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Competitiveness of CWRS Wheats in World Markets: Relevance of the Canadian Wheat Grading System with Respect to End Use Products

by

Dale V. McKeague

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

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Abstract

The major thrust of Canada's wheat marketing strategy was to acquire a reputation as an exporter of high quality pan bread wheat through the application of stringent standards and grades. However, some concern exists that the wheat grading factors used in Canada may not reflect the economic value of the wheat sold. In addition, a declining market for the Hard Red Spring wheat used to produce pan bread flour may necessitate a reorientation of Canada's wheat marketing program. The study examined the relevance of the grading system by determining how well suited Canada Western Red Spring (CWRS) wheats were for milling into flour which met the characteristics required for the production of the various types of bread. A Linear Programming package was used to determine which wheat flours would be selected to produce the least cost flour blends containing the specific quality characteristics required to produce these breads. The quality factors used in the analysis were Wet Gluten, Protein Content, Starch Damage, Alpha-Amylase Activity, Alveograph W, Water Absorption and Thousand Kernel Weight. The results showed that when only CWRS wheat was available, the two "lowest" grade/segregations of CWRS wheat were the most economic for producing suitable pan bread flours. When wheats could be selected from three exporting countries, Canada, U.S. and Australia, CWRS grades and protein segregations were selected less often than those of competitors. Only two CWRS segregations, No.1 CWRS (14.5) and No. 3 CWRS were selected with any frequency. The low utilization of the CWRS grades indicates that U.S. and Australian wheats can provide a lower cost grist suitable for pan bread production than can CWRS. In the French bread analysis, the results indicate that CWRS could compete on a limited basis in the French bread flour market but only as a blending wheat. Parametric analysis demonstrated that the competitiveness of CWRS may be greatly enhanced if the actual landed prices are lower than the listed asking prices for this wheat.

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This dissertation is dedicated to my family, my wife and best friend Lorraine, our daughter Maureen and our new son Reed. Hopefully now Daddy will be home more in the evenings and on weekends.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. CANADIAN WHEAT IN THE INTERNATIONAL ENVIRONMENT

1.1. Introduction

During the past century, Canada developed and maintained a reputation as an exporter of high quality bread wheats. Much of this reputation was based upon the stringent grading system for wheats produced in western Canada which ensured that customers received consistent quality. Due to this high and consistent quality most of the bread wheat produced in western Canada has been sold for premium prices in the world market. The maintenance of this reputation for exporting high quality has been a major factor in Canada's wheat marketing strategy. However, a changing world wheat market may necessitate a reorientation of Canada's wheat marketing program. The market for the Hard Red Spring wheats produced in western Canada appears to be declining due to changes in the overall pattern of the world wheat trade. Some of these changes, which have had predominantly negative effects on western Canada's wheat sales are discussed below.

The introduction of the Chorleywood baking process in the United Kingdom (U.K.) and the entrance of that country into the European Community (E.C.) combined to reduce its imports of Canadian Western Red Spring (CWRS) wheat. The Chorleywood baking process introduced in 1961[1], allows the use of lower protein content and different quality flour in the bread making process. Thus bakers in the U.K. and other countries which use the process require flour from grists containing lower proportions of hard red

1 Chamberlain, N. "The Chorleywood Bread Process; International Prospects" *Cereal Foods World*, Vol 29, No. 10, October 1984, pp 656-658.

wheats. In addition, the United Kingdom's entrance into the E.C. in 1973 and the attainment of wheat self sufficiency among the E.C. countries reduced the U.K.'s need for Canadian wheat. The end result was a decline of Canadian wheat exports to the U.K. from 1374 thousand tonnes in 1979/80 to 274 thousand tonnes in 1989/90[2]. The decline of this market has forced Canada to seek other markets for the high protein hard spring wheat produced on the prairies.

The emergence of the E.C. countries, especially France, as net exporters of wheat had further ramifications for Canadian wheat exports. The E.C. countries which produce a different quality wheat which is lower priced and highly subsidized now compete with Canada in the world wheat market. Thus Canada has not only lost a large customer but also gained a very aggressive competitor.

Increased production of wheat in the Peoples Republic of China which has moved them closer to their goal of self-sufficiency, is of concern to the Canadian wheat producers for two reasons. First, the P.R.C. has been a large importer of Canadian wheat in the past, averaging 3.8 million tonnes of CWRS wheat per year during the decade between 1979/80 to 1989/90[3]. A change in the purchasing pattern of the P.R.C could leave Canada with a need to secure alternative markets. Second, a continuation of production increases in the P.R.C. could diminish Canada's potential for penetrating and maintaining the markets along the Pacific Rim. The P.R.C. is much closer to many

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[2] Canada Grains Council. *Canadian Grains Industry Statistical Handbook 85*. Winnipeg: C.G.C. 1991.

[3] *Ibid.*

of the Pacific Rim countries than Canada hence lower transportation costs may allow them better market access if and/or when P.R.C. production exceeds domestic needs and that country becomes an exporting nation. The loss of existing and potential markets resulting from the P.R.C.'s increasing production could have severe consequences for the incomes of western Canadian producers.

The accumulation of large stocks of wheat and other grains in the U.S. led to an escalation of the wheat price war between the U.S. and the E.C. In order to support their farmers and reduce the stocks of wheat held in the U.S. and E.C., these stocks were offered at low subsidized prices. The subsidies offered by the U.S. and E.C. forced other exporting nations such as Canada and Australia to export their wheat at reduced prices leading to lower producer returns. In addition, the expansion of the U.S. export enhancement program to include the Centrally Planned economies has been detrimental to Canadian producers. Traditionally the centrally planned countries have absorbed a large proportion of Canada's wheat exports.

Canada, having a relatively small population, does not have the financial resources to compete with the U.S. and E.C. either on the basis of export subsidies or farm support programs. As well it is doubtful that lost markets such as those in western Europe will be regained. In addition, other markets such as Japan appear to be static and have very limited potential for expansion. Therefore, Canada, in order to survive as a major wheat exporting nation, must find new ways to be competitive. Due to the greater financial resources of other exporters, competition must be in a form other than pure price competition. Exacerbating Canada's small financial might vis-a-vis competitors such as the U.S. is that fact that wheat production in Canada is much more export oriented. About 80 percent of the CWRS wheat produced in western Canada is exported whereas the U.S. exports about 50 percent or less of its wheat production. Thus Canada must provide a product which more closely meets customer needs, or become more efficient in its total marketing system, or both. Grading may be one method by which Canada's position in the world wheat markets can be maintained.

1.2. The Problem

Wheat in the world market is sometimes viewed as being a homogeneous product enabling free substitution between the various classes of wheat from the different countries of origin. However, wheat produced even in the same country is not homogeneous. Rather there tends to be a quality continuum within a class of wheat produced in any year. Thus wheat may be best viewed as a heterogeneous product with some possible substitutability between classes and origins. As wheat production is subject to the effects of nature, wheat quality may vary substantially from year to year and region to region even within the same country.

Canada, through the judicious application of stringent grading standards has established a reputation for exporting high quality wheat. One of the major reasons Canadian wheat is held in such high esteem in the world wheat market is the consistency (or uniformity) of the product within each grade segregation. Canadian wheat customers know when they receive cargoes of Canadian wheat, of the same grade, the last cargo received will be virtually the same as the first cargo received during a crop year. Millers regard consistency highly, as it means fewer adjustments to equipment must be made between grists and during the milling process resulting in reduced downtime and labour costs.

The reputation for consistency has allowed Canada to maintain her market share in an increasingly competitive wheat market. However, the present system of grading Canadian wheat may require modification in light of the changes in the world wheat market. The grading system still provides customers with high quality, uniform wheat, but the factors used for grading may not reflect the economic value of the wheat being sold. Thus Canadian wheat producers may not be receiving the real value to the wheat which they produce. In addition, the present grading system may be placing an undue burden on the grain handling and transportation system contributing to the higher marketing costs experienced for Canadian wheats. Studies by McKeague *et al* and Hoar *et al* have shown that the grading system has a deleterious effect of the efficient operations of terminal and primary elevators[4]. Specifically, the results of both studies indicated that the plethora of grades reduced elevator throughput and increased operating costs. They also concluded the number of grades would impact on the operational efficiency of the rail transport of grain.

Many of the factors used for grading wheat in Canada are holdovers from a less technical age. These factors at one time were good proxy measures for the quality

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4 McKeague, D.V., M.L. Lerohl, and M.H.Hawkins. "The Canadian Grain Grading System and Operational Efficiency within the Vancouver Grain Terminals" *Agribusiness* Vol. 3, No.1. 1987. pp.19-42.
Hoar, W.J., M.H. Hawkins and M.L. Lerohl, "Effects of Domestic Grain Grades on the Operational Efficiency of Alberta Primary Elevators" *Agriculture and Forestry Bulletin*, Vol. 6(4) Edmonton: University of Alberta, 1983, pp.53-56.

factors desired by millers and bakers. However, increased sophistication in wheat quality measurement techniques has reduced the value of some of the grading factors. A parcel of wheat in the system may be downgraded on the basis of a factor which may not be relevant in the current wheat market. A reduction in grade is generally reflected in the price received for the wheat. In addition, if customers needs are not truly reflected by the grading system, then the premiums available for desired quality characteristics may be overlooked. Thus, the present grading system, if it does not accurately reflect the true needs of the market may result in lower revenues for wheat producers.

The present grading system for wheat has contributed greatly to the maintenance of Canada's past market share in the world wheat trade, therefore it is imperative that the commitment to quality and consistency be maintained. However, if the grading system fails to reflect the true desires of the market then those grading factors which are not representative of market desires should be replaced by others which do reflect these desires. Two studies by the Canada Grains Council[5], indicated that changes in the grading standards for wheat and barley could improve market opportunities. The problem is, therefore, to determine which grading factors do reflect the attributes desired by end-users, and to what extent they relate to economic value. The impact of changing the grading system on other facets of the grain industry needs to be examined since the operational aspects of marketing may be affected by changes in the grading system.

The U.S. has begun to place increasing emphasis on end-use value for their grains

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[5] Canada Grains Council, *Grain Grading for Efficiency and Profit*. Winnipeg: C.G.C., 1982. and Canada Grains Council, *Maintaining the Excellence: Wheat Grades for Canada*,Winnipeg: C.G.C. 1985.

and oilseeds. Thus it is imperative that Canada reassess its grading system in order to maintain competitiveness in the world market. Grain products from the U.S. have, in the past been considered inferior in quality compared to Canadian grains due to the lack of consistency[6]. However, if the U.S. continues to target its grading system on the needs of the end-user, Canada's competitive position may be impaired it the country fails to respond to U.S. initiative.

Western Canada produces and exports six different classes of wheat. These include Canada Western Red Spring wheat (CWRS), Canada Prairie Spring wheat (CPS), Canada Western Soft White Spring wheat (CWSWS), Canada Western Amber Durum wheat (CWAD) Canada Utility wheat (CU) and Canada Western Red Winter wheat(CWRW). The CWRS wheat class will be the focus of this study. This class of wheat is produced throughout the prairies and constitutes about half of Canada's grain exports. Although there are only three numerical grades in the class 1, 2, and 3, protein segregations and other factors such as weathering, moisture contents and disease damage greatly increase the number of actual segregations which must be transported and handled separately. Reductions in the number of grades may enhance the ability of the system to handle the volume product and also reduce marketing costs.

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6 See for example various issues of Milling and Baking News and the End Use Quality Conference Proceedings.

1.3. Objectives

The objectives of this study are to determine:

1. whether the quality factors and their predetermined levels distinguishing grades and protein segregations in the Canadian Western Red Spring grading system reflect those desired by end-users in the production of flour suitable for baking Canadian style pan breads.

2. the competitiveness of CWRS vis-a-vis wheats from other countries in the production of flours suitable for pan and french style breads.

3. the impact of CWRS price on the selection of wheats for various flour blends.

4. the implications of the current set of CWRS grades and standards on the income of western Canadian wheat growers' and for the grain handling and transportation system.

1.4. Data Requirements and Potential Sources

The study will evaluate the CWRS grade characteristics in relation to those desired by end-users. The information requirements of the study, therefore, are substantial. Data pertaining to the needs of end-users, as related in the characteristics required for different products, were obtained from published sources and the Canadian International Grains Institute (C.I.G.I.). The pilot bakery at C.I.G.I. tests Canadian wheat with respect to quality required for baked products used in other countries. Wheat quality information for CWRS wheat was obtained from the *Quarterly Cargo Bulletins* which are published by the Canadian Grain Commission's Grain Research Laboratory (G.R.L.) for CWRS and other wheats.

Information related to the grades and protein segregations of CWRS wheats shipped to various countries is available from the Canada Grains Council's *Canadian Grains Industry Statistical Handbook*. Although this publication only lists the top six importers of each segregation, this information supplements the end product information needed to determine the ultimate use of CWRS wheat. Wheat quality information for Australian wheat was obtained from the Australia Wheat Board (A.W.B.) crop reports covering several years. Quality information for comparable wheats produced in the United States was obtained from North Dakota State University. The Canadian Wheat Board only publishes asking prices for wheat and not the actual selling prices. All price information was therefore obtained from the International Wheat Council's Annual Wheat Statistics, supplemented with information from Canadian Wheat Board Annual Reports and other information.

1.5. Outline of The Thesis

The remainder of the thesis is organized as follows. Chapter 2 outlines the theory and application of grading and standardization as applied to wheat in Canada. Chapter 3 presents a discussion of the economic theory and the applications of linear programming used in this study. Chapter 4 reviews the literature pertaining to the topic. Chapter 5 presents the methods used to analyze the present grading system for CWRS wheat and its relationship to end-use. The limitations of the available data which account for the approach taken in the study are also discussed. Chapter 6 contains a discussion of some of the results which pertain to CWRS being used for the production of North American Pan breads. Chapter 7 discusses the implications of CWRS wheat being blended with wheat from Australia and the U.S. for the production of pan breads.

Chapter 8 examines at the possibility of blending CWRS wheat with U.S. and Australian wheats to produce flour required for French bread. Chapter 9 contains a summary of the study, subsequent conclusions and a discussion of the policy implications of the research. Recommendations for further research in the area are also made.

CHAPTER 2. GRAIN GRADING SYSTEMS

2.1. Standardization and Grading

The agricultural products marketing literature offers several different methods for studying the subject. Amongst the various approaches, three major methods are frequently described (i) the study of marketing institutions, (ii) the study of marketing behaviour or systems, and (iii) the study of marketing functions (functional approach). Although these various approaches are convenient for teaching and descriptive purposes, in actual practice it is very difficult not to include in any research elements of all approaches. The functional approach will be used for descriptive purposes, but it is important to remember that wheat marketing is a dynamic and interactive process which cannot be adequately studied using one approach alone. The behaviour of the whole system and the institutions involved in the marketing of wheat have a major impact on the efficacy and reliability of the grading system.

The functional approach to agricultural product marketing analyzes the role of specific marketing functions used to move product from the producers to the consumers. The approach generally identifies three specific types of marketing functions: (i) the exchange functions such as buying and selling, (ii) the physical functions such as storage, transportation and processing; and (iii) the facilitating functions of standardization, financing, market intelligence gathering and risk bearing. Grain grading falls within the realm of the market facilitating function of standardization.

Standardization may be defined as the establishment and maintenance of uniform measures which facilitate the performance of the other marketing functions. The uniform measures which are established by standardization are commonly known as standards. It follows then that standards are, therefore, the yardsticks by which product quality is defined. Grades, become subdivisions of the product quality which represent certain standards. Nichols *et al* use the following definitions,

> "Grades are used in the classification of commodities and are defined as numerical or descriptive categories which have specified characteristics in common. Standards are the values, the limits and measurement procedures which determine the grade of a product--the criteria by which a product is divided into its various grades"[7]

Not all authors and researchers follow these definitions for grades and standards. Bockstael, in her research concerning the economic efficiency of grading and minimum quality standards states.

> "While the term standards is frequently used in conjunction with grades to denote the boundaries of grades, it is used here in a more specialized fashion. Throughout, standards will refer to minimum quality standards such as those set forth in agricultural marketing orders"[8]

As there may be some confusion emanating from the literature with respect to the terms grades and standards for the purposes of this work, the term grades will refer to divisions of product quality and standards will be the devices by which quality is measured. This distinction was stated very concisely by Mehren in 1961, "Grades are subdivisions of

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[7] Nichols, John P., Lowell D. Hill and Kenneth E.Nelson, 1983 "Food and Agricultural Commodity Grading" in *Federal Marketing Programs in Agriculture: Issues and Options*, eds. W.J. Armbruster, D. R. Henderson, and R.D. Knutson. Danville Illinois: The Interstate Printers and Publishers . 1985 pp. 62-63

[8] Nancy E. Bockstael 1987. "Economic Efficiency Issues of Grading and Minimum Quality Standards" in *Economic Efficiency in Agricultural and Food Marketing*. eds. R.L.Kilmer and W.J. Armbruster Ames: Iowa State University Press, 1987.

product classes defined by attributes, magnitudes, and ranges or tolerances."[9]

Standardization, therefore, involves a plethora of considerations which include but are not limited to such things as, package size, product weight, quality standards, product dimension, and shelf-life. The sophistication and complexity of standardization varies from industry to industry, being partially dependent upon the level of control the producer has on the end product. For food and agricultural products the more processing the product undergoes, the less complex are the grades and standards as the processor gains more control of the end product with increased processing. In the production of pan breads, for example, several different grades and classes of wheat can be used to produce an acceptable flour. These wheats can be graded or segregated on the basis of a multitude of quality characteristics. However, the resulting flours, irrespective of the parent, which are capable of producing a saleable pan bread will be quite similar with respect to the quality characteristics.

Agricultural products, such as wheat, are subject to the influences of environmental factors in addition to the biological nature of the crop. Thus the product produced in any one year may represent a broad spectrum of quality characteristics. In order to facilitate the marketing of such a product, a system of grades must be developed to arbitrarily group like quality characteristics together within this spectrum. Grain grading, therefore, may be defined as "the segregation of heterogeneous material into

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[9] George L. Mehren, "The Function of Grades in an Affluent, Standardized-Quality Economy" *Journal of Farm Economics* Vol. 43, pp. 1377-1383, Dec. 1961.

a series of grades reflecting different quality characteristics of significance to users"[10]

Wheat grading is then, a method for standardizing quality so that parcels of wheat with similar quality characteristics may be commingled to facilitate the marketing of the product. Thus grading provides a method of communication between buyers and sellers with respect to the quality of the product being exchanged, thereby improving the opportunities for selling wheat. In addition to enhancing the price discovery mechanism, "A good grading system should facilitate, not impede, the efficient handling and transport of the product as it moves through the marketing system."[11] Thus grading should enhance both the pricing and operational aspects of a marketing system. The effectiveness of a grading system is dependent, therefore, on the ability of the system to reflect the quality characteristics of the product to the needs of the purchaser. The inducement for the development of grading schemes was summarized by Zusman as follows:

> ... (a) the sale of unsorted products involves certain constraints on buyers freedom of choice; (b) the existence of established standardized grades removes many uncertainties inherent in exchange; and (c) grading and sorting may serve in obtaining certain monopoly gains. More specifically, if only unsorted products are being offered on the market, buyers are forced to purchase a product consisting of a predetermined combination of homogeneous grades. Second, unless products are sorted into standardized grade, buyers are ignorant of the product composition and each transaction is beset with uncertainty. Finally, sorting and grading may be instrumental in establishing certain types of price discrimination

[10] Canada Grains Council, *Grain Grading for Efficiency and Profit*. Winnipeg, 1982 p. 6.

