982 Data

Regression	Intercept	Backfat Coefficient	Weight Coefficient	R^2	D.F.	Σe^2
A1) Light subsample < 72 Kg.	-1.417 (1.045)[1]	-5.141 (1.020)	-0.269 (0.124)	.364	67	868.529
A2) Heavy subsample > 77 Kg.	-1.624 (0.467)	-4.051 (0.576)	0.218 (0.071)	.336	106	646.330
A3) Subsamples pooled	0.165 (0.231)	-4.599 (0.555)	-0.061 (0.033)	.360	176	1677.353
Chow F-ratio*						6.186
B1) Lean subsample < 2.9 inches fat	0.123 (0.640)	-3.958 (1.311)	-0.147 (0.057)	.163	99	1322.378
B2) Fat subsample > 3.2 inches fat	-0.473 (0.705)	-4.139 (1.343)	0.049 (0.055)	.113	76	620.771
B3) Subsamples pooled	0.054 (0.250)	-4.445 (0.534)	-0.070 (0.041)	.360	178	2010.180
Chow F-ratio*						2.012

1 Standard errors
* Critical F-value for the 0.05 level is 2.60; for the 0.01 level is 3.78.

The same test was applied to the subsamples of "lean" and "fat" carcass subsamples (Table D.2). At the 5 percent level of significance, the calculated value for the F-statistic was not significant, leading to the conclusion that no significant difference existed between the coefficients obtained from these two carcass subsamples.

Appendix E

TESTS FOR MULTICOLLINEARITY AND HETEROSCEDASTICITY IN THE QUALITY-CARCASS MEASUREMENTS RELATIONSHIP

To determine whether the coefficients obtained by the ordinary least squares regression of carcass value indices on carcass measurements could be accepted as reflecting the true relationship, the relationship was estimated for 1982 average price data, then tests for multicollinearity and heteroscedasticity were applied to the estimated relationship.

E.1 TEST FOR MULTICOLLINEARITY

A high degree of linear correlation between the independent variables carcass weight, backfat thickness, and muscle thickness could render the coefficient estimates highly unstable and imprecise. The method used here to test for multicollinearity is one suggested by Koutsoyiannis,[125] in which additional explanatory variables are inserted in the relationship one by one. If the new variable improves the R-square without seriously affecting the standard errors or the estimated values of the other coefficients, it is kept as an explanatory variable.[126] If the ad-

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[125] A. Koutsoyiannis, Theory of Econometrics, (London: The Macmillan Press Ltd., 1977), pp. 238-242.

[126] The usual procedure is to insert explanatory variables one by one, starting with the variable that is most strongly correlated with the dependent variable. While backfat thickness better explains carcass value than does carcass weight, the latter variable is the first variable inserted in the test performed here. This is because carcass weight is considered necessary information in establishing pay-

dition of a variable seriously affects the other coefficients, this warns of multicollinearity.

The relationship of carcass value indices to carcass measurements was estimated using average 1982 value indices as the dependent variable, and warm carcass weight as the independent variable. Regressions then were estimated using carcass weight and each of the four alternative backfat measures included in this study. As illustrated in Table E.1, in none of the four cases did the addition of backfat as an explanatory variable seriously affect the standard error of the estimated weight coefficient, nor was the sign or magnitude of the estimated weight coefficient rendered unreasonable. In all four cases, the addition of backfat improved the R-square. Further, the addition of muscle thickness measurements at the last rib and 3-4th last rib sites produced similar results; an improvement in R-square without seriously affecting the estimated coefficients for backfat or weight.

On the basis of the above results, it was concluded that none of the estimated relationships examined in this study exhibited a serious degree of multicollinearity.

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ment for a carcass.

TABLE E.1

Estimated Regressions for Detecting Multicollinearity -- 1982 Data

Regression	Intercept	WCW*	FSUM*	RLOINF*	FMLR7F*	FMLR7M*	FM34R7F*	FM34R7M*	R^2
1	2.767^{-10} (0.232)**	-0.169 (0.036)							.084
2	1.988^{-8} (0.120)	-0.057 (0.033)	-4.530 (0.486)						.325
3	3.053^{-8} (0.202)	-0.072 (0.033)		-7.998 (0.895)					.310
4	2.048^{-9} (0.192)	-0.062 (0.031)			-0.461 (0.043)				.374
5	1.758^{-9} (0.189)	-0.088 (0.032)			-0.422 (0.044)	0.075 (0.025)			.397
6	9.782^{-10} (0.192)	-0.078 (0.031)					-0.424 (0.040)		.375
7	1.257^{-9} (0.190)	-0.094 (0.031)					-0.404 (0.040)	0.059 (0.024)	.390

* See Table 5.6 for definition

** Standard Errors

E.2 TEST FOR HETEROSCESDASTICITY

If the variance of the error term in an ordinary least squares regression is correlated with one of the explanatory variables, the coefficient estimates are not minimum-variance. Consequently, predictions of the dependent variable will have a high variance, and less confidence can be placed in the estimated coefficients. The stronger the heteroscedasticity, the more severe its effects can be.

To test for heteroscedasticity, the Spearman rank correlation test[127] was applied. Regressions for each of the six combinations of carcass measurements were tested, using carcass value indices calculated using average 1982 price data for the dependent variable. Table E.2 indicates that none of the variables in any of the trials displayed a correlation coefficient whose value tested significantly different from zero at the 5 percent level (though carcass weight in trial 4 came close to being significant at the 10 percent level). Since none of the calculated correlation coefficients were considered to be significantly different from zero, heteroscedasticity was not considered to be a problem in any of the estimated trials.

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[127] A. Koutsiannis, op. cit.

TABLE E.2

Spearman Rank Correlation Coefficients -- 1982 Data

Trial	WCW	FSUM	RLOINF	FMLR7F	FMLR7M	FM34R7F	FM34R7M
1) r'e·x Prob > r' *	-0.070 0.273	-0.024 0.705					
2) r'e·x Prob > r'	-0.091 0.156		-0.062 0.331				
3) r'e·x Prob > r'	-0.072 0.257			0.007 0.914			
4) r'e·x Prob > r'	-0.105 0.101			0.004 0.956	-0.043 0.503		
5) r'e·x Prob > r'	-0.099 0.120					-0.038 0.550	
6) r' e·x Prob > r'	-0.087 0.173					-0.048 0.451	-0.016 0.797

*Under Ho: rho = 0