[11] E.W. Tyrchniewicz. "Western Grain Transportation Initiatives: Where Do We Go From Here?" *Canadian Journal of Agricultural Economics*, Vol. 32, July 1984 pp.253-264.

and product differentiation by sellers."[12]

Effective grading systems for grains including wheat should fulfil certain objectives some of which are stated by Wills[13] as;

1. Be accepted by the trade;
2. Provide a truly representative sample;
3. Be easy to evaluate;
4. Provide an evaluation in a short period of time;
5. Minimize the number of subjective factors to be considered;
6. Be relatively inexpensive from the standpoint of personnel, facilities, and value of the sample; and
7. Measure factors that reflect the value of the product.

In addition, grain grading should make the overall marketing system more efficient, both from an operational and a pricing perspective. Some of the potential efficiency improvements resulting from grading have been listed by Shepherd and Futrell[14] as follows:

Operational Efficiency

1. Grading provides a more precise definition of the commodity and permits bargaining to settle down quickly to the basic price issues which relate to supply and demand.

2. Grading has increased specialization.

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[12] Pinhas Zusman, " A Theoretical Basis for Determination of Grading and Sorting Schemes" *Journal of Farm Economics* Vol. 40 No.1 Feb. 1967 p. 89-90.

[13] Wills, Walter J. *An Introduction to Grain Marketing*, Danville Illinois: The Interstate Printers and Publishers Inc. 1972 pp. 35-36.

[14] Geoffrey S. Shepherd and Gene A. Futrell, *Marketing Farm Products*. Seventh Edition. Ames: Iowa Stated University Press, 1982, pp.180-181.

3. Grading has reduced the expense of brand advertising.

4. The enlarged market area for both buyers and sellers which grading provides encourages more efficient movement to ultimate outlets, thus minimizing transportation costs.

Pricing Efficiency

1. Grading provides a more accurate language for price quotations. Hence buyers and sellers can understand each other more easily. Grading makes market news much more meaningful and enables them to be transmitted more effectively. By enlarging the area of informed decision making in the marketing process, grading makes the pricing system a more articulate means for communicating consumer preference to producers.

2. Grading increases buying by description.

3. Grading increases the level of competition in the market. This enables the marketplace to allocate more systematically the available supplies of each kind of quality.

4. Grading helps in achieving a measure of standardization and quality control in the merchandising process.

These lists of potential gains in terms of operational and pricing efficiency from grading systems present a favourable picture of the inherent advantages of developing effective grading systems such as those which are in effect in Canada. However, there are several problems outside the system which can reduce the ability of the users of grades to capture all these benefits. These problems may be related to the operational efficiency aspects of the delivery mechanism for the product, as were the case with the Hoar *et al*[15] and McKeague *et al*[16] studies mentioned in Chapter I. The Grain

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[15] Hoar, W.J., M.H. Hawkins and M.L. Lerohl, "Effects of Domestic Grain Grades on the Operational Efficiency of Alberta Primary Elevators" *Agriculture and Forestry Bulletin*,

Handling and Transportation System (GHTS) was constructed at a time when there were multitudinous grades in effect and smaller vehicles available for delivering the product. This situation places binding constraints on the ability of grain marketers to fully capture all the potential efficiency gains available from the present grading system. Furthermore, wholesale changes to grading systems may not overcome the constraints of the delivery system.

Pricing efficiency problems may be exacerbated by the artificial price signals emitted by highly subsidized exporters such as the U.S. and E.C. The distortion of price signals by subsidies may prevent the system from systematically determining quality. In addition, the confusing price signals fail to provide an accurate language and result in less informed decision making on the part of some participants.

The advantages attainable from effective grading systems make the development of such systems attractive to many participants in the marketing channel. However, problems which may arise with respect to grade boundaries may deter organizations and agencies from either developing new grading systems or revamping old systems. As the development of a grading system necessitates the placement of arbitrary boundaries which define each grade, some criteria are required to ensure the best possible system. Williams and Stout have made the following statements relevant to an appropriate grading system.

1. Distinct or potentially separable demand functions, based

Vol. 6(4) Edmonton: University of Alberta, 1983, pp.53-56.

[16] McKeague, D.V., M.L. Lerohl, and M.H.Hawkins. "The Canadian Grain Grading System and Operational Efficiency within the Vancouver Grain Terminals" *Agribusiness* Vol. 3, No.1. 1987. pp.19-42.

on real rather than illusory differences, exist. This means that one or more basic quality attributes are of economic importance to a significant number of consumers for all uses or for significantly large volume categories.

2. In the absence of grades, consumers, marketing firms or both cannot readily and accurately distinguish among significantly large differences in basic quality attributes or differences in combinations of these attributes.

3. Grade standards are established which provide the most effective basis possible for the distinct and separable demand functions of consumers and other buyers. This means that:

    a. Variations in all economically important attributes can be measured precisely and all are employed as grade-determining criteria in the standards.

    b. The standards should separate units of the commodity into groups such that for each grade the within-grade variation between quality attributes, relative to the variation in that grade and each of the two possible adjacent grades, has been minimized.

    c. The standards should maximize differences among grades in the range of quality attributes which means that overlapping has been reduced to a minimum.

4. Any net reductions in cost are maximized or, alternatively, the value represented by the additional average price consumers or other buyers are willing to pay minus average(net) unit marketing costs is positive and maximized.

5. In so far as possible, the first three criteria should be satisfied simultaneously. In addition, the system must be

    a. simply, easily, widely, and uniformly understood,

    b. fixed and unchanging in a short term sense, and at the same time, subject to change as warranted by longer-term considerations, and

c. workable in the marketplace.[17]

The list of qualifiers for a grading system presented above is extensive and very difficult to achieve particularly with agricultural products. Thus, any grading system for agricultural products is, therefore, a set of compromises between the pricing and operational aspect of marketing while attempting to satisfy all of the above criteria. The amount of compromise between these two ends will depend upon the maturity and diversity of the markets for the products. How these compromises meet the needs of all involved measures the effectiveness of the grading system.

Mehren in 1961 made the case that

> Only in an *affluent economy* are there many technical alternatives of production with substitutable inputs and many subdemands within broad classes of end-goods. Its producers, handlers, exporters, and consumers can rationally pay different prices for different grades of related goods or services.[18]

This statement may not be true given that grading seems to be needed to successfully market a product in a world of mixed economies. It is true that only the affluent can afford to purchase the premium priced high grades of a product. However, through the segregation of product into grades of varying quality levels, poor or "non-affluent" economies can purchase the lower quality product at prices below the average price of

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[17] Williams, Willard F. and Thomas T. Stout, *Economics of the Livestock-Meat Industry*, New York: MacMillan Company, 1964 pp.486-488.

[18] George L. Mehren, "The Function of Grades in an Affluent, Standardized-Quality Economy" *Journal of Farm Economics* Vol. 43, Dec. 1961. p.1377

an unsegregated commodity. Segregation of a commodity through grading provides the seller the opportunity to maximize returns and satisfy two separate markets.

Canada uses a range of merchandising techniques in order to move her wheat into the world market. Amongst these merchandising techniques are grading, as well as price, regularity of supply, long term agreements, and credit arrangements. The segregation of wheat into grades permits the customer to decide whether or not the lot in question is consistent with his needs. As this question is the focus of this dissertation, a brief review of the Canadian grain grading system and its history with emphasis on CWRS wheat is presented below.

2.2. Wheat Grading in Canada

In 1863 the first legislation dealing with the inspection and grading of grains in Canada was enacted by the 'Province of Canada'[19]. This was the first, in a long succession of Acts dealing with grain grading in Canada. Although this first act was defined for the whole 'Province of Canada' (as the country was known at the time), the legislation borrowed heavily and directly from the system of grades established by the Chicago Board of Trade. The major focus of the legislation was toward grains produced in what are now the Provinces of Ontario and Quebec as grain production in the Prairies was essentially nonexistent. In 1873, six years after Confederation, the Parliament of the Dominion extended the legislation to cover the whole nation. A further revision was made to the legislation with respect to wheat in 1874. All this early Canadian legislation

[19] G.N. Irvine, *The History and Evolution of the Western Wheat Grading and Handling System* (Winnipeg: Canadian Grain Commission, 1984), p. 17.

was similar to U.S. legislation, particularly the 1871 Illinois statute[20]. An example of the spring wheat grades of the time is found in Irvine p.19:

SPRING WHEAT

> No. 1 Spring wheat shall be plump and well cleaned.
> No. 2 Spring wheat shall be sound, reasonably clean, and weighing not less than fifty-six pounds to the measured Winchester bushel.
> No. 3 Spring Wheat shall be reasonably clean, not good enough for No.2, weighing not less than fifty-four pounds to the measured Winchester bushel.
> All Spring Wheat damp, musty, grown, badly bleached or from any other cause unfit for No.3 shall be graded as rejected.
> A mixture of Spring and Winter Wheat shall be called Spring Wheat and graded according to the quality thereof.
> Black Sea and Flinty Fife Wheat shall in no case be inspected as higher than No. 2.

The major change from 1873 to 1874 was that the unit of measure was changed from the Winchester[21] to Imperial bushel[22].

The first standards for grains produced in Western Canada were established in 1884. In that year, Captain William Clarke became the first inspector of the new Inspection District of Winnipeg. In the House of Commons it was stated that standards for Canadian wheat would be higher than in the U.S. because Canadian wheat was "better". This attitude of having "better" wheat than the U.S. exists in Canada still, more than one hundred years later.

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[20] *Ibid.* p. 19.

[21] A Winchester bushel is a U.S. bushel. A bushel is equal to 8 gallons, therefore a Winchester bushel is equal to approximately 5/6 of an Imperial (British) bushel. An Imperial bushel is equal to .3637 hectolitres.

[22] *Ibid.* p. 20.

The first grade definitions specifically for wheat produced in Western Canada came with the *General Inspection Act* of 1886. The other grains produced in Western Canada maintained the same grade definitions as those produced in Eastern Canada. Under the *General Inspection Act* a Board of Examiners was set up in Toronto for the purposes of selecting and approving standard samples. Pressure from Winnipeg grain merchants resulted in an 1889 amendment setting up a Board consisting of persons from the west. In 1891, the *Act* was amended again to include commercial grades of grain for samples which did not meet the statutory standards.

The first Act dealing specifically with grain was the 1900 *Manitoba Grain Act*, which resulted from the Senkler Commission. However, despite its title this act dealt mainly with issues such as handling and storage and the regulation of elevators and warehouses. The 1900 Act also changed the terms of the grain inspector as they became salaried government employees rather than being paid by inspection fees. It was amendments to the *General Inspection Act* in 1899 which provided some of the grading restrictions which are still in effect. Irvine states:

> The legislation also forbade the mixing of different grades in public elevators and the use of special bins for segregation of parcels which might be of especially high quality. ... A further regulation stated that any wheat shipped from any terminal elevator would be inspected only at a lower grade if it showed evidence of being below the average quality of the grade in the bins of public elevators (where no mixing was allowed). This was the origin of what became known as the Export Standard, in the 1929 revision of the Canada Grain Act".[23]

The *Canada Grain Act* of 1912 consolidated several previous acts which referred to grain

[23] *Ibid.* p. 47

grading, inspection and handling. This *Act* authorized the Board of Grain Commissioners for Canada, the precursor of the present Canadian Grain Commission. The Act was amended in 1925 and again in 1929 which was when export standards were first incorporated in the Act.

In 1930 a new *Canada Grain Act* gave the power to control grain grading and handling to the Board of Grain Commissioners. In addition, the commissioners were given increased regulatory powers and were provided with a laboratory to do grain research. Patent rights to grade names were established in the 1930 *Act*. The 1930 *Act* was in effect until the *Canada Grain Act* of 1971 was passed.

The 1971 *Canada Grain Act* made significant changes to the number and names of grades and allowed for protein segregations among the top three grades of CWRS wheat. The 1971 Act defines grain as "any seed named in Schedule 1 or designated by regulation as grain for the purposes of the Act".[24] Schedule 1 of the Act which is subject to amendment by Order in Council on the advice of Parliament states the statutory grades of grain. Western Grain is defined by Schedule 1 as any grain which is produced in the region west of the meridian which passes through the Eastern Boundary of Thunder Bay Ontario.

The *Canada Grain Act* establishes four classes[25] of grades for grain and grain screenings produced in Canada.

1. Class I Grades (Statutory)

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[24] Canada Grain Act, *Statutes of Canada*, 1970 c.7 s.2(16)

[25] Not to be confused with classes of wheat such as CWRS, CPS and CWAD.

2. Class II Grades (Special Grades)

3. Class III Grades (Off Grades)

4. Class IV Grades (Screening)

The Statutory Grades (Class I) are the most often used grades and are the grades into which CWRS wheat falls. These grades are designed to segregate the various qualities of different grains. Special Grades (Class II) are established under the Canada Grain Regulations and are most often used for new types of grains and for other special circumstances in which grain is not included in the Class I Grades. The Off Grades (Class III) are for grains which cannot be included in the statutory grades due to presence of other species of grain or a particular condition. Included in this group are the tough and damp grades as well as rejected grades arising from the presence of stones, ergot, fireblight, or damage from heating or drying. The Screening (Class IV) grades are used for the material recovered during the cleaning process and also the pellets made from grain, dust, weed seeds and other material.

Statutory grades are based on recommendations of the Canadian Grain Commission to the Cabinet which then passes an Order of the Governor in Council. These recommendations are given to the Canadian Grain Commission by the Grain Standards Committees for Eastern and Western grain. The Western Grains Standards Committee is explained as follows:

> The Western Grains Standards Committee is composed of: a commissioner, grain inspector and chemist from the Canadian Grain Commission; the chairman of the Western Division Grain Appeal Tribunal; two persons nominated by the Deputy Minister of Agriculture Canada; one person nominated by the Canadian Wheat Board ; two grain processors; two grain exporters; twelve

grain producers and not more than three other persons selected by the Commission.[26]

The Canadian Grain Commission establishes the non-statutory grades (Classes II,III,IV) which do not need an Order of the Governor in Council.

The grain grading system in general and the wheat grading system in particular rely on several quality characteristics for segregating the grain into grades. The grading factors are 1) test weight, 2) varietal purity, 3) vitreousness[27], 4) soundness[28], 5) foreign material, 6) dockage[29], 7) moisture content, and 8) protein content. Three of these grading factors, varietal purity, soundness and vitreousness are measured by visual inspection which require that inspectors be highly trained in order to ensure consistency. In addition, standard samples for all statutory grades and special grades are prepared each year to assist in visual inspection.

Wheat grading in Canada is facilitated by regulation which requires wheat

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[26] Canadian International Grains Institute, *Grains & Oilseeds; Handling Marketing and Processing* (3rd. ed; Winnipeg: C.I.G.I., 1982) p. 248 .

[27] Vitreousness refers to the glossy or glassy appearance of the wheat. Generally, high protein wheat tends to have kernels which are more vitreous than lower protein wheat.

[28] Soundness relates to the amount of kernel damage in the sample. Undamaged, well developed and mature kernels are sound kernels. Unsound kernels can be caused by a variety of factors including frost, disease and poor storage.

[29] Dockage only affects the grade given to the grain at the primary elevator as this material is removed at the terminal elevators by cleaning. Foreign material is that which is not removed from the sample at the terminal and is thus an important factor with respect to export grain.

varieties to be registered.[30] The registration of new wheat varieties requires that wheats in one class be visually distinguishable from wheats of other classes.[31] Although this regulation has been criticised by some researchers for reducing the yield potential of Canadian wheat, the regulation does assisting in grading wheat into appropriate grades. The requirement for visual distinguishability for different classes of wheat has been credited by some for the consistent quality of Canadian wheat grades through the past decade[32]. However, the question is not whether (or not) the grading of Canadian Wheat has been consistent from year to year, although this is a very important component of wheat marketing. Rather, the question is, are the grades of wheat Canada is using and the standards which define these grades meaningful to the end-user? Canada has a long tradition among wheat exporters for providing a good quality product. However, to ensure this reputation remains intact perhaps it is time to reassess the grades and standards used in the wheat grading system.

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[30] The registration process for new varieties is defined under the *Canada Seeds Act*. The process provides for the maintenance of specific quality requirements for each major class of grain. For some classes a standard variety is named, in the case of CWRS wheat, that named standard variety is Neepawa.

[31] The visual distinguishability requirement for new wheat varieties to be registered for use in Canada provides a proxy for quality. Varieties which have similar visual characteristics but do not conform to the quality characteristics of a class of wheat are not licensed for use in Canada, thereby limiting the potential erosion of quality.

[32] K.R. Preston, B.C. Morgan, and K.H. Tipples, "A Review and Analysis of Export Cargo Quality Data For Canada Western Red Spring Wheat: 1973-1986" *Canadian Institute of Food Science and Technology Journal*. Vol 21, No. 5. pp. 520-530.

CHAPTER 3. THEORETICAL FOUNDATION FOR ANALYZING GRADES ON THE BASIS OF THE DEMAND FOR CHARACTERISTICS

3.1. Introduction

Wheat like many other agricultural products is not usually desired by consumers in its natural state, rather it is the products such as bread, rolls, cakes, noodles, etc, produced from wheat which consumers desire. Therefore, wheat can be viewed as having a derived demand, i.e. the demand for wheat is derived from the demand for the products which require wheat in the production process. Thus, in order to determine the demand for Canada Western Red Spring (CWRS) wheat, the demand for wheat based products should first be determined. Once the product demand has been determined the demand for wheat as an input can be analyzed. However, the question is: why is a particular wheat demanded? Is it because one wheat makes better bread that others or because the customer for some reason prefers one vendor to another? If the latter reason is the case then perhaps Canada should work on her image. If the former reason is the case, then there must be differences between the characteristics of the wheat used as inputs. As there are many different classes of wheat produced throughout the world, it may be safe to assume that every class has a composition which differs from all other wheats. So is it the class itself which is demanded or is it that the class contains the desired characteristics?

The theoretical foundation for this part of the study will be presented in the following order to be consistent with the preceding statement. First Consumer Demand theory with specific reference to Lancaster's "New Theory of Consumer Behaviour" as related to product characteristics including the concept of hedonic pricing will be discussed. Next is a discussion of the application of Lancaster's theory to the Neoclassical "Theory of the Firm". This will be followed by a discussion of duality and the use of shadow prices as a method of imputing values to input characteristics of a commodity.

3.2. Consumer Demand and Product Differentiation

Traditional economics postulates that consumers derive utility from the consumption of goods and services. Thus, a consumer would derive a given amount of utility from a loaf of bread irrespective of the type of bread purchased. This notion of consumer demand for products may have precluded the concept of product differentiation. Prior to 1966, several studies were carried out by economists which focused on the characteristics of products and the effects of product characteristics on product prices and demand[33]. However, these studies, while soundly based in empirical techniques, lacked a microeconomic theory base.

In 1966, Kelvin Lancaster presented in two papers a theoretical foundation for the analysis of the demand for goods based upon their characteristics[34]. In essence, Lancaster's theory states that given a budget constraint, the consumer will maximize his

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33 Zvi Griliches (ed) *Price Indexes and Quality Change*, Cambridge: Harvard University Press, 1971.

34 Kelvin Lancaster, "A New Approach to Consumer Theory" *Journal of Political Economy*. Vol 74 (April 1966) pp.132-157. and Kelvin Lancaster, "Change and Innovation in the Technology of Consumption" *American Economic Review, Proceedings*, Vol 56, (May, 1966), pp. 14-25.

utility by choosing the products which provide the characteristics he most desires. In other words," the consumer's choice problem under a regular budget constraint can be formulated as the optimization problem.

$$\text{Max} \quad u(z)$$

$$\text{Subject to:} \quad z = Bx,$$

$$x > 0,$$
$$px \leq k.$$

Where:

u is utility.

z is a subset of Z, the collection of characteristics.

B is the matrix of coefficients relating goods and characteristics. (Lancaster calls this the consumption technology matrix)

x is the vector of goods.

p is the price vector of goods,

k is the consumers income[35].

This form of the consumer's utility maximization problem differs from traditional analysis in that the consumer maximizes utility from characteristics rather than goods. Lancaster's theory permits the use of product differentiation in the analysis of consumer demand for products. For example, rather than bread being viewed as one good providing a certain utility, the consumer can choose between several breads having

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35 Kelvin Lancaster, *Consumer Demand: A New Approach*, New York: Columbia University Press, 1971, p.21.

different characteristics and therefore providing different levels of utility. In addition, the consumer with a fixed budget may choose between purchasing bread or some other product on the basis of characteristics such as nutritional value, versatility in meal preparation and storability. Thus Lancaster's theory depicts consumer behaviour in a more realistic light than traditional demand analysis.

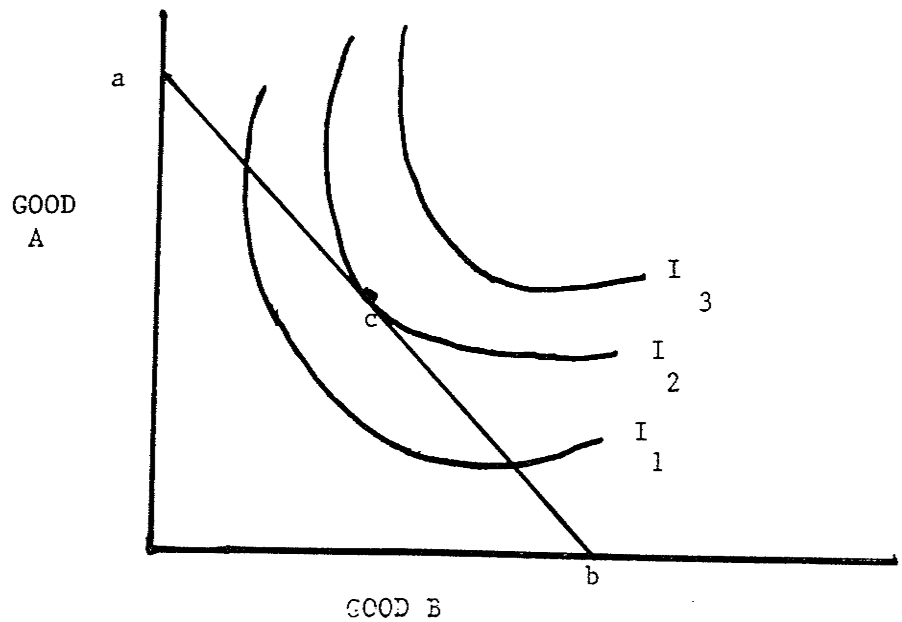
Lancaster extended his basic model of utility maximization to introduce the concept of an efficiency frontier. The efficiency frontier is similar to the traditional concept of the indifference curve in that it represents the frontier along which a consumer's utility is maximized. However, whereas in traditional economic analysis there exists one point where a consumer's utility is maximized given a budget constraint (Figure 4.1), an efficiency frontier represents a continuous set of points where the consumer's utility is maximized for a given budget constraint (Figure 4.2). Thus, since the consumer is maximizing his utility on the basis of product characteristics, rather than on the basis of individual products, he has several efficient options from which to choose.

Lancaster's analysis is based on two fundamental proposition.

1. All goods possess objective characteristics relevant to the choices which people make among different collections of goods.

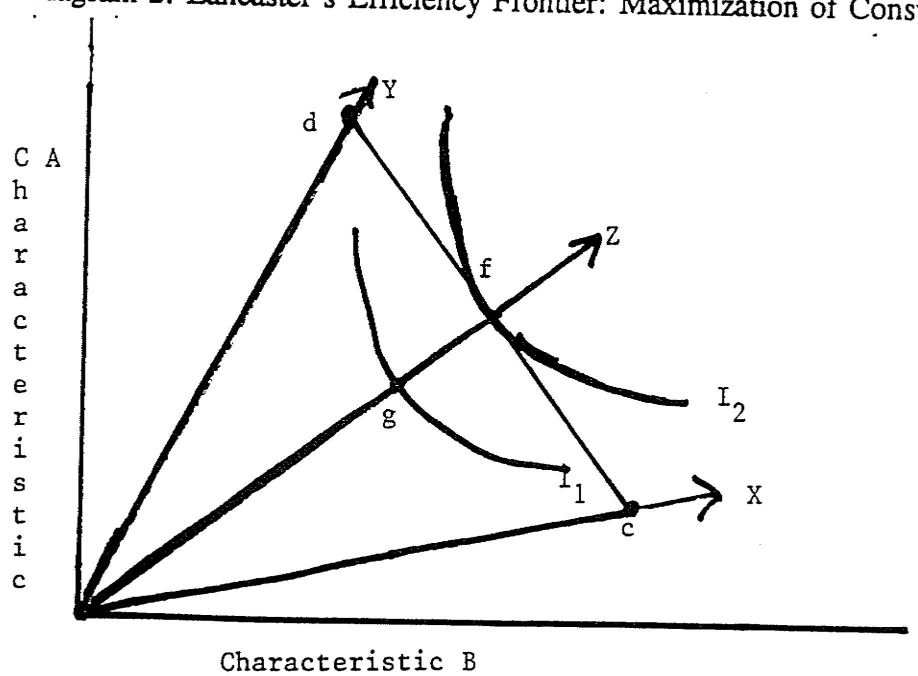
2. Individuals differ in their reactions to particular characteristics rather than in their assessment of the characteristics content of various goods collections. It's the characteristics in which consumers are interested. They possess preferences for collections of characteristics, and preferences for goods are indirect or derived in the sense that goods

Diagram 1. Traditional Economic Analysis: Maximization of Consumer Utility.



The consumer maximizes his/her utility for a given budget constraint a,b at point c.

Diagram 2. Lancaster's Efficiency Frontier: Maximization of Consumer Utility.



Assuming the consumer spends his/her whole income on one product, the maximum they can buy of each product is at points c, d, and g for goods X, Y and Z. Depending on the relative prices, the consumer maximizes his utility along a frontier, cd in the example at point f on I_2.

are required only in order to produce the characteristic[36].

He further expounds on these two basic propositions by stating

> We view the relationship between people and things as at least a two-stage affair. It is composed of the relationship between things and their characteristics (objective and technical) and the relationship between characteristics and people (personal involving preferences).[37]

Lancaster's position that his 'New Theory' is needed is made clear in the following statement.

> The omission in the traditional analysis of any provision for using information concerning the technical characteristics of goods renders it completely incapable of handling the most important aspects of demand in an advanced consumer society--the effects of product variations and differentiates, model changes, new goods, and new variants of existing goods.
>
> Suppose that a certain good is changed somewhat in terms of its characteristics. In the traditional analysis, we can only do one of two things: (i) ignore the changes, and proceed as if the new variant is the same good as before or (ii) regard the variant as an entirely new good, throwing out any information concerning demand behaviour with respect to the original variant, and start from scratch. The first of these ignores relevant information and will predict unchanged demand where demand conditions have probably changed. The second throws away previously gathered information that is likely to be relevant and gives us nothing in its place. Traditional demand theory, like the traditional theory of the firm, has its roots in the economics of an earlier, and simpler, society, when there were fewer products, each more or less standard, and a simpler technology. It is a "coarse structure" theory, the contribution of which is to show that the demand for goods shows broad substitution properties. It is not a "fine structure" theory, designed to handle the effects of product variation on demand and other problems involving relatively small difference in the characteristics associated with different

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[36] Kelvin Lancaster, *Consumer Demand: A New Approach*, New York: Columbia University Press,1971, p. 7.

[37] *Ibid.*

goods.[38]

The contributions of Lancaster's model to consumer behaviour theory were listed by Ratchford as follows:

1. The model explains the role of price in determining the demand for differentiated products, a point which is not explained well by the traditional economic theory, and hardly at all by models in other areas.

2. The model provides a framework for estimating the sensitivity of demand to changes in the relative price of a brand.

3. The model provides a theoretical perspective for models of brand share determination.

4. The model gives an economic explanation of the phenomenon of brand loyalty.[39]

The four points highlighted by Ratchford plus the explanatory ability of Lancaster's model with respect to substitutes and complements on the basis of characteristics make this theory attractive for this study. However, there are some shortcomings inherent in Lancaster's work, both from a theoretical perspective and also with respect to the method of imputing prices to characteristics found in the various products. Ladd and Zober[40] listed three assumptions of Lancaster's model which were subject to criticism:

(i) every characteristic has nonnegative marginal utility (NNMU),

(ii) utility is independent of the distribution of characteristics among

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[38] *Ibid.*, p.8

[39] Brian T. Ratchford, "The New Economic Theory of Consumer Behaviour: An Interpretive Essay." *Journal of Consumer Research*, Vol. 2, September 1975, p.67.

[40] George W. Ladd and Martin Zober, "Model of consumer reactions to Product Characteristics" *Journal of Consumer Research*, Vol.4 September 1977, pp. 89-101

products (IDC) and

(iii) linear consumption technology (LCT).[41]

The problem with the assumption of NNMU is that characteristics do exist which may have negative marginal utilities. The example used by Ladd and Zober is nicotine in cigarettes. They indicate that a characteristic with a negative marginal utility has indifference curves which slope upward to the right. In Lancaster's theory if the NNMU assumption is violated, consumers preferences need to be known to judge the efficiency of his/her choice.

With respect to utility being independent of the distribution of characteristics among products, Ladd and Zober state:

> Lancaster's analysis breaks down if this assumption is violated. His analysis is valid if each point in characteristics space represents a specific combination of characteristics *and* a unique level of utility.[42]

Violation of this assumption means that different products with different characteristics may have different levels of utility yet will occupy the same point in characteristics space. The example given by Ladd and Zober is:

> the consumer ... obtained 278 grams of protein from 3 quarts of milk and 2 pounds of chuck roast. A person can also obtain 278 grams of protein from 7 quarts of milk and 0.6 pounds of chuck roast. According to IDC, a consumer is indifferent between these two ways of obtaining 278 grams of protein. The IDC assumption is violated if the consumer prefers to obtain most of the 278 grams from steak.[43]

Ladd and Zober criticize the linear consumption technology assumption for the

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[41] *Ibid.*, p. 89.

[42] *Ibid.* p.90.

[43] *Ibid.*

following reasons.

> The LCT assumption means that if N_1 units of product 1 and N_2 units of product 2 are consumed, the amount of each characteristic obtained equals [(N_1) X (amount of characteristic in each unit of product 1)] + [(N_2) X (amount of characteristic in each unit of product 2)][44].... If consumption technology is not linear, it is not possible to judge a consumer's efficiency without detailed knowledge of the consumption technology.[45]

In addition to the theoretical framework, empirical methods are needed to calculate imputed prices for different product characteristics. This need led to an increased interest in Hedonic pricing.

3.3. Hedonic Pricing

Following the publication of Lancaster's two papers the interest in attempting to determine the value of individual product characteristics increased. The use of quantitative techniques in order to impute prices to the various characteristics of different products is known as hedonic pricing. Hedonic pricing could be described as the empirical justification for Lancaster's "New Theory of Demand". Although several empirical studies imputing prices to product characteristics were undertaken prior to Lancaster's seminal articles, during the past two decades there has been a increase in this gendre of article. Rosen's 1974 article "Hedonic prices and implicit markets: Product differentiation in pure competition"[46] seems to have been somewhat of a seminal article

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[44] For example say that a slice of toasted bread contains 100 calories and that a spoon of blueberry jelly contains 175 calories, then a person obtains 550 calories from eating two slices of bread and two spoons of blueberry jelly: (2 X 100) + (2 X 175) = 550.

Ibid.

[46] Rosen, Sherwen, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 82(1): 1974 pp.34-55.

for Hedonic pricing studies. Rosen defined hedonic prices and how they are obtained as follows:

> Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them. They constitute the empirical magnitudes explained by the model. Econometrically, implicit prices are estimated by the first-step regression analysis (product price regressed on characteristics) in the construction of hedonic price indexes.[47]

One of the motivations behind Rosen's work was Lancaster's assumption of infinite divisibility which precluded large indivisible goods such as motor cars and houses from the model. As a result of Rosen's work many of the early works relating to hedonic pricing were carried out on consumer goods rather than agricultural products. However, the assumption of infinite divisibility of goods is admirably suited to agricultural products such as wheat. Another assumption in the Lancaster model which is not evident in Rosen's model is that different brands can be used in combination. Thus a consumer could use two or more brands of coffee to make a pot, or a wheat miller could blend several different types of wheat to make flour. This is not possible with Rosen's model because it is difficult to assume that parts of two motor cars would normally be used by consumers.

In general Rosen's model examined the price which would occur at a competitive equilibrium where there is a class of goods with several objectively measured characteristics $z = (z_1, z2, \ldots, z_n)$, where z_i measures the amount of the i^{th} characteristic

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[47] *Ibid.*, p. 34

in each good[48]. In this class of goods there are many products and Rosen assumes that the" choice among various combinations of z is continuous for all practical purposes". That is, there is a "spectrum of products among which choices can be made"[49].

The competitive equilibrium is described by the market clearing prices $p(z) = p(z_1, z_2, \ldots, {}_n)$[50] which relate the prices of the product and their characteristics. The price function gives the minimum price for a bundle of characteristics as it is assumed that consumers will shop around for the best price. In addition, as the model portrays a competitive market, no individual consumer or producer can influence the price of the generic product. This assumption, with respect to agricultural products such as wheat may be somewhat unrealistic. The world wheat market consists of five or six large exporting nations (sellers) and a limited number of large importing nations (consumers). The world market for wheat, therefore, may more closely relate to an oligopoly/oligopsony situation where certain large sellers or buyers may have a very direct influence on the price of the generic product, wheat. Nevertheless the model presented by Rosen provided the framework for an analysis of wheat quality factors by several authors.[51]

Hedonic pricing was described by Ratchford as consisting of fitting regression relationships on cross sections of brands of models of the form $P_j = f(z_{1j}, z_{2j}, \ldots, z_{nj})$

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[48] *Ibid.*, p. 35

[49] *Ibid.*, p. 37.

[50] *Ibid.*, p. 35

[51] Some of these works will be discussed in Chapter 4, the review of related literature.

where P_j is the price of the j^{th} model and z_{1j}, z_{2j}, ..., z_{nj} are levels of characteristics, 1, . . . , n contained in the j^{th} model[52]. The addition of dummy variables to reflect price changes not due to characteristics changes and combining the cross sectional data for several years permitted the development of price indexes and quality change indexes[53].

In a critique of Rosen's paper with respect to the estimation of prices it is pointed out that;

> The problem with Rosen's approach is that the hedonic estimation problem is not due to demand-supply interaction. An individual consumer's decision cannot affect suppliers in the hedonic model because an individual consumer does not affect the hedonic price function.[54]

Bartik also points out that consumers in the hedonic model are actually choosing both the marginal price and quantities from within the model, i.e. nothing is exogenous.

3.4. Input Characteristics and Theory of the Firm

The traditional neoclassical view of a firm's behaviour is one in which firms produce goods and services through the use of factors of production. The goal of the firm is either the maximization of profit from the sale of goods and services produced, or the minimization of the cost of producing these goods and services. The factors of

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52 Brian T. Ratchford, "The New Economic Theory of Consumer Behaviour: An Interpretive Essay." *Journal of Consumer Research*, Vol. 2, September 1975, p. 73.

53 *Ibid.*

54 Timothy J. Bartik "The Estimation of Demand Parameters in Hedonic Price Models" *Journal of Political Economy*, 1987 Vol. 95 No.1, p. 83.

production, defined as " any scarce resource used in the production of a good or service"[55] are usually assumed to be homogeneous, in that for any given type of factor there are no quality differences between different parcels of the same factor[56]. Thus, in the case of wheat used to produce flour, this assumption would indicate that all wheat is the same. A variation of the neoclassical theory of the firm which identified the role of the characteristics of inputs in a production process was published in 1976 by Ladd and Martin[57].

Commencing with the premise that in some instances, the characteristics of the product are important to the producer, Ladd and Martin discuss two themes.

> The first theme is that the price of a purchased input equals the sum of money values of the inputs' characteristics to the producer. The money value of each of the input's characteristics equals the input's marginal yield of the characteristic multiplied by the marginal money value of one unit of the characteristic. The second theme is that the demand for an input is affected by the inputs characteristics.[58]

In order to illustrate and discuss these two themes the authors present two theoretical models. The first, " The Neoclassical Input Characteristics Model(ICM)" is a variation of the neoclassical theory of the firm in which the authors indicate the importance of factor characteristics, rather than just the factors themselves in the production process.

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[55] C.E. Ferguson, *The Neoclassical Theory of Production and Distribution*, Cambridge:Cambridge University Press,(Reprinted) 1979, p. 6.

[56] B.R. Beattie and C. R. Taylor, *The Economics of Production*. New York: John Wiley & Sons, 1985.

[57] G.W.Ladd, and M.B. Martin, "Prices and Demands for Input Characteristics", *American Journal of Agricultural Economics*, Vol. 58, 1976, pp.21-30

[58] *ibid., p.21.*

The second model 'the Linear Programming Input Characteristics Model' offers an alternative method of determining the value of input characteristics by using the theory of duality in a linear programming blending model.

The assumptions for the ICM, are (i) a multiproduct firm which has each production function independent of the other production functions, and (ii) "The total contribution of an input to production depends upon the amounts of the various characteristics it provides, and total production depends upon the total amounts of all characteristics provided by all inputs".[59] Their model is defined as follows;

Let v_{ih} = the quantity of the ith input used in production of the hth product.

r_i = price paid for the ith input.

p_h = price received for product h,

q_h = quantity of hth output produced,

x_{jih} = the amount of characteristic j provided by one unit of input i that enters into production of product h.

$x_{j.h}$ = the total quantity of characteristic j that enters into production of product h.[60]

The model also assumes that x_{jih} values are parameters which are beyond the user of the inputs' control. The production function for product h is written as

$q_h = F_h(x_{1.h}, x_{2.h}, \ldots\ldots x_{m.h})$, where m is the number of characteristics. The production function states that " the output of the hth product depends upon the amounts of various

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[59] *Ibid.*, p. 22.

[60] *Ibid.*

input characteristics used in its production."[61] Expressing the total quantity of each characteristic as a function of both the quantities of inputs used and of the input-output coefficients allows $x_{j.h}$ to be written as $x_{j.h} = X_{jh}(v_1h, v_2h, \ldots, v_{nh}, x_{j1h}, x_{j2h}, \ldots, x_{jnh})$. This allows the production function to be rewritten as

$g_h = G_h(v_{1h}, v_{2h}, \ldots,_{nh}, x_{11h}, x_{12h}, \ldots, x_{mnh})$ where n is the number of inputs.

The profit maximizing function of the firm subsequently is written as

$$\pi = p_h F_h(x_{1.h}, x_{2.h}, \ldots x_{m.h}) - \Sigma^{i=1} r_i v_{ih}.$$

Using the function of a function rule, the profit function is differentiated with respect to v_{ih} to yield.

$$\delta\pi / \delta v_{ih} = p_h \bullet (\delta F_h / \delta x_{j.h}) (\delta x_{j.h} / \delta v_{ih}) - r_i = 0$$

then: $r_i = p_h \bullet (\delta Fh / \delta x_{j.h}) (\delta x_{j.h} / \delta v_{ih})$;

where:

$\delta x_{j.h} / \delta vi_h$ is the marginal yield of characteristic j to production of the h<u>th</u> product from the i<u>th</u> input.

$\delta F_h / \delta x_{j.h}$ is the marginal physical product from one unit of characteristic j used in production of the h<u>th</u> product.

$p_h \bullet (\delta F_h / \delta x_{j.h})$ is the value of the marginal product of the j<u>th</u> characteristic used in production of output h.

This is the imputed price which is paid for the j<u>th</u> characteristic used in the h<u>th</u> product. Letting $p_h \bullet (\delta F_h / \delta x_{j \cdot h} = T_{jh}$, then, $r_i = T_{jh} (x_{j.h} / v_{ih})$ which states " that for each input used in producing output h, the price paid equals the sum of the values of the marginal yields of the input characteristics to the product." The

[61] *Ibid. p. 22.*

authors indicate that this is the hypothesis of their first theme.

In order to state the hypothesis of their second theme, the authors indicate that if the second order conditions for maximizing the differential equation for profit with respect to the quantity of the inputs used are satisfied, then each element of the system can be expressed as $v_{ih}^* = v_{ih}(p_1,..p_H, r^1,..r_n, x_{111}, x_{211},.., x_{21h},..,x_{mnh})$

The authors then cite several studies which support their first hypothesis through the use of regression techniques.

The second theoretical model put forward by Ladd and Martin, offers an alternative to the use of regression techniques for imputing prices to input characteristics. This model uses the theory of duality in a linear programming blending problem to impute values to the characteristics of the inputs. The authors present two different problems, one a cost minimization problem and the other a profit maximization problem.

The cost minimization problem assumes that the firm purchases the blending ingredients at fixed prices and is stated as follows;

(1) Min $p_j x_j$

subject to;

(2) $a_{ij}x_j > a_{10}$, $i= 1, 2, \ldots, m_0$

(3) $a_{ij}x_j = a^i_0$, $i=m_0+1, m_0+2,\ldots m$

(4) $x_j > 0$, $j =1,2,\ldots, n_o$ and

(5) x_j unrestricted; $j = n_0+1, n_0+2, \ldots., n$

where. p_j = price of jth ingredient

x_j = quantity of the j<u>th</u> ingredient used per unit of output

a_{ij} = the quantity of the i<u>th</u> characteristic in one unit of the j<u>th</u> purchased input.

a_{i0} = the amount of the i<u>th</u> characteristic required in one unit of output.

The Dual of the problem is:

(6) Max $a_{i0}y_i$

subject to:

(7) $a_{ij}y_i < p_j : j= 1,2, \ldots, n_0$

(8) $a_{ij}y_i = p_j ; j= n_0+1, n_0+2, \ldots, n$

(9) $y_i > 0 \quad i = 1,2, \ldots, m_0$

(10) y_i unrestricted; $i = m_0+1, m_0+2, \ldots m$

Duality theory indicates that the minimum value of the primal equals the maximum value of the dual thus Min p_jx_j = Max $a_{i0}y_i$. Then if a_{i0} is changed by some amount $\blacktriangle a_{i0}$, the primal minimization must change by the same $\blacktriangle a_{i0}$ amount. Then $\blacktriangle \min \; p_jx_j/\blacktriangle a_{i0} = \blacktriangle \max \; a_{i0}y_i/\blacktriangle a_{i0} = y_i$, where y_i is the shadow price of the i<u>th</u> characteristic. The y_i9 shadow price " measures both the effect on minimum total ingredient cost per unit of output of varying a_{i0} and also the effect on maximum monetary value of nutritional (or other characteristic) requirements of varying a_{i0}."[62] The authors note that expression (8) indicates that "the total money value of all characteristics in one

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[62] G.W.Ladd, and M.B. Martin, "Prices and Demands for Input Characteristics", *American Journal of Agricultural Economics,* Vol. 58, 1976, p.25.

unit of input j (for j = n_0+1, $n_0+2,\ldots n$) equals the price of ingredient j."[63] Then if x_i* and y_i* are the primal and dual optimal solutions respectively, and $x_i* > 0$, then the sum of all characteristics in ingredient j times the shadow prices for the i characteristic equals the price of ingredient j, i.e. $a_{ij}y_i = p_j$. This expression is the exact counterpart to the solution of r_i in the ICM model (where $r_i = T_{jh}(\delta x_{j \cdot h}/\delta v_{ih})$). Thus they show that the linear programming blending problem is a derivation of the first theme of the theory, i.e." the price of a purchased input equals the sum of money values of the input characteristics to the purchaser."[64] The profit maximization model shows that the shadow price of a characteristic is the maximum amount a firm can pay for one more unit of the characteristic and still maximize its profit.

The ICM and the Linear Programming Input Characteristics Model provide a theoretical basis for analyzing factors of production on the basis of their characteristics. Thus, just as the consumer derives utility from the characteristics of the products, rather than the products themselves (in Lancaster's theory), the manufacturer or processor may be more interested in the characteristics or quality of his purchased inputs rather the than the inputs themselves. Ladd and Martin indicate that for the analysis of certain problems, such as product differentiation, grades and standards, and quality, the assumption of input homogeneity may be too restrictive. Their approach provides a theoretic basis for analyzing heterogeneous input in the production of goods and services

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[63]. *Ibid.* p.25.

[64] G.W.Ladd, and M.B. Martin, "Prices and Demands for Input Characteristics", *American Journal of Agricultural Economics*, Vol. 58, 1976, p.21.

as an alternative to homogeneity.

Due to the econometric problems associated with hedonic pricing as pointed out by both Epple and Bartik, data limitations and limited degrees of freedom, the linear programming approach was chosen as the appropriate technique to analyze CWRS grades.

3.5. Duality in Linear Programming

The Linear Programming Input Characteristics Model proposed by Ladd and Martin makes reference to the use of duality and shadow prices for input characteristics. However, the Ladd and Martin study fails to explain either duality or shadow prices while using them. This section of the paper discusses the properties of the dual to linear programming, shadow prices and the use of parametric programming to provide a theoretic foundation for the use of these methods later in the analysis.

Linear programming "is a mathematical method of allocating scarce resources to achieve an objective."[65] The use of a linear programming model implies two essential assumptions; (1) the problem is linear, and (2) that the production functions for different products are independent of one another. The linear programming in canonical form is written as:

$$\text{Minimize: } Z = \quad c_j x_j$$

$$\text{subject to;} \quad a_{ij}x_j > b_i;\ i = 1,2,\ldots..,m$$

$$xj > 0;\ j = 1,2,\ldots.n$$

[65] Lee, S.M., L.J.Moore and B.W.Taylor III, *Management Science*, 2nd ed., Dubuque Iowa: Wm Brown Publishers, 1985, p. 25.

where Z is the objective function

x_j are the decision variables.

c is an n x 1 matrix of contributions per unit of activity for the decision variables.

a is an m x n matrix of the amount of resources consumed by an activity.

b is an m x 1 matrix of the parameters in the model (i.e. the amount of each resource available or other constraints)

The canonical form of the dual to the minimization problems above is;

Maximize $V = b_i y_i$

subject to: $a_{ij} y_i < c_j$; $j = 1,2, \ldots, n$

$y_i > 0$; $i = 1,2,\ldots,m$

where c,a,b, are the same as in the primal form, and y is an m x1 matrix of the dual variables.

The interpretation of the y matrix is that these are the shadow or imputed prices of each of the factors used in the objective function. A shadow price " measures the scarcity value of the factor in the eyes of its owner, since it tells us how much he could advance his own objective by having one more unit of the factor."[66] Non-zero shadow prices exist only for those factors of production which are binding, i.e. all used up in the production process. For factors which are non-binding,i.e. a surplus exists, the shadow price is zero. The zero shadow price implies that the optimal amount of the factor has already been used in the production process. Additional use of a surplus factor

[66] Layard, P.R.G. and A.A. Walters, *Microeconomic Theory*, New York: McGraw-Hill Book Company, 1978, pp. 281-282.

would add nothing to the objective function.

Baumol explains shadow prices in a profit maximizing problem. He relates that a company's profits are imputed to its scarce resources.[67] Thus, the total imputed value of all the scarce resources (i.e. those which are binding) is equal to the total profit of the firm. In the case of a cost minimization problem, the value imputed to an input could be the amount a processor's total cost would be reduced if he had one more unit of the particular input.

One of the limitations of duality theory with respect to this study is that shadow prices are determined only for the inputs which are binding. This limits the analysis of the non-binding constraints. In an analysis of problems such as one involving grades of wheat, where it may be necessary to determine the levels at which one characteristic ceases to be important and another characteristic becomes important, duality theory may not provide enough information. A method for overcoming or correcting the problem of duality limitations is through the use of parametric programming. Parametric programming is described as being " where one of the parameters of the problem is continuously altered and the corresponding solution values for the quantities and shadow prices is traced out."[68] Parametric programming can, therefore, provide additional information not obtainable from the dual of the linear programming blending problem

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[67] Baumol, William, J. *Economic Theory and Operations Analysis*. 4th ed., Englewood Cliffs, N.J.: Prentice-Hall Inc., 1977.

[68] Layard, P.R.G. and A.A. Walters, *Microeconomic Theory*, New York: McGraw-Hill Book Company, 1978, p. 282.

directly. The application of parametric programming can indicate the demand for input characteristics over the range from the initial imputed value to the zero shadow price. In addition, the levels at which characteristics lose or gain importance in the blending problem can be determined. Thus, trade offs between grading factors can be analyzed from an end-use perspective.

CHAPTER 4. REVIEW OF RELATED STUDIES

4.1. Introduction

The relationship between the existing hierarchy of wheat grades in Canada and the end-use value of CWRS wheat encompasses several concepts. First there is the concept of wheat quality and the pertinent question: what is wheat quality? Second, what methods of determining the quality characteristics are useful in setting grades. Third there are the empirical concepts related to hedonic pricing and how they have been used with respect to agricultural products, in particular wheat. In order to cover these three concepts adequately they will be discussed separately below. The first studies reviewed will be those relating to wheat quality in both economic and non-economic terms. Second, will be a review of three studies which used linear programming techniques to assess either grades for agricultural products or product quality. Finally, two studies which used hedonic pricing to impute implicit values for wheats in the world market will be reviewed. A summary will conclude the chapter.

4.2. Wheat Quality Studies

In the past, the agricultural economics profession appears to have been remiss with respect to the determination of the economics of wheat quality, at least in North America. The study of wheat quality with respect to end-use has been mainly the realm of the physical scientists in agriculture, particularly the cereal chemists. However, the studies carried out by millers and bakers and other physical scientists have focused mainly on the physical attributes of the product rather than the economics. While these studies do not provide much in the way of economic insight they do provide sound technical information which may be used in the process of determining the economic value of different quality characteristics. One non-economic wheat quality study will be reviewed in order to provide a basis for further analysis. The section will begin with a review of one of the few economic wheat quality studies carried out during the last two decades.

4.2.1. Wheat Price-Quality Relationships in the U.S.

One economic wheat quality study was done at the University of Minnesota in 1970[69]. Hyslop studied the relationship between the grading system for spring wheat in the U.S. and the actual quality factors which were demanded by buyers. His study had two objectives.

1. To analyze the role that the system of official grades plays in the discovery of price-quality relationships in wheat and the effectiveness of this system in differentiating among wheats.

2. To analyze the demand for hard wheat protein.[70]

The questions he felt that must be answered to satisfy his first objective were:

a. Does the system of official grades adequately describe spring wheat in terms of its value differentiating characteristics?

b. How important to the value of spring wheat are the quality factors that are measured in official mandatory inspection?

c. Is there an alternative to the present system of official grades? That is, how might the present system of numerical grades be improved to aid in the discovery of price-quality relationships?[71]

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[69] Hyslop, John D. *Price-Quality Relationships in Spring Wheat*. Technical Bulletin 267, Agriculture Experiment Station, University of Minnesota, 1970.

[70] *Ibid.*, p.4

[71] *Ibid.*

In order to avoid any confusion, Hyslop clarified his second objective by stating:

> protein premiums are an important source of revenue to hard wheat producers. Protein is the quality factor unique to bread wheats and is the most important and readily available indicator of baking quality.[72]

Hyslop also indicated that by analyzing the demand for protein, the wheat market could be made more efficient, as well the analysis may assist in the development and release of new varieties.

In his analysis assessing the premiums and discounts for various grading factors, Hyslop showed that the premiums for various factors tended to be less than the corresponding discounts. For example, for weights above the standard 58 pounds per bushel there was a premium of one cent per pound per bushel, whereas for test weights below 58 pounds per bushel the discounts were 2 cents per pound per bushel.[73] He further indicated that while grading factors do have some relevance to prices paid, there are some problems in that "they may be criticized for failing to yield as much quality information as present standards would permit."[74]

Hyslop also studied price differentials attributable to the assigned grades. He found cases where wheat of a lower grade carried a higher price than the wheat in the grade above. In addition, he found that due to the practice of downgrading on the basis of a single factor, the value of a wheat could be unjustly discounted. His findings were that,

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[72] *Ibid.*, p. 5

[73] *Ibid.*, p. 9.

[74] *Ibid.*, p. 10.

> Of the 121 sales at the Minneapolis Grain Exchange on a single day the grade other than Number 1 was determined by a single factor in 37 cases. Of these only 17 had all other factors in the Number 1 range.[75]

In order to overcome the problem of downgrading on the basis of a single factor Hyslop suggested the use of composite grades.

> This composite grade would be an average of the grades for each factor in the sample... Grading wheat according to this system would increase the likelihood of attaining proper rank-ordering in the market place.[76]

Hyslop then proposed his composite grades to evaluate price differentials. He found that by using these composite grades, there was better 'rank-ordering' of the grades and they did a "better job of differentiating among wheats on the basis of recognized quality factors."[77] He concluded that the grading system for wheat in the U.S. did not achieve a good rank ordering of quality factors and there should be a move to composite grading. In pursuit of his second study objective concerning the demand for protein, Hyslop showed that there was significant variability in protein premiums throughout the study period.

All aspects of the study were carried out using regression techniques. Official grades were analyzed using dummy variables for the non-quality factors which were sources of price dispersions in a linear regression model. The analysis of protein demand utilized multiple regression to estimate the intercept term, spring and winter

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[75] *Ibid.*, p. 11.

[76] *Ibid.*

[77] *Ibid.*, p.13.

protein quantities and a shift variable. The shift variable was " an attempt to account for changes in the demand for hard wheat relative to soft wheat." [78]

4.2.2. Wheat Quality Data Analysis

In 1988 researchers with the Grain Research Laboratory (GRL) of the Canadian Grain Commission performed some statistical analyses on the quarterly cargo data collected by the GRL[79]. For the three grades of CWRS wheat and the three protein segregation within the top two grades, they determined the average coefficient of variability for each quality factor. In addition, they used unpaired t-tests to determine differences between exports through the Atlantic and Pacific ports and the differences between grades. In general, they found that for No. 1 CWRS there is high uniformity for milling and baking quality between years and also between export locations. For many of the factors they found no statistically significant differences within the grade between years. However, for some years when growing conditions may have been less than normal some of the bread dough characteristics were somewhat varied. In addition, the authors mentioned that some of the variability may have been introduced due to the length in store and rounding errors in the data.

One interesting finding of their study was that No. 1 CWRS wheat had high test weights but the kernel size in the grade tended to be smaller than other grades. However, there was uniformity in size from year to year which would minimize millers

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[78] *Ibid.*, p. 16.

[79] K.R. Preston, B.C. Morgan, and K.H. Tipples, "A Review and Analysis of Export Cargo Quality Data For Canada Western Red Spring Wheat: 1973-1986" *Canadian Institute of Food Science and Technology Journal.* Vol 21, No. 5. pp. 520-530.

problems in selecting screens for cleaning. In general, they found the protein segregations for No.1 and No. 2 CWRS, both within the grade and between years to be consistent. They indicate that much of the difference between No. 1 and No. 2 CWRS was due to less stringent standards for No. 2. In this respect they state:

> Normally the differences between No. 1 and No. 2 CWRS wheats can be related to "weathering". Grading specifications for No. 2 CWRS wheat allow higher levels of bleached, immature and lightly frosted kernels and lower percentages of vitreous kernels. No. 2 CWRS is similar to No. 1 in overall milling and baking quality.... No significant differences between the grades at corresponding protein levels (12.5 and 13.5 %) were apparent for flour ash, loaf volume and baking absorption. However, flour yields were slightly lower and flour colour values were slightly higher for the No. 2 grade[80].

One set of important quality factors that did differ between No. 1 and No. 2 CWRS was the alpha-amylase activity. However, the authors do indicate that the alpha-amylase activity levels for No. 2 would not cause problems for users.

With respect to No. 3 CWRS, which is not segregated by protein level, the authors found:

> The No. 3 CWRS grade generally showed lower average quality and greater variability compared to the No. 1 and No. 2 grades both in terms of year to year (higher C.V. values) and Atlantic versus Pacific shipments. These effects can be attributed to two major factors. First, grade specifications for No. 3 CWRS allow considerably higher levels of weather related degrading factors such as bleached, immature, frosted and sprouted kernels which generally tend to reduce quality[81].

In addition, No. 3 CWRS had higher alpha-amylase activity , lower milling quality and

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[80] *Ibid.*, p. 527

[81] *Ibid.*

for the most part lower baking quality. Thus, quality for No. 3 CWRS was lower and more variable than for the top two grades, which should be expected.

4.3. Linear Programming Studies as Pertaining to Grading

Linear programming, as discussed in the theoretic foundations chapter of this study, provides a viable method of analyzing product quality factors. In this section, two studies apply duality theory to the linear programming blending model to analyze the grades and standards of agricultural products. In addition, a study which utilized a linear programming least-cost feed formulation is also reviewed. The first study is an extension of the Ladd and Martin paper which examines corn grades in Iowa in 1971. The second paper, presented in 1986 by Jones-Russell and Sporleder, examines the factors used for determining the price of cotton in the U.S. The third paper is research work done in Montana regarding the possibility of paying protein premiums for feed barley.

4.3.1. Corn Grades in Iowa

Ladd and Martin used the profit maximization linear programming blending model to "determine the optimum use of four carloads of corn actually shipped from a central Iowa elevator in the fall of 1971".[82] The model used five characteristics;

$i=1$ moisture content,

$i=2$ test weight,

$i=3$ broken corn and foreign material(BCFM),

$i=4$ damaged kernels, and

[82] Ladd, G.W. and M.B.Martin, "Prices and Demands for Input Characteristics", *American Journal of Agricultural Economics*, Vol. 58, 1976, p.25.

$i=5$ actual weight,

which were to be blended into five products corresponding to U.S. corn grades 1 through 5. The five products were denoted as $j=1$ for No.1 U.S. corn to $j=5$ for No.5 U.S. corn. The profit Maximizing model was:

$$\text{Max} \quad c_j x_j$$

subject to

$$a_{ij} x_j < r_i \ , \ i=1,2,\ldots,5$$

$$x_j > 0 \ , \ j=1,2,\ldots,5$$

where cj = price

x_j = production,

with a corresponding dual;

$$\text{Min} \quad r_i y_i$$

subject to

$$a_{ij} yi > c_j \ ; \ j=1,2,\ldots,5$$

$$y_i > 0, \ i = 1,2,\ldots 5$$

where; r_i = the amounts of each of the 5 characteristics,

y_i = the shadow price of the 5 characteristics.

The a_{ij} in the primal constraint denotes the amount of characteristic i allowed per unit of product (i.e. grade). As standards within grades of corn are ranges rather than one specific number, the authors used the maximum allowable amount under U.S. standards for moisture content, BCFM, and damaged kernels, and the minimum allowable test weight, for each grade. Thus a_{11} would be the maximum allowable moisture content in U.S. No.1 corn. Using this model, the authors ran 11 problems created by varying the amount of BCFM by 56 pound increments (i.e. in each problem r_3 increased by 56 pounds). In each of the 11 problems, the actual weight of corn had a positive shadow price, implying that the company could have increased its net revenue by having cleaner corn. Moisture content, damaged kernels and test weight all had zero shadow prices in each of the 11 problems, implying that these factors had no influence on the grades. BCFM had a zero shadow price for the first five problems and a negative shadow price for the last six problems. This implied that up to a certain point, the amount of BCFM in the corn had no influence on the revenue of the firm. Once the point was passed, an increase in BCFM caused a decrease in the firm's revenue. A 12th problem was run using a set level of BCFM and a reduced test weight which resulted in a positive shadow price for broken kernels. The authors point out that the purpose of these problems was to demonstrate use of the dual to obtain shadow prices, rather than to evaluate corn grades.

Following their demonstration of the use of duality to obtain shadow prices, Ladd and Martin discuss the application of input characteristics models to grading systems. They indicate that two questions have to be considered when a grading system is either established or evaluated. The two questions are; 1) "What characteristics of the product should be included?" and 2) "How should the information be reported?"[83]. They then indicate that the second of their two questions raises several issues with respect to the reporting of characteristics, as numerical grades tend to allow products to be downgraded

[83] *Ibid.* p.27.

on the basis of one factor. In answer to the reporting question, the authors present three conditions for a grading system which they discuss in the following statement;

> Given a list of characteristics, let us say that a grading system is sign optimal for a given firm with respect to that list (a) if the list of grading characteristics having positive marginal implicit prices for the firm is the same as the list of characteristics that raise the grade (eg. No.3 to No.1) when their yield per bushel rises; (b) if the list of grading characteristics having negative marginal implicit prices for the firm is exactly the same as the list of characteristics that lower the grade (eg. No.1 to No.2) when their yields per bushel rise; and (c) if the list of characteristics having zero marginal implicit prices is the same as the list of characteristics whose variations have no effect on grade. These three conditions can be summarized in one condition. For every characteristic, varying the yield per bushel of the characteristic has the same effect on grade as on the per bushel unit value of the commodity to the firm." [84]

Thus they in effect say that grades should be based on the end use value of the characteristics.

Ladd and Martin suggest that a grading system should be sign-optimal with respect to the firm, i.e. that the positive and negative shadow prices of the characteristics reflect their value to the firm's product. However, they indicate that one of the problems encountered in the linear programming approach is this concept of sign-optimality. For example, in the 12 L.P. problems run for corn grades, moisture content had a zero shadow price, but moisture content does affect grades. In regards to this problem of the sign of the shadow price not conforming to a priori expectations, the authors cite an unpublished MSc. thesis from Iowa State University by Knapp. Knapp used a linear programming model to study the blending and merchandising of 190 bins of corn. The net marginal value product (NMVP) of the corn was determined as the "excess of per

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[84] *Ibid.* p. 27.

bushel MVP (marginal value product) over the market price of corn having the same characteristics as the corn in the bin"[85]. The MVP for the corn in the bin was determined by adding the NMVP to the price of the corn having the same characteristics. The MVP for the corn equals $\Sigma\ y_i \blacktriangle r_i$[86], which is the change in the firm's net revenue resulting from an additional bushel of corn containing $\blacktriangle r_i$ amount of the i<u>th</u> characteristic. Ladd and Martin state that if a grading system is sign-optimal, "the highest MVP for one grade of corn would be less than the lowest MVP for the next better grade of corn."[87] In Knapp's study this did not occur as Sample grade corn (the lowest grade) had a high MVP which exceeded the low MVP of all other grades. This implied that a firm could afford to pay a higher price for sample grade corn than for some parcels of grades 1 through 5. The authors therefore state that the results of the linear programming problems support their contention that a numerical system of grades that is sign-optimal for a number of firms is impossible to develop further. Evidence showing the difficulty of developing a numerical grading system which is sign-optimal was obtained by a survey of corn users in six industries. The results of the survey showed no consensus of the important characteristics between industries, and a substantial amount of variation within industries. The authors suggest that an alternative to

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[85] *Ibid.* p.27.

[86] From the discussion of the general model in the preceding chapter, $\blacktriangle r_i$ is the amount of the i<u>th</u> characteristic in the bushel of corn. The resulting change in the firms net revenue is $\blacktriangle \text{Max}\ \Sigma c_{ix} j = (\Sigma_{i\ \text{Max}}\ \Sigma\ c_i x_j / \blacktriangle r_i) \blacktriangle r_i = \Sigma i\ y_{i \blacktriangle r} i$, and the firm can afford to buy the bushel if $\Sigma\ y_{i \blacktriangle r} i \geq p$, thus this is the maximum price.

[87] *Ibid.* p. 28.

numerical grades would be a specific order method. Thus, instead of characteristics being used to define a grade, the actual value of each of the characteristics would be listed. A firm would be able to purchase the product on the basis of the desired characteristics. The authors suggest that the linear programming model could be used to assist in determining the characteristics to be excluded from a grading system. Characteristics which have a zero (or a very small) shadow price for firms could be excluded as they have no effect on the grade.

4.3.2. Implicit Prices for Cotton Fibre Properties

Jones-Russell and Sporleder[88], used the duality properties of linear programming to analyze the factors affecting cotton prices. Their study had three objectives; a) to derive the minimum cost lay down mix of growths meeting a minimum set of characteristics b) to consider the effect of additional end-product quality requirements, and c) to derive the implicit values of these characteristics for selected yarn counts and alternative spinning technologies. The study used a cost minimizing linear programming model for four different end-products, three spinning technologies, with 46 different growths of cotton from four production areas as inputs. The model was defined as;

$$\text{Min } p_i G_i$$

s.t.

$$Q_i > A_{jk}$$
$$L_i > B_{jk}$$
$$M_i > C_{jk}$$
$$S_i > D_{jk}$$

[88] Jones-Russell, E. and T.L. Sporleder, *Implicit Prices for Cotton Fibre Properties by Spinning Technology and End Use.*, paper presented at the A.A.E.A. Annual Meeting Reno Nevada, 1986. (Mimeograph)

$Gi > 0$ for all i.

where

$P_i =$ December 1984 spot market prices adjusted for prevailing premiums and discounts on grade, length and micronaire.

$G_i =$ growth from region r

$A_{jk} =$ Minimum grade requirement given technology j and yarn count k

$B_{jk} =$ minimum length requirement given technology j and yarn count k

$C_{jk} =$ minimum micronaire requirement given technology j and yarn count k

$D_jk =$ minimum strength requirement given technology j and yarn count k

Three of the four fibre characteristics were factors traditionally used for pricing cotton. The fourth factor, strength, carried no weight in pricing but was thought by the authors to be important in end-use. The authors of this study indicated that the hedonic(multiple regression) work done on cotton has been limited to a single product(or growth) and its price at any one point in time. Consequently, they felt that hedonic pricing was not general enough for their study. Alternatively, they formulated a general L.P. model which could be changed for the different spinning technologies and end products. Following their calculation of the cost minimizing mixes for each end product, technology and location of the input's production, they used the dual of the cost minimizing problem to impute values to the four characteristics with respect to each end product and spinning technology. Using these imputed values they indicate that strength, the characteristic not used in the price formation process, is as least as important as length and grade in determining the demand for cotton at mills using a certain technology.

4.3.3. Barley Protein Study

LaFrance and Watts at Montana State University studied the impact of protein content in feed barley on the costs of feeding livestock using a linear programming approach[89]. They indicate that a premium is paid for higher protein wheat as there is a derived demand for protein for products which require a rising dough. Conversely, in the malting barley market, there is a derived demand for low protein barley and price differentials are based upon the ability of malting barley to germinate. High protein barley is avoided as the malt extracted is lower which causes the beer to be cloudy. They deduce that:

> The demand for feed barley is derived from the demand for feed grains for beef, dairy cattle, and swine. When feeding livestock, greater rates of gain and levels of milk production imply greater protein requirements, which suggest that feed barley with a higher protein level would be more valuable to feeders[90].

The approach used in their study was to analyse the marginal value of additional protein

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[89] Jeffrey T. LaFrance and Myles J. Watts, "The Value of Protein in Feed Barley for Beef, Dairy, and Swine Feeding. *Western Journal of Agricultural Economics* 11(1) 1986 pp. 76-81.

[90] *Ibid.* p. 76.

to livestock feeding using a least-cost feed formulation model[91].

The model was based on von Leibig's "Law of the Minimum," a standard biological axiom "which roughly states that the nutrient in the shortest supply constrains the rate of growth (or other production) of a plant or animal[92]." Their model first defined the law of the minimum as

$$y = \text{minimum}\ [\phi_1(w,b_1),\ \phi_2(w,b_2),\ . . . ,\phi_m(w,b_m)]$$

Where: y denotes the performance goal either weight gain or milk production.

w is the live weight of the animal; and

b_i is the quantity of the i<u>th</u> nutrient consumed per day. $i=1,...,m$.

$\phi_i(w,b_i)$ is a function expressing the relationship between the performance of the animal, animal's weight and amount of i<u>th</u> nutrient consumed[93].

They then formulated a linear programming problem for finding the least-cost feed ration which had the nutrients (b_i, $i = 1, . . ., m$) available to satisfy the performance level as follows:

Minimize $p'x$

subject to $Ax \geq b$,

$x \geq 0$

where: x_j is the quantity of j<u>th</u> foodstuff

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91 The use of a least-cost formulation for determining the marginal value of inputs is of particular interest to this study.The least-cost approach to flour blending is utilized in the research undertaken for this dissertation.

92 *Ibid.* p. 77.

93 *Ibid.*

a_{ij} is the quantity of i<u>th</u> nutrient in a unit of the j<u>th</u> food

p_j is the price of the j<u>th</u> food for i-1,. . .m, j=1, . . n.

"The vector of cost-minimizing feeds is a function of prices, nutrient requirements, and the nutrient content of the feeds, $x^* = f(p,b,a)$ where $a \equiv \text{vec } A \equiv (a_{11}, a_{22}, , \ldots, a_{m1}, a_{12}, \ldots, a_{m2}, a_{1n}, \ldots a_{mn})'$ and denotes matrix transposition. Substituting the choice functions for x into the objective function $c(p,b,a) \equiv p'f(p,b,a)$[94]. They then define two types of prices by identities; (i) defines the price which would make producers indifferent between barleys with different protein levels, and (ii) to define the constant feed cost of barley which they use to estimate the marginal value of the nutrients in barley fed. They then pose two questions:

> First, what is the relationship between the optimal feed cost for beef, dairy, and swine and the protein content of barley at different liveweights, rates of gain, or performance rates? Second, does this relationship vary significantly with the animal's liveweight and/or performance rate? The answer to the first question indicates whether or not there is any demand-related basis for considering protein premiums for feed barley. The answer to the second question indicates what sort of structure such a price function would naturally have.[95]

The results of their analysis showed that the establishment of protein premiums for feed barley would probably be untenable as the cost would exceed the benefits. However, they also found that lower protein barley does have a lower nutritional value than higher protein barley.

Although this study discussed the barley market in Montana, some of the

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[94] *Ibid.*

[95] *Ibid.*, p. 78

principles of linear programming are of interest. In addition, the fact that the researchers found in the case of feed barley the benefits of segregating a product on the basis of one quality factor were outweighed by the cost is also interesting. This later finding is particularly interesting in that it appears to be contrary to the conventional wisdom that segregation does pay.

4.4. Hedonic Pricing Models for Wheat

This section reviews two papers which used hedonic pricing to investigate wheat quality in the world market.

In 1987 Michele Veemam from the University of Alberta published a study of wheat quality using a hedonic pricing model[96]. In her study she used the demand for productive inputs approach of Ladd and Martin discussed in as discussed in Chapter 3. She used both pooled time-series and cross-sectional data in her model which is described as follows:

$$P_{it} = B_0 + B_1Z_{1t} + B_2Z_{2t} + B_3Z_{3t} + B_4Z_{4t} + B_5Z_{5t} + e_{it}$$

where:

P_{it} = the price in U.S. dollars per tonne of the ith type of wheat at time t.

Z_{1t} = the dry weight basis percentage protein content of each of the nine wheat types, so expressed that 1 = 100%

Z_{2t} = colour, with a value of 0 applied to red wheats and 1 to white wheat

[96] Michele M. Veeman, "Hedonic Price Function for Wheat in the World Market: Implication for Canadian Wheat Export Strategy" *Canadian Journal of Agricultural Economics*, Vol 35, Nov. 1987 pp.535-552.

Z_{3t} = the year of observation, t = 1, . . .8;

Z_{4t} = country of origin; Z_{4t} = 1 for U.S. wheat and 0 otherwise

Z_{5t} = country of origin: Z_5 = 1 for Canadian wheat and 0 otherwise

e_{it} = the error term[97]

This model used two different functional forms, a linear form and a partial semilogarithmic form, with continuous variables P_{it} and Z_{it} in logarithmic form. She then utilized two estimation procedures, (i) Ordinary Least Squares for pooled time-series and cross-sectional data, and (ii) a double transformation procedure for estimating heteroscedastic and autoregressive forms of the model.

In her study she used nine different wheat categories five of which were segregated by protein content and four of which were not protein segregated. The protein segregations were, No. 1 CWRS 13.5, No. 1 CWRS 12.5, No. 2 Dark Northern Spring (DNS) at 14% protein, No. 2 Hard Winter (HW) at 13% protein, and Australian Prime Hard (APH) at 14% protein. The four wheat categories unsegregated by protein but identified by the midpoint of their normal protein levels were, No. 2 Hard Winter Ordinary (HWO) at 12.5% protein, No. 2 Soft Red Winter(SRW) at 10% protein, No. 2 Western White (WW) at 9% protein, and Australian Standard White (ASW) at 10 % protein. The price data used were from the International Wheat Council's World Wheat Statistics adjusted for Canadian wheat so as to convert to instore F.O.B. Prices.

She found that Canadian and U.S. wheat was discounted relative to that from Australia. Although she expected this result for U.S. wheat, the implication that

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[97] *Ibid.* p. 542.

Canadian wheats are discounted relative to Australian wheat was surprising. One reason offered was that the prices for Canadian wheat were based on price quotations rather than actual selling prices as the Canadian Wheat Board (C.W.B.) refuses to release actual selling prices for Canadian wheat exports[98]. Since Australia exports white wheat only, her finding that there was a premium for white wheat, may have contributed to the apparent discount for Canadian wheats. It is well known that, except for a very small amount of Soft White Spring wheat and White Winter wheat, Canada produces exclusively red wheats. This fact may have mitigated against Canada in Veeman's research. Another factor which may have affected this result is that "Canada as a country of origin is a long distance from major markets may contribute to this apparent price discount"[99]. This distance[100] may overcome the benefits derived from Canada's grading system such as higher prices due to consistent quality.[101]

Another finding of interest concerned protein premiums. She found that during the middle to late 1970's there was a nominal protein premium of (U.S.) $ 3.34 per tonne for a one percent increase in protein (a 0.32% premium). During the early part

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[98] The problem of obtaining real selling prices for Canadian wheat exports was also encountered during the process of doing the research for this dissertation.

[99] *Ibid.*, p. 547.

[100] To avoid confusion, it should be noted that the distance which is referred to by Veeman is sailing distance by ships rather than rail distance to export port.

[101] Since the prices used in the study are FOB export prices, the hypothesis that the factors associated with country of origin, such as the Canadian grading system and its associated related features including visual distinguishability, have been successful in obtaining higher levels of prices for Canadian wheat in the world market relative to other exporters, is not rigorously tested.

of the 1980's the nominal premium was (U.S.) $6.00 per tonne (a 0.47% premium). She indicates that this finding is particularly interesting in relation to the fact that it was estimated that a one percent increase in protein content cost about a 10 percent reduction in yield. She concludes that this factor may have policy implications for the direction of Canadian wheat breeding which traditionally has avoided higher yielding lower protein varieties in favour of those of higher protein content.[102]

In a study somewhat similar to that of Veeman, W.W. Wilson at North Dakota State University examined the characteristics of differentiation adopted in the world wheat market using hedonic pricing[103]. The main premise for his study was as follows:

> There are two reasons to distinguish among wheats of the same type grown in different counties or areas of the same county. One is that wheats of similar type do not possess identical characteristics. Classification by type may be too general to account for differences in demands for imported wheats. The second reason is that the country of origin is thought to be one basis of differentiation in demand for wheat[104].

He further states:

> Colour, protein level and quality, strength, and hardness are all indigenous characteristics of wheat. Some of these may be unique to each country, and most are a product of environmental conditions and breeding programs. Plant breeding programs differ greatly across regions and result in wide variations in inherited

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[102] The development of lower protein higher yielding varieties would be a boon to producers in those areas which tend to have higher precipitation levels and lower grades of hard red spring wheat. The top grades of CWRS wheat tend to be produced in the lower precipitation areas of the prairies, i.e. the area referred to as the Palliser Triangle.

[103] William W. Wilson, "Differentiation and Implicit Prices in Export Wheat Markets" *Western Journal of Agricultural Economics* Vol. 14(1) July 1989, pp. 67-77.

[104] *Ibid.*, pp. 67-68.

attributes[105].

He further indicates that there is a varying amount of control on the part of public authorities in different countries with respect to the release of varieties. Canada has very rigid control of varietal release whereas in the U.S. varietal success depends on the seed market. The result of varying control is measured in terms of productivity growth and uniformity. He indicates that while the U.S. has achieved growth in productivity, their wheat has often been criticized for lack of uniform performance.[106]

Wilson indicates that there are typically two types of market for wheat, one bread type market which requires higher protein levels and one for softer wheats used for cookies, etc. As protein quality is not easily measured, protein content is used as a proxy for quality. The desire for protein quality has led to use of premiums for higher protein wheat. However, he conditions his remarks with the following statement:

> Premiums for protein are implicitly reflected in export prices depending upon protein level. However, these are not readily observable because most reported export prices are for a particular protein level which varies only across countries. Explicit premiums for protein, however, can be identified at selected U.S. grain exchanges. This data suggests that explicit protein premiums in U.S. cash prices are unstable through time; thus the implicit protein premiums in export prices for hard wheats are potentially unstable as well[107].

He also indicates that there exist differences in grading systems between export countries and this may have an effect on the market. During his study period, wheat exported

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[105] *Ibid.*

[106] Implicit in his arguments but not stated is that while Canada has maintained uniformity, productivity growth has not been as great.

[107] *Ibid.*, p. 68

from Canada (CWRS) had .33 percent non-millable material whereas wheat exported from the U.S. contained between 1.04 and 1.20 percent[108].

Although the formulation of his models will not be described it is interesting to note that unlike Veeman, Wilson included destinations in his model and used the International Wheat Council's wheat price index. The wheat price index was used to account for price variability over time. Included in his model was a variable to indicate whether the wheat was spring or winter seeded and a Hufbauer Index[109] as another measure of differentiation to further test his results.

Wilson's findings were somewhat different than those of Veeman. Although he also found that protein premiums had increased in the 1980's, the relative increase in the premium for CWRS for Canada exceeded that for Dark Northern Spring(DNS) wheat from the U.S. As well he found that Australian Prime Hard (13%) did not appreciate in relative terms compared to either CWRS or DNS"[110]. His Hufbauer index showed that there has been an increase in differentiation in each market during the 1970's and 1980's. He also found that "there is an implied value for spring planted wheats relative to winter, at least at higher protein levels, even while holding other factors constant"[111]. Premiums for hard wheats relative to soft wheats were also found to have

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[108] *Ibid.*

[109] Wilson indicates that the Hufbauer index is a measure of vertical differentiation. The index is defined as $H = \sigma_i/\mu_i$, where σ_i is the standard deviation of price across all goods and μ_i is the mean. If all prices are the same then $H = 0$.

[110] *Ibid.*, p. 72

[111] *Ibid.*, p. 76.

diminished over time. However, he holds the view that the impact of the country of origin is relatively unclear as to importance and wonders about the costs and benefits of a highly regulated system such as that in Canada.

4.5. Summary

A search of the literature and the studies reviewed shows that although there exist viable techniques for analyzing the grading system for CWRS wheat on an economic basis, this has yet to be done. The differences in the results of the two hedonic pricing models discussed may be in part due to the inadequacy of the data for such sophisticated research. The prices which are quoted for CWRS wheat are the C.W.B.'s asking prices and are not the actual selling prices for different grades. This must have influenced the results of these studies.

It appears from the studies cited that linear programming can provide the means to evaluate both product quality and grades. The GRL study shows that the Canadian grading system for CWRS does maintain consistency, but says nothing about the economics of the grades. In addition, the study shows that good data are available concerning quality characteristics. Given the availability of data and adoption of the linear programming technique, it would appear that objective research on the economics of wheat grading can be undertaken.

CHAPTER 5. METHOD OF ANALYSIS

The perception that wheat is a homogenous product is patently inaccurate. Wheat quality varies substantially within and between classes. Each particular class of wheat is essentially targeted towards specific end-use target markets. For example amber durum wheat is targeted toward the pasta market, soft white wheat toward the (baking) confectionery market and hard red spring wheat is for the pan-bread market. Despite this targeting of wheat classes towards specific markets there is nevertheless some substitutability between wheat of different classes and countries of origin in the production of the various products. In addition, wheat from various countries of origin may have differing quality characteristics from competitor wheats, but be targeted toward similar markets. End-users, therefore, may choose between various grades, classes and countries of origin in order to accommodate their wheat requirements for a specific end-use.

If a grading system is accomplishing its goals, then wheat targeted for a particular market should generally be used in that market. The development of a method for testing whether or not the Canadian grading system for CWRS wheat accomplishes this goal is the purpose of this chapter. The next section of the chapter identifies the end-user, and is followed in Section 3 by an explanation of the selection and operation of the software chosen. Section 4 of the chapter is devoted to a discussion of the data and its manipulation in the conduct of the research. Section 5 contains a discussion of the various quality factors used in the least cost flour blending linear programming model and the relationship of these quality factors to the form of flour produced. The final section of the chapter outlines the procedures used to determine the end-use value of CWRS wheat with a short summary of the research method also being provided.

5.1. The Representative End-User

The marketing channel for wheat between the producer and consumer is protracted and complex, there being numerous private and public organizations which impact upon it. The consumer at one end of the marketing channel is quite insulated from the producer as a result of these intervening organizations. Producers, therefore, receive little if any direct feed back from the consumers concerning their preferences for wheat quality. This situation is exacerbated by the fact that most wheat is consumed in a form bearing little if any resemblance to the original product. The consumer has no concept of a kernel of wheat when eating a glazed donut or slice of enriched white bread. The length of the marketing channel and the processed form in which most wheat is consumed complicates analysis of wheat demand. Relating the ultimate end-users' (i.e. the consumers') desires for wheat quality back through the grading system to producers would be difficult if not impossible.

The flour mill is the first entity where wheat processing occurs, the form of the wheat being changed so that the kernels are no longer recognizable[112]. The miller purchases wheat in order to produce flour that is acceptable to his customers whether they be commercial or home bakeries. Customers desire flour that will fulfil certain baking requirements and it is therefore incumbent upon the miller to satisfy these

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[112] Cleaning and drying of grain at elevators may be considered to be a type of processing. However, these operations do not change the physical characteristics of the grain, i.e. cleaned and dried wheat is still recognizable as wheat.

requirements to retain customers.

In addition to fulfilling customer requirements with respect to quality, the miller must also ensure that the cost of the product is reasonable when compared to competitors' prices. Thus the miller's goal is to produce an acceptable flour at the least possible cost in order to ensure continued business success. Millers, therefore, select wheat which when blended yields the least cost flour which meets the customer's requirements.

Bakers in different countries tend to have different flour requirements for the end-use products they produce in view of local consumer tastes and preferences. Differences in consumers' tastes and preferences may even vary between regions within a country.[113] Millers in the various importing countries would need to produce flours which conform to the diversity of local tastes. The specific quality characteristics of one type of wheat, however, are not restrictive. As a rule, millers can blend different grades and classes to obtain the correct quality characteristics required to produce flour suitable for specific baking purposes. In addition, bakers can and do modify their baking processes in order to compensate for the quality of flour available.

Wheat grades contain specific ranges of quality factors and either minimum or maximum tolerances for individual characteristics are identified. Likewise flours for specific end-uses also have specified ranges for certain quality characteristics. In the

[113] An example of tastes differing between regions of a country can be found in the brewing industry in Canada. It is well known that in Canada consumers of brewed beverages in Eastern Canada prefer the heavier ales while Western Canadian tipplers prefer the lighter lager beers.

analysis, a hypothetical representative mill will be used for analyzing wheat for preparation of flour. The goal of the representative mill is to produce the least-cost flour suitable for the end-use product. The specifications required in flour according to the different end-use products will be discussed later in the chapter.

5.2. The Soft-Ware Package and its Operation

Linear programming (L.P.) will be used to determine the value of particular characteristics in the production of a number of end products. Although there exist a multitude of computer soft-ware packages which are capable of performing nonspecific linear programming operations, the package chosen for the research was the Brill Flour Formulation, Flour Blending package(BFFP). The BFFP was developed jointly by the Canadian International Grains Institute and the Brill Corporation of Norcross, Georgia. The BFFP is based on the Brill Feed Formulation Program which uses linear programming to determine least-cost rations for livestock.

The package, although in the pre-commercial development stage and having several problems, was chosen over more conventional L.P. packages for several reasons. First, many of the technical factors in flour production which require specialized knowledge were already embedded in the package. Second, the package contains a spreadsheet which is used for determining the real cost of wheat when used for the production of various flour mixes[114]. The calculated cost of wheat can also be transferred directly to other parts of the package. This removes the manual work of

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[114] This point is expanded upon later in this Chapter.

entering different prices several times as would be the case using a separate spread sheet package and an L.P. package. The integration of the spreadsheet with the rest of the package is probably the major advantage of this soft-ware. Third, the package is able to run several flour formulations at the same time thereby speeding up the process of evaluating the different wheat grades. Lastly, expert knowledge with respect to the operation of the package was available locally from the flour milling specialist who contributed to the package's formulation.

5.3. The Logic and Operation of the Spreadsheet

The spreadsheet permits the true cost of the flour extracted from the wheat to be determined. Data concerning both wheat and flour characteristics are requested from the user. Information pertaining to wheat includes type of wheat, price, amount of foreign material, ash content, original moisture and extraction rate. To estimate the cost of the flour thus produced from the given wheat, information is required concerning desired ash content, ash correction factor, first break moisture (IBK), milling loss and the price of millfeed. The spreadsheet portion of the package is depicted in Figure 5.1.

The milling process, particularly those aspects which affect the cost of producing flour, will be briefly described to simplify the review of the procedure used to calculate the true cost of extracting flour.

5.3.1. Milling Process

When millers purchase wheat from a grain company or a central selling agency, they pay on the basis of the wheat being of a certain grade which implies specific

Figure 5.1. Brill Feed Formulation Program Spreadsheet

UNIV. OF MANITOBA Formulation Spreadsheet TE

		1	2	3	4	5	6
1	G	Wheat I.D.	Number	9144	9147	9113	9114
2	G	Wheat	Date	06-14-1989	06-14-1989	06-14-1989	06-14-1989
3	G	Wheat	Type	2CWRS 13.5	3 CWRS	1CWRS 12.5	2CWRS 13.5
4	G	Wheat	Cost	249.16	239.13	252.33	251.5
5	G	% Foreign	Material	.75	1.25	.4	.4
6	G	% Initial	Moisture	13.1	13.7	12.9	13.2
7	G	% IBK	Moisture	16	16	16	16
8	G	% Flour	Extraction	74.9	73.4	75.2	74.4
9	G	% Ash in	Flour	.46	.48	.46	.46
10	G	% Std Ash	Required	0.5	0.5	0.5	0.5
11	G	Ash Correc	Factors	.48	.5	.38	.48
12	G	% Ash Corr	Extraction	75.1	77.08	76.71999	76.32
13	G	Raw Wheat	(Kgs.)	1000	1000	1000	1000
14	G	Less For.	Material	12.5	4	4	4
15	G	Clean Untm	Wheat	987.5	996	996	996
16	G	Water Add	to Wheat	29.38988	37.94286	36.75715	33.2
17	G	Total clea	tmp wheat	1016.89	1033.943	1032.757	1029.2
18	G	Flour	Produced	763.6844	796.9633	792.3311	785.4854
19	G	% Milling	Loss	1.75	1.75	1.75	1.75
20	G	Quantity	Mill loss	17.79558	18.094	18.07325	18.011
21	G	Net	Millfeed	235.41	218.8857	222.3525	225.7036
22	G	Plus For.	Material	12.5	4	4	4
23	G	Gross	Millfeed	247.91	222.8857	226.3525	229.7036
24	G	Market val	/tonne	80.00	80.00	80.00	80.00
25	G	Value of	Millfeed	19.8328	17.83086	18.1082	18.37629
26	G	Flour $/MT	wheat gr	216.1372	237.8391	234.2218	233.1237
27	G						
28	G						
29	G	Cost of	Flour				
30	G	per	tonne	283.019	298.4317	295.611	296.7893
31	G						
32	G						

characteristics. However, the price which millers pay for the wheat is not the actual cost of the usable wheat. Wheat purchased from grain companies or other organizations may have varying moisture content, or may exhibit other characteristics which alter the net cost of the wheat to be milled or contain non-millable material.

Wheat consists of essentially three separate components, the endosperm which is the starchy material which makes up about 85 percent of the kernel, the seed coat or bran which makes up about 13 percent of the kernel, and the embryo or germ which accounts for about 2 percent of the kernel[115]. The milling process involves a series of operations whereby the endosperm is progressively removed from the wheat bran and germ in order to produce flour.

At the onset and during the milling process, water is added to the wheat to "temper" it. This is done as water adds to the weight of the flour produced. Another and perhaps more important reason for tempering is that adding water to the wheat facilitates the milling process. Water toughens the bran which makes it easier to separate from the endosperm during the milling process. Tempering also mellows the endosperm facilitating its reduction to flour. Thirdly, by tempering wheat prior to milling, the miller compensates for the moisture lost during the milling process. Mills are kept very dry resulting in the evaporation of water during the milling process. Tempering provides a means for the miller to compensate *ex ante* for this loss.

Each stage of the milling process results in a flour stream. These flour streams

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[115] Canadian International Grains Institute, *Grains & Oilseeds: Handling, Marketing, Processing*, 3rd ed. Winnipeg: C.I.G.I. 1982 , p. 559

are blended together to produce different classes of flour, e.g. patent. The output is analyzed to determine the proportion of flour which is obtained from each flour stream and the amount of ash present in the flour from each stream. Flour production and total ash on a cumulative basis can be plotted on a graph to indicate the relationship between the volume of flour produced (extraction rate) and the ash content. This plotted relationship is called an "Ash Curve". As the extraction rate increases, so does the amount of ash contained in the flour. The ash curve of most wheats is generally increasingly curvilinear, with the slope of the curve increasing rapidly as the extraction rate approaches 100 percent.

Over small incremental changes in the extraction rate, the ash-extraction relationship is thought to be linear, or at least a very close approximation to linear. This linear relationship is the basis for the ash correction factor, which is the percentage change in flour extraction for each percentage change in ash content.

The data published by the GRL in the *Quarterly Cargo Bulletins*, includes the flour extraction rate and ash content for the various grades of CWRS wheat. This flour extraction rate is determined from wheat samples milled by the GRL. However, the allowable or desired ash content in flours designated for specific end-use products did not always correspond to the ash content determined by the GRL in their milled wheat samples. Using ash correction factors incorporated in the spreadsheet, the extraction rate of different grades or classes of wheat is calculated so all flour milled for a specific end-use product will have an identical ash content. The costs of the flour streams are then adjusted in the spreadsheet to reflect differences in extraction rates. These costs are subsequently used in the linear programming package to determine the least cost formualations of different flour blends. As various wheats differ in ash content, and flours also differ in ash content depending on eventual use, these factors were frequently adjusted in the spreadsheet to determine their impact on the cost of flour.

One other factor believed to be important in the determination of the cost of flour was the price of millfeed. Millfeed is material not usable in flour, the major proportion being fed to livestock. This material includes the byproducts of milling such as bran and shorts. Although the price of millfeed was held constant at $80.00 per tonne throughout most of the computer runs, several runs were carried out using different millfeed prices in order to determine if the price of millfeed caused any change in the composition of the flour used for pan breads.

5.3.2. Spreadsheet Calculation

The following points outline the procedure followed in the spreadsheet to estimate the cost of producing flour.

1. The amount of foreign material is subtracted from the wheat which is purchased. e.g. if foreign material was .5 percent and 1000 tonnes of wheat were purchased, the actual amount of wheat the mill paid for is 995 tonnes.

2. Wheat is generally milled at some standard moisture content, so water is added to the wheat to bring it up to this standard. As water is a relatively free good, the drier the wheat received at the mill, the greater the gain for the miller. The addition of water up to the desired moisture content results in a total weight of clean tempered wheat. For example, say 995 tonnes of wheat contained 12

percent moisture. The miller would increase the moisture content to 16 percent (1BK), raising the total tonnage to 1034.8 tonnes of clean tempered wheat.

3. During the milling process moisture is lost through evaporation. This milling loss is deducted from the clean tempered wheat so the net flour yield and amount of millfeed can be determined. For example, if the milling loss is 1.75 percent then the miller would have approximately 1017 tonnes of wheat (1034.8 X .9825).

4. The flour extraction rate is multiplied by the amount of clean tempered wheat to determine the flour yield. However, the required or allowable ash content of the flour to be produced, relative to the ash content in the wheat, has a direct impact upon the flour extraction rate. The extraction rate for the flour is determined by an ash correction factor. For example, given an extraction rate of 75 percent, then the wheat would yield 1017 tonnes X .75 = 762.75 tonnes of flour. (But if the wheat ash content were .46 and the desired ash content was .48, assuming an ash correction factor of .3 an extraction rate of .756 could be used yielding 768.85 tonnes of flour.)

5. Millfeed is the material not usable in flour, the major proportion being used as livestock feed. The value of the millfeed is determined and deducted from the cost of the wheat as this amount is returned to the miller. Continuing with the above example, the miller would have 762.75 tonnes of flour and 264.24 tonnes of millfeed. Assuming the millfeed is worth $80.00/tonne, the miller would receive $21,140 or $21.40 per tonne of wheat purchased.

6. The cost of flour per tonne of wheat milled and the cost of the flour is then

determined. It is this cost of wheat flour from the different grades and protein segregations which is used in the least-cost flour blend formulation. For example, if the wheat cost \$200/tonne to purchase, the cost of the flour per tonne of wheat milled might be \$178.86 but the cost per tonne of flour would be: (\$200/tonne -\$21.14/tonne millfeed) / 762.75 kg flour = \$234.39/tonne flour.

5.4. Linear Programming Model and Limitations

The general format of the BFFP linear programming model is as follows:

1) $\text{Min } Z = \Sigma\, c_i x_{ij}$

subject to quality constraints

2) where i=different flours, j = 1 or 2 and is the end use product of the intended flour.

The least cost flour blends (x_i), produced from CWRS and competitive wheats of other countries, were determined for various products (j) for each quarter crop year from the first quarter of 1980/81 to the second quarter of 1986/87, for a total of 26 quarters[116]. Each analysis was done for both Atlantic and Pacific cargoes, totalling a minimum of 52 runs for each product. For the crop years 1981/82 through to the second quarter of crop year 1986/87, the flour blends were rerun with the Australian wheats. The data available for U.S. DNS wheat limited the analysis to 10 quarters from crop year 1984/85 to 1986/87.

Each modification to the quality constraints required an additional 52 runs for

[116] One computer run was required for each product, hence 26 runs were required to determine the least cost blend for one product over the 26 quarters, at one port for each level of constraint specified.

each change. For example, in an attempt to determine more accurately the imputed price of protein, Canadian pan breads were analyzed at varying protein contents. Availability of grades and protein segregations were also restricted necessitating further computer runs. For example, the least cost flour formulation for a large Canadian bakery producing pan bread requiring 12.0 to 12.5 percent protein, could be determined using No.1 CWRS wheat alone. Alternatively, the same flour formulation could be run allowing free choice of both No.1 and No.2 CWRS wheat, followed by a third analysis including No. 3 CWRS wheat. Flour formulations were also determined using CWRS and U.S. DNS wheats, CWRS with Australian wheats, and CWRS with both U.S. DNS and Australian wheats. Overall, varying the ports, the classes, grades and segregations of wheat, flour ash contents, protein content, and end-use products in the study required over 2500 computer runs.

One of the limitations of using linear programming is that the relationships between the objective function parameters and the constraints are assumed to be linear. The choice of quality constraints to use in the L.P. least-costing approach are therefore somewhat limited due to the requirement of linear relationships[117]. The GRL performs as many as 30 different wheat quality tests on the cargo samples received from the export locations. The results of the tests and those conducted by agencies outside Canada are

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[117] The possibility of attempting to modify the package to accommodate non-linear constraints was briefly considered and dismissed as the thrust of the research was not to develop a flour blending package. Incorporation of non-linear constraints is the package would have required a complete rebuilding of the program. In addition, discussions with Mr. Sarkar, the Milling Technologist at C.I.G.I., indicated that the characteristics which exhibited non-linear relationships may respond very differently in flour blends.

utilized in this study and presented in Table 5.1. However, many of these quality tests do not represent linear relationships. For example there are four tests carried out using the alveogram, but only one, the alveogram W is linear. Nevertheless there are several measurements of quality factors which have linear relationships normally, or can be linearized using some conversion technique or which can be assumed to have linear relationships over the specific ranges of the analysis.

Two of the quality tests, falling number and amylograph peak viscosity, have non-linear relationships. The falling number test is described by C.I.G.I. as follows:

> "**Falling number (Hagberg test)** A rapid screening test for soundness (freedom from sprouting) of grain. Ground whole wheat is mixed with water in a test tube and immersed in boiling water. After 60 seconds of mixing, a plunger is allowed to fall a measured distance through the slurry. The falling time plus the mixing time (measured in seconds) is the Falling Number. The higher the Falling Number, the sounder the wheat. Sometimes called the Hagberg test after the man who developed the test."[118]

The other test, the Amylograph Peak Viscosity, is described by Mailhot and Patton:

> "The amylograph can be used to measure viscosity. A standard quantity of flour solids is placed in a buffered water suspension, and the viscosity of this uniform suspension is measured and charted throughout a standardized heating cycle. The amylograph value indicates the rate and extent to which the viscosity of the suspension changes during the controlled cycle. Swelling and gelatinization of the starch thicken the suspension and thus raise its viscosity. Under the test conditions, as temperature is increased, the activity of thermostable starch-liquefying enzymes increases and part of the total starch is hydrolyzed, thus reducing viscosity. The recorded maximum or peak measurement can be used to

[118] Canadian International Grains Institute, *Grains & Oilseeds: Handling, Marketing, Processing*, 3rd ed. Winnipeg: C.I.G.I. 1982, p. 954.

Table 5.1. A Comparison Of Wheat Quality Tests Used By Three Countries

TEST TYPE	COUNTRIES USING	USED IN STUDY
Wheat Tests		
Test Weight Kg/Hl.	A, C, U,	
lb/bu.	U	
Thousand Kernel Weight,g	A, C, U,	**
Alpha-Amylase Activity(units/g)[119]	C, U,	
Protein Content[120]	A, C, U,	
Falling Number	A, C, U,	**
Flour Yield[121]	A, C, U,	**
Ash %	A, C, U,	
Grain Hardness (PSI)	A	
Screening %		
Foreign Material[122]	A, C	
Total Screenings[123]	A, C, U,	**
Flour Tests		
Protein %	A, C, U,	**
Wet Gluten %	A, C, U,	**

[119] The N.D.S.U Laboratory uses a similar test called the Grain Amylase Analyzer which is somewhat different than the test used by the GRL. However, as these tests were not used in the analysis, the differences, for the purposes of the study are not important.

[120] N.D.S.U. does two protein tests on wheat, one at 14 % moisture basis and one on an "as is basis".

[121] The N.D.S.U. publication lists this test as Flour Extraction in their flour tests section.

[122] The GRL does not report screenings or dockage as export shipments are assumed to have foreign material close to the maximum tolerances for each grade.

[123] N.D.S.U. calls this dockage.

TABLE 5.1 (Continued)

TEST TYPE	COUNTRIES USING	USED IN STUDY
Ash Content %	A, C, U,	**
Colour Units	A, C,	
Starch Damage (Farrand Units)	C,	*
Alpha-Amylase Activity (units/g)	C,	
Amylograph Peak Viscosity (B.U.)[124]	C, U	*
Maltose Value(g/100g)[125]	A, C,	
Baking Absorption	C,	
F.Y. 5 minute points	A,	
Yellow Pigment	A,	
Bread Tests		
Loaf Volume[126]	A, C,	
Appearance	C,	
Crumb Colour	C,	
Blend Loaf Volume	C,	
Loaf %	A,	
Absorption	U,	
Dough Handling Characteristics	U,	
Farinogram		
Absorption %	C,	
Development Time(minutes)[127]	A, C, U,	
Stability	A,	
Mixing Tolerance	U,	

[124] N.D.S.U. uses both a 65 gram and 100 gram sample, where as the GRL uses just the 65 gram sample.

[125] A.W.B. reports a similar test called Diastatic Activity which is measured in mg.

[126] The A.W.B. uses two "baking tests" rather than bread tests, one of their baking tests is loaf volume.

[127] N.D.S.U. calls this test Peak Time. However the description of the test is the same as that described by the GRL.

Table 5.1 (continued)

Mixing or Mechanical Tolerance Index	U,	
Farinograph Classification	U,	
Extensigram[128]		
Length, cm.	C,	
Height at 5 cm.	C,	
Maximum Height	C, A	
Area, $cm.^2$	A, C,	
Extensibility	A,	
Alveogram		
Length, mm.	C,	
P(height x 1.1)	C,	
Area, $cm.^2$	C,	
W x 100^3 ergs	C,	*
Moisture Content[129]	C, U,	**[130]

* Indicates test used for evaluating CWRS wheats only
** Indicates test used for evaluating all three wheats.
C = Canada, U = United States, A = Australia

SOURCES: Australian Wheat Board, Crop Report Australian Wheat, Melborne: A.W.B.: Canadian Grain Commission, Grain Research Laboratory, Quality of Canadian Grain Exports, Red Spring Wheat Quarterly Bulletin, Winnipeg: GRL.: North Dakota State University , Department of Cereal Science and Food Technology, Cargo Sampling Project; Duluth/Superior Exports, Quality Report, N.D.S.U.

[128] There exist some differences in the use of this instrument between Canada and Australia.

[129] The GRL reports moisture content as a weighted mean as well as several measures of distribution including the unweighted mean, the standard deviation, and the maximum and minimum moisture contents in the sample. For the purposes of this study, the weighted mean of the moisture content in the sample was used.

[130] The A.W.B. does not report moisture content. However, since wheat delivered to the A.W.B. must be below a specified moisture content, a constant moisture of 11 % was used in the study.

estimate enzyme activity as a means of determining the quantity of enzyme that might be added to the flour. The enzyme tested is predominantly alpha-amylase."[131]

However, these quality tests can be linearized through a simple conversion. The linear form of a falling number is called the liquefaction number. Liquefaction number is defined as being equal to 6000/(falling number - 50). This is an important conversion, especially in the case of bread wheat such as CWRS, as the falling number is also an indicator of alpha-amylase activity. Alpha-amylase is an enzyme which occurs naturally in wheat. The amount in the kernel increases as germination proceeds, and converts starch to sugar. Excess alpha-amylase results in sticky doughs having poor rising characteristics. A high falling number indicates low alpha-amylase activity in the wheat. Since the liquefaction number is largely the inverse of the falling number, flours having low liquefaction numbers are desirable for pan-bread productions.

Amylograph Peak Viscosity, which like the falling number also measures alpha-amylase activity, is linearized by the formula 1/(Amylograph P.V.). This formula produces values in the order of 10^{-3} to 10^{-5} which are awkward to use in the program. The values of modified amylograph peak viscosity used in the least cost flour formulation were therefore multiplied by 10^4 in order to provide more convenient numbers for use in the program. As all values were multiplied by the same factor the integrity of the magnitude of the differences between different wheats was maintained.

[131] William C. Mailhot and James C. Patton, "Criteria of Flour Quality"in *Wheat Chemistry and Technology Volume II*, 3rd. edition. Y. Pomerantz, ed. St. Paul: American Association of Cereal Chemists. 1988. p.73.

The other quality factors used in the L.P. are assumed to have linear relationships. There are several quality tests which were omitted from the study due to non-linearity and the absence of methods to linearize the results. Omitted quality factors included the Farinograph and Extensigram tests, and three of the four Alveograph tests. However, none of these tests are common in Canada, Australia and the United States to, the three countries whose wheats are analyzed. The quality tests used cover the major quality factors important in milling wheats suitable for several purposes.[132]

Two quality factors, moisture and ash content which were predetermined from the spread sheet, are held constant throughout the analysis. Ash content was varied for different sets of flours and analyses, but was held constant during each run of the model for specific flours. For example, a set of analyses may have been done holding the ash content at 0.48 percent and then redone at a constant ash of 0.50 percent. Moisture content was held at 14.25 percent. The other quality factors considered are described below.

It is interesting to note that relationships which are linear when two flours are blended, may not be linear when two wheats are blended and milled to produce flour.[133] The reason for this is in the milling process. Millers make adjustments in

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[132] Extensive conversations were carried out with Mr. Sarkar and other millers at C.I.G.I. with respect to the non-linear quality constraints. As the major technical developer of the package Mr. Sarkar was satisfied that millers would receive a true indication of the least cost flour. In addition, he expressed doubt that the nonlinear constraints could be modeled into the least cost program.

[133] Ashok Sarkar,"Optimising Wheat Mixes For End-Use"

the milling process based on the laboratory results to extract the most economic value from the wheat. If two wheats are blended and then milled, adjustments to the milling process are limited and therefore the characteristics relationships may not be linear. Sarkar indicates that the results from blending flour are more precise than those obtained from blending wheat. Therefore, in this research, the cost of the flour obtained from individual wheats is determined before flour is blended.

5.5. The Quality Constraints Used in the Analysis

The following section identifies and explains the following constraints incorportated in the model to determine the least cost flour blends necessary for producting the end-use products identified. The effect of the constraints are discussed later in the paper.

5.5.1. Wet Gluten

Gluten is not one compound, rather it is a complex "composed of two main groups of proteins: gliadin (a prolamin) and glutenin (a glutelin)[134]. The complex of gluten proteins are essentially the wheat storage proteins and are thought to be the unique characteristic of wheat which causes breads to rise.

> Gluten is responsible for the superiority of wheat over the other cereals for the manufacture of leavened products, since it makes possible the formation of a dough that retains the carbon dioxide produced by yeast or chemical leavening agents.[135]

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[134] R. Carl Hoseney, *Principles of Cereal Science and Technology*, St. Paul, Minnesota: American Association of Cereal Chemists, Inc. 1986. p. 77

[135] Y. Pomeranz, *Modern Cereal Science and Technology*, New York: VCH Publishers Inc., 1987, p. 42.

Pomeranz, indicates that "many European cereal chemists determine gluten content as an estimate of protein content."[136] As Canada at one time exported much of its CWRS wheat to Europe this may be one reason why the GRL carries out this test. The formula for the Wet Gluten test is:

$$\% \text{ wet gluten} = (\% \text{ protein} - a)/b$$

$$\text{with } a = 7.34 \text{ and } b = 0.227.$$[137]

He continues his discussion of the wet gluten test stating:

> Gluten determinations offer several advantages over the conventional Kjeldahl-protein test. The physical properties of the cohesive gluten ball can be tested by an experienced operator. Large differences in protein quality of various varieties or advanced stages of deterioration in storage, which cannot be detected by Kjeldahl test, are brought out by the simple test of washing out a gluten ball.[138]

Pomeranz also explains why the test is infrequently used in the U.S.

> (1) it is not precise: attempts to standardize the test by using salt solutions and a mechanical gluten washer have reduced the error somewhat. (2) Gluten can be washed easily from flour but not from wheat; consequently, it is of limited value in plant breeding programs. (3) The test is not suited for large scale routine determinations.[139]

The wet gluten content of flour is normally thought to have a linear relationship with protein content, so despite the above criticisms, for the purposes of this study it was assumed to be linear over the small range evidenced particularly for Canadian wheat.

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[136] *Ibid.*, p. 94.

[137] *Ibid.*

[138] *Ibid.*

[139] *Ibid.*

In addition, wet gluten was one of the quality factors which was reported for both U.S. and Australian wheats. Consequently, it was decided to include wet gluten as a constraint in order to maintain some consistency between wheats for all three countries.

Wheat quality testing in Australia and the U.S. is much less intensive, in terms of the number of quality tests performed, and less extensive, when compared with that conducted by the GRL, and the number of samples and study periods involved. Therefore, data from the few common quality tests available were utilized even though some may involve only pseudo-linear relationships.

5.5.2. Protein

Protein is probably the most important wheat quality factor in bread making. It must be noted that with respect to protein quality there are actually two aspects which could be analyzed; bread making quality and nutritional value. Although the nutritive value of bread is an important issue, this study will concentrate on the bread making property of wheat as the breads used in the study are fairly nutritious. In addition to the two value aspects for wheat protein, there is also the issue of protein quantity and quality. Wilson's study, reviewed in Chapter 3, indicated that it is very difficult to measure quality. Therefore, protein quantity is often used as a proxy. However, tests are available to determine the quality of protein in wheat samples but many of these tests are time consuming and therefore cannot be carried out at elevators or terminals sufficiently rapidly to permit segregation on delivery of wheat according to protein quality. The ultimate protein quality test with respect to bread making is the loaf volume test which consists of actually baking standard sized samples of flour in order to determine the volumes of the resulting loaves.

The protein present in a sample of wheat is a result of two factors; (1) the genetic or hereditary traits bred into varieties of wheat by the plant breeders, and (2) the environmental conditions under which the sample was produced. In Canada, the genetic factors are strictly controlled by the varietal licensing system and new CWRS varieties must be at least "equal to Neepawa" to be released.[140] The maintenance of high varietal standards is important given the fact that there is a linear relationship between protein content and loaf volume within a single wheat variety. Pomeranz expands upon this by stating.

> When bread is baked from flours milled from wheat varieties grown under widely different climatic and soil conditions, protein is the major factor to account for variation within a single variety..... Because the protein content - loaf volume relation is linear within a single variety, the bread-making quality of a new wheat can be easily determined.[141]

CWRS wheats, as a result of stringent licensing requirements, exhibits similar quality characteristics with respect to bread making.

The grading system, if it is consistent, should permit the protein quantity to reflect the quality of the protein contained in the wheat. The relationship between the protein in the parcel of wheat and the protein in the flour produced from the parcel of wheat is for the most part a linear relationship. However, Sarkar cautions;

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[140] Much of Canada's reputation for quality was based on the "equal to Marquis" requirement which was changed to "equal to Neepawa" in 1987. For half a century Marquis was the standard by which new CWRS varieties were measured.

[141] Y. Pomeranz, *Modern Cereal Science and Technology*, New York: VCH Publishers Inc., 1987, p.165.

> Differential protein losses must also taken into account when calculating flour protein of a grist. For example, protein losses are higher in soft wheat than in hard wheat flours. Consequently, the protein content of flour from a grist containing hard and soft wheat will be lower than the one that is calculated for the same mix using hard wheat flour protein loss figures. Even though protein content itself is linear, differential protein losses, must be taken into account to prevent erroneous results.[142]

However, as this study involves hard wheats exclusively, it is assumed that there will be no differential protein loss between the wheats used for the grists. Hence, the relationship between the protein levels in the wheats selected for a grist and the protein levels in the ensuing flour is assumed to be linear over the flour protein ranges considered in this study.

5.5.3. Starch Damage

Starch is the major component of bread flour contributing between 75-80 percent of the dry matter material in the flour. Prior to milling the starch granules are birefringent, meaning that they are well ordered, but not crystalline. Undamaged starch granules are generally quite insoluble in water and are not very susceptible to enzyme activity. During the milling process some of the starch granules are damaged due to the crushing, shearing and scraping actions in the mill designed to remove the endosperm of the wheat kernel from the bran. Milling as indicated by Hoseney can cause two types of starch damage.

> There are also different types of starch damage. A starch granule can be broken in two,... Although the granule is clearly damaged, this type of damage results in starch that is still birefringent, not

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142 *Ibid.*, p.20

> soluble in water, and not susceptible to enzymes. The more classic starch damage produced during milling results in granules that have lost birefringence,..., and are susceptible to fungal alpha-amylase.[143]

It is the susceptibility to enzyme activity that is important in breadmaking. E.J. Bass states:

> Damaged starch is an important flour specification because it affects water absorption and gas production in fermenting doughs. Consequently, the miller must understand the factors affecting the generation of the damaged starch, particularly if the mill's grist consists of wheats of different hardness levels..... Damaged starch is directly related to wheat hardness. Thus the harder the wheat, the higher the starch damage. A moisture level below the optimum for milling will generate a higher than normal damaged starch level.[144]

Although Bass indicates that starch damage is an important quality characteristic, Hoseney takes the opposite view in the following statement:

> People often state that damaged starch is necessary in bread making; however, why this would be true is unclear. Perhaps in formulas containing little or no added sugar, damaged starch would be helpful; however, bread formulas in the United States practically always have sufficient sugar added so that the level of damaged starch is not important from the standpoint of gassing power. Damaged starch increases the water absorption of dough. It also produces weak side walls and a sticky crumb if sufficient enzymes are available.[145]

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[143] R. Carl Hoseney, *Principles of Cereal Science and Technology*, St. Paul, Minnesota: American Association of Cereal Chemists, Inc. 1986. p. 147

[144] E.J. Bass, "Wheat Flour Milling" in *Wheat Chemistry and Technology Volume II*, 3rd. edition. Y. Pomeranz, ed. St. Paul: American Association of Cereal Chemists. 1988. p.42.

[145] R. Carl Hoseney, *Principles of Cereal Science and Technology*, St. Paul, Minnesota: American Association of Cereal Chemists, Inc. 1986.p. 147

It should be pointed out that Hoseney in his statement was referring to breads in the U.S. Conditions in other countries could differ substantially from those in the U.S. thereby contradicting Hoseney's view. In addition, there is the relationship between starch damage and amylase activity to consider.

> There are at least three areas where damaged starch and amylases are particularly important;
> -the determination of baking absorption
> -the production of fermentable carbohydrates for gas production in the dough, throughout fermentation, proofing and the early stage of baking.
> -the control of the level of dextrin production by enzymic degradation of starch during baking. Starch damage and amylase activity are extremely important in determining the baking absorption of a flour. Normally, undamaged starch granules are relatively insoluble and absorb only half of their own weight of cold water. Damaged granules, on the other hand, absorb considerably more water (two times their own weight).[146]

It is not just a minimum of starch damage which is important for baking quality as is noted in the following statement:

> If damaged starch is increased above a certain maximum value, bread quality suffers. The higher the protein content, the higher damaged starch may be raised without serious bread quality deterioration. However, starch damage cannot be increased indefinitely for at least two reasons. First as the water-starch mass is increased a result of increased damage, the air-dough interface becomes unstable during the oven stage and this results in loss of volume and coarsening of crumb. Second, if starch damage level is too high, there will be insufficient gluten to cover the surface area of the starch, resulting in a loss of gas retention capacity and consequently a reduction in loaf volume and a deterioration of crumb grain.[147]

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[146] Canadian International Grains Institute, *Grains & Oilseeds: Handling, Marketing, Processing*, 3rd ed. Winnipeg: C.I.G.I. 1982, p. 613.

[147] *Ibid.*, p. 614

In regards to the linearity of starch damage used as a constraint in the BFFP, Sarkar states:

> "For example, a wheat flour A has starch damage of 4% and wheat flour B has 8%. When these two flours are blended flour would be 6%. However, if the two wheats are blended in equal proportions and then milled, the flour thus produced may not have 6% starch damage. Similarly, water absorption is not linear when wheats are mixed because it is dependent on both protein and starch damage. However, water absorption is fairly linear on flour blends."[148]

5.5.4. Amylase Activity (Falling Number and Amylograph Peak Viscosity)

Wheat may be downgraded on the basis of the number of sprouted kernels in the sample. The use of sprouted kernels is essentially a proxy for the level of alpha amylase activity present. The amylases (alpha and beta) are enzymes which break down the large starch molecules in flour doughs into dextrins and fermentable sugars[149]. This breakdown of the starch molecules is a necessary part of bread making. However, the amount of these enzymes present in the flour is critical to the baker.

> "Because alpha-amylase may be added to wheat flour to achieve any desired level of enzyme activity, the response of this additive is an important criterion of flour quality. This response can be carefully controlled by careful grinding to maintain a desirable uniform level of damaged starch to serve as the substrate for amylase action. The optimum level of enzyme activity is ultimately governed by the end use of the flour and the type of processing

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[148] Ashok Sarkar, "Optimising Wheat Mixes for End Use",

[149] A.H Bloksma and W. Bushuk, "Rheology and Chemistry of Dough" in *Wheat Chemistry and Technology Volume II*, 3rd. edition. Y. Pomeranz, ed. St. Paul: American Association of Cereal Chemists. 1988. p.179.

involved in the end use."[150]

The reason for controlling the amylase activity is discussed by Mailhot and Patton.

> In the manufacture of yeast-leavened products such as bread, rolls and soda crackers, carbon dioxide is the gaseous agent that causes the product to rise during fermentation and baking. This gas is produced by yeast cells from simple sugars in the dough that were present in the flour or were added as an ingredient of the process formula or produced during fermentation. To regulate the production of carbon dioxide at a rate that does not exceed the ability of the gluten network of the dough to stretch and retain gas, the extent of enzyme modification must be controlled.[151]

They continue their discussion of amylases by stating:

> "The two main types of amylases present in wheat are alpha-amylase and beta-amylase, Most cereal chemists agree that beta-amylase,.., is present in adequate quantity in flour milled from sound (unsprouted) wheat. Alpha-amylase is not present in adequate quantity. Wheat flour that is to be used in yeast-fermented products must be supplemented with malted wheat, malted barley flour, or fungal enzymes."[152]

Although sound wheat contains relatively low levels of alpha-amylase, sprouted wheat contains very high levels of the enzyme which adversely affects the quality of the wheat for baking some products as is indicated by Bloksma and Bushuk:

> "An excessive amount of alpha-amylase, as in sprout damaged flour,... causes excessive liquefication and dextrinization and consequently results in a wet sticky crumb that is characteristic of

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[150] William C. Mailhot and James C. Patton, "Criteria of Flour Quality"in *Wheat Chemistry and Technology Volume II*, 3rd. edition. Y. Pomerantz, ed. St. Paul: American Association of Cereal Chemists. 1988. p.74.

[151] *Ibid.*

[152] Ibid.

bread from sprouted wheats."[153]

As Canada competes essentially in the bread wheat markets, testing for alpha-amylase activity is important.

There is one property arising from the action of the amylases, particularly alpha-amylase, which is conducive to testing as is explained by Hoseney:

> The result of the enzyme action is, therefore, to rapidly decrease the size of large starch molecules and thereby reduce the viscosity of a starch in solution or slurry. The enzyme works much faster on gelatinised starch than on granular starch; however, given sufficient time, it will also degrade granular starch. Because of its rapid effect on viscosity such tests as the amylograph and falling number (both measures of relative viscosity) have been widely used to measure enzyme activity.[154]

The two tests alluded to by Hoseney and used in the study were described previously.

5.5.5. Alveograph

There are several methods for diagnosing the protein quality of wheat. As mentioned previously, the baking tests uses loaf volume as the index of quality. However, other mechanical tests exist which measure the physical properties of the dough. Pomeranz states:

> Physical dough testing devices are used to evaluate bread-making potentialities (strength) and performance characteristics of flours under mechanized conditions. Such evaluation has assumed considerable importance as a result of high-speed

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[153] A.H Bloksma and W. Bushuk, "Rheology and Chemistry of Dough" in *Wheat Chemistry and Technology Volume II*, 3rd. edition. Y. Pomerantz, ed. St. Paul: American Association of Cereal Chemists. 1988. p.180.

[154] R. Carl Hoseney, *Principles of Cereal Science and Technology*, St. Paul, Minnesota: American Association of Cereal Chemists, Inc. 1986. p.103.

mixers and continuous processing.[155]

Pomeranz[156] breaks down the physical dough testing equipment into two categories: Recording dough mixers, which include the farinograph and mixograph; and load extension meters which include the extensigraph and alveograph. Unfortunately, for this study, only the alveograph has parameters which are usable in a linear programming model.

The use of the alveograph in testing flour is described by Bloksma and Bushuk:

> A circular sheet of dough, clamped at its circumference, is inflated by air blowing through a hole in the base plate into an expanding, nearly spherical dough bubble; eventually the bubble ruptures. The excess pressure of the air in the bubble is recorded....The usual interpretation of the alveogram[157] is similar to that of the extensigram. The maximum height of the curve is a measure of resistance, and its length is a measure of extensibility. Because the doughs are made with a constant water addition, the resistance is strongly affected by the water absorption of the flour. Instead of using the area under the curve itself, this area is multiplied by a constant factor; the product is called the **W** of Chopin.[158]

The **W** of Chopin mentioned by Bloksma and Buskuk is a linear parameter and thus can be used in the linear programming model.

5.5.6. Thousand Kernel Weight

Millers tend to prefer plump wheat kernels as they are easier to mill and contain

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[155] Y. Pomeranz, *Modern Cereal Science and Technology*, New York: VCH Publishers Inc., 1987, p.96.

[156] Ibid.

[157] The record of the alveograph is called an alveogram.

[158] A.H Bloksma and W. Bushuk, "Rheology and Chemistry of Dough" in *Wheat Chemistry and Technology Volume II*, 3rd. edition. Y. Pomerantz, ed. St. Paul: American Association of Cereal Chemists. 1988. p.156.

more starchy endosperm relative to the amount of bran. The thousand kernel weight is exactly as it states, the weight per 1000 kernels. Higher thousand kernel weights indicate that the kernels are larger and more dense than the samples with lower weights. This test is included as a constraint even though it an indicator of a wheat quality rather than flour quality, in that plumpness of kernels may be a factor a miller uses when choosing amongst wheats of otherwise similar quality.

5.5.7. Water Absorption

As mentioned several times in the discussion of wet gluten and starch damage, water absorption by flour is important in baking different products. Due to its importance relative to other testable qualities, it was included as a quality constraint. It was also included as water absorption was one of the few quality tests which was standard to the United States, Canada and Australia. As mentioned above, water absorption in different flours is linear though it is not linear in wheat mixes.

5.6. Quality Constraint Ranges

Having determined which constraints to include in the model, the next requirement was to determine the ranges of the constraints to incorporate in the linear programming package. The initial constraint information for pan breads was obtained from personal communication with Mr. John Van De Wiel at the C.I.G.I. However, this information while being very useful, was limited to the Canadian pan breads so that an alternative source of information was required. The major source of ranges for constraints, as pertaining to other end-use products, was obtained from Mailhot and

Patton's article[159]. A list of the constraints ranges used in the study is provided below in Table 5-2.

With the exception of protein content, the ranges set for all the other quality constraints remained constant through out the study. However, the protein content range was varied so as to assess the impact of changes in the protein range on the price and composition of the flour. For example, the flour requirements for a large Canadian bakery producing pan bread was determined over a range of 11.3 to 12.0 percent protein during one set of runs, subsequently followed by another run utilizing a protein range of 11.8 to 12.5 percent. Ash content and ash correction factors incorporated in the spreadsheet were also altered in different sets of the analysis to determine both the effect of different ash correction factors on price and flour composition, and ash content on flour composition.

5.7. End Use Products Analyzed

The flour produced from CWRS wheat, as discussed previously, is suitable mainly for the production of pan breads. Although CWRS may be a superior class of wheat for this purpose, inherent characteristics of the wheat restrict its usage in other potential markets. CWRS tends to have higher protein content than required for the baked products of many Lesser Developed Countries (LDC's) and Middle Income Countries (MIC's). As protein levels exert a major positive influence on price, CWRS wheats are often too expensive for LDC's and MIC's to purchase given the funds available.

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[159] William C. Mailhot and James C. Patton, "Criteria of Flour Quality"in *Wheat Chemistry and Technology Volume II*, 3rd. edition. Y. Pomeranz, ed. St. Paul: American Association of Cereal Chemists. 1988. pp. 82-86

Table 5.2. Constraint Range Specifications For Wheat Products In The Study.

CHARACTERISTIC	CANADIAN PAN BREADS LARGE	CANADIAN PAN BREADS SMALL	FRENCH BREADS BRAZIL	FRENCH BREADS ALGERIA
Wet Gluten (%)	30-40	30-40	30-40	30-40
Ash Content (%)	.48-.52	.48-.52	.55-.60	.50-.60
Moisture Content(%)	14.25	14.25	14.25	14.25
Protein Content(%)	11-12.5	12-13.8	10.5-11	11-11.5
Water Absorption(%)	60-69	60-69	60-69	60-69
Liquefaction #	15-25	15-25	15-35	15-35
Amylograph P.V. MOD.[160]	1-10	1-10	1-10	1-10
Starch Damage (Farrand Units)	29-36	29-36	28-36	28-36
Alveogram W (100^3 ergs)	325-370	325-370	325-370	325-370

Note: Falling Numbers and Amylograph Peak Viscosity Numbers are not listed. Although the printouts of the various formulations show actual numbers for these quality characteristics, they do not have any bearing on the results of the formulation.

[160] The determination of the modified Amylograph Peak Viscosity produces number in the range of 10^{-3}. In order to accommodate the package all these results were multiplied by 10^3.

Another factor which mitigates against CWRS in the world hard wheat market is the colour of the bran. Being a red wheat, CWRS has a dark coloured bran which is considered undesirable in many LDC's and MIC's, as the consumers in many of these countries prefer a low cost white flour. Although CWRS and other red wheats can produce white flours, the production of white flour requires that the extraction rate of the wheat be reduced to 75 percent or lower. White wheats having a white coloured bran can be extracted at higher levels while still maintaining a white coloured flour. CWRS wheat, therefore, is often uncompetitive. Compared to white wheats, particularly those with lower protein contents, CWRS wheat tends to be higher priced due to protein content and lower in flour yield due to bran colour.

The top two grades of CWRS wheat exported are for the most part segregated into one of three protein levels, 12.5 percent protein, 13.5 percent protein and 14.5 percent protein while No. 3 CWRS remains unsegregated. The guaranteed protein levels mean that for products which require less than 12.5 percent protein, CWRS wheat must be blended with lower protein wheats in order to produce suitable flour. The choice of baked products for which CWRS might be competitive, or at least acceptable, was drawn from a list obtained from the millers at C.I.G.I. These products are presented in Table 5-3. This table listing many of the major baked wheat flour products used in the world, is not a compendium of all the food uses of wheat, particularly hard wheats[161]. However, Table 5-3 identifies several end-use products which may be suitable for CWRS

[161] This C.I.G.I. list also presents similar information for Cookies and Cakes. However as these products are confectionery products requiring soft wheats, they were excluded from the table as they are unsuitable end-uses for CWRS wheat.

Table 5.3. Flour Specificiations For Baked Products

BAKED PRODUCT	PROTEIN Content	PROTEIN Strength	ASH Content	ENZYME Tolerance	PREFERRED Wheat
CANADIAN PAN BREAD					
SMALL BAKERY	12.6-13.8	Strong	.48-.50	Low	HS
LARGE BAKERY	11.8-12.5	Strong	.48-.50	Low	HS
RYE BREADS	15 - 16	Strong	.70-.80	Low	HS
KAISER ROLLS	13.6-14 (plus gluten)	Strong	.48-.50	Low	HS
HAMBURGER BUNS	13.2-13.8 (plus gluten)	Strong	.48-.50	Low	HS
FRENCH BREADS					
FRANCE	10 - 11	Medium	.48-.50	Medium	HW/HS
BRAZIL	10.5-11	Medium	.55-.60	Medium	HW/HS
ALGERIA[162]		Medium to Weak	.50-.60	Medium	HW/HS

162 Although C.I.G.I. listed no protein range for this product, a value of 11-11.5 percent protein was arbitrarily chosen

ARAB BREAD					
SYRIA	8 - 10.0	Medium to Weak	.7 - .8	High	D/W
EGYPT	8 - 10.0	Medium to Weak	.8 -1.0	High	HW/Others
CHAPATTIS	9 - 10.0	Medium	1.1-1.2	High	White
STEAMED BREADS					
ASIA	10.5-11.0	Medium		High	HW/HS
CHINA	11.5-12.0	Medium		High	HW/HS
NOODLES					
JAPANESE	8.0-9.0	Weak	.38	Low	WW/AW
INSTANT	11.0-12.0	Strong	.45-.50	Low	HS
CHINESE	10.0-11.5	Medium to Strong	.45	Medium	HS/HW
CRACKERS	10.0-10.5	Medium to Weak	.44-.46	High	HW/SW

HS = Hard Spring, **HW** = Hard Winter, **D** = Durum, **W** = White, **WW** = Western White, **AW** = Australian Winter.
SOURCE: Canadian International Grains Institute. Mimeograph.

wheat alone or CWRS blended with other wheats.

From the list of potential end-uses, two were chosen for the study. Pan breads which are produced by small and large Canadian bakeries and Algerian and Brazilian French breads which require a slightly lower protein product but with a similar ash content. Products such as kaiser rolls and hamburger buns, requiring protein levels and ash contents within the relevant range of CWRS wheat, were not studied for two reasons. First, the market for these products was thought to be rather limited when compared to other products. Bread is considered to be a normal part of the diet whereas these rolls and buns[163] tend to be specialty products and are consumed by various segments of the population at periodic intervals. The second reason for not including buns and rolls was that the production of these products required added gluten. Although the production of gluten is one outlet for CWRS wheat, little information was available with respect to the amount of extra gluten required and the price of gluten.

The Arabic breads of the middle east were not included in the study in view of their low protein and high ash content requirements. Furthermore, durum and white wheats are listed for the production of Syrian type bread. Colour often plays an important role in the consumer's choice of product and if the Syrian style of Arabic bread required a light coloured wheat, it would be inconsistent to try to force CWRS wheat into this formulation.

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[163] Although hamburgers are a large outlet for flour in the U.S. very little CWRS is exported to the that market. In order for Canada to increase exports the major outlets appear to be the third world where the general populace lacks the income to consume products such as hamburgers.

The Egyptian Arabic bread which uses Hard Winter wheat and other wheats, may be a potential outlet for the lower protein segregations of CWRS wheat when blended with other lower protein wheats. However, in order to mill CWRS wheats to a high enough ash content to satisfy these products, there would be some increase in the protein content as well as a large amount of bran present in the flour rendering it undesirable for that use.

Chapattis from India, although representing a large potential market for Canadian wheat were not included in the analysis as flour for these products requires white wheat with high extraction rates and high ash content. CWRS wheat may be milled to produce flours with extremely high ash content levels, but most, if not all, the darker bran would be included in the flour possibly rendering it undesirable for the consumer until such time as tastes may change.

The Steamed Breads of Asia and China were also not used in the analysis due to the lack of information concerning the various quality requirements for these products. Both these breads, although requiring lower protein contents than normally found in CWRS wheats, represent the diets of a large group of consumers and thus may be an outlet for lower protein CPS wheat. In the Noodles category, although none were considered due to lack of information, two types are potential outlets for CWRS wheat, at least for blending purposes. Instant noodles with a protein requirement of 11-12 percent and ash contents of .45 to .50 have requirements somewhat similar to large bakery Canadian pan breads. Chinese noodles have a similar protein content requirement to the French breads studied, but require ash contents lower than normally found in flours produced from CWRS wheat. Crackers, while listed as using Hard Winter Wheat, a competitive product to CWRS wheat, were not studied since soft white wheat is also used in their production.

5.8. Data Limitations and Manipulations

The lack of suitable price data may limit the findings of the research. Price data for Canadian export shipments during the study period were not publicly available due to C.W.B. secrecy. In order to accurately determine the end-use value of wheat, prices actually paid for the specific grades and protein segregations shipped are necessary. If this type of price data were available prices and quality shipped during the study period could be matched and an actual value determined. Since the price data were unavailable, price data reflecting market conditions were derived from the I.W.C. *World Wheat Statistics*.[164]

The I.W.C. publication lists the C.W.B. asking F.O.B. prices for No.1 CWRS 13.5 and 12.5 percent protein from various export ports by month. The GRL wheat quality data which was used for determining the suitability of specific grades and protein segregations for different end-uses is reported on a quarterly basis. In order to make the price data consistent with the wheat quality data, quarterly average prices for the two listed segregations were calculated. Quarters coincided with the C.W.B. crop year. These were simple rather than weighted average prices as there was no means to objectively weight the prices.

[164] International Wheat Council, *World Wheat Statistics*, Various Issues,London: International Wheat Council.

Prices by grade and protein segregation for CWRS wheat not provided in the I.W.C. publications were calculated from final payments to producers published in the C.W.B. *Annual Reports*[165]. No.3 CWRS prices were calculated using the following method. First, I.W.C. reported prices for No.1 CWRS 13.5 and No.1 CWRS 12.5 were averaged for each quarter to yield a representative quarterly price for No.1 CWRS. Secondly, the difference between the final payment/tonne for No. 1 CWRS and No.3 CWRS was determined from the C.W.B. Annual Report for each year. The annual price differential between No.1 CWRS and No.3 CWRS was subtracted from the representative quarterly price for No.1 CWRS to provide a quarterly price for No. 3 CWRS wheat. For example, the average prices for No.1 CWRS 13.5 and No.1 CWRS 12.5 F.O.B. the Pacific Ports were $249.33/tonne and $245.66/tonne, respectively, for the first quarter of the 1981/82 crop year. The difference in the final payment to producers from the C.W.B. between No.1 CWRS and No.3 CWRS was $11.86/tonne in that year, 1981/82. Thus the first quarter price used for No.3 CWRS F.O.B. the Pacific was {($249.33 + $245.66)/2} - $11.86 = $235.63 per tonne.

Similarly, prices for No.2 CWRS wheat were determined by subtracting the final payment differential between No.1 and No. 2 from the respective No. 1 CWRS 13.5 and No.1 CWRS 12.5 prices listed by the I.W.C. This provided representative prices for the two most common protein segregations within the Number 2 grade, 13.5 percent protein

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165 Canadian Wheat Board, Annual Reports, Winnipeg, Manitoba: C.W.B. Various Issues.

and 12.5 percent protein[166].

The price of No. 1 CWRS 14.5 percent protein was determined by adding the average differences between No.1 13.5 and No.1 12.5, for each quarter, to the quarterly price of No.1 13.5.[167]. This method of manufacturing prices assumes a constant relationship between selling prices F.O.B. the ports and producer final payments, which may not exist. However, in view of the non-availability of the actual selling prices, the above method was considered to be the best that could be developed to provide some representative selling prices[168].

Prices for U.S. and Australian wheats were determined in somewhat the same manner as those for No.1 CWRS (13.5) and No.1 CWRS (12.5) wheats, simple averages on a quarterly basis. However, prior to the calculation of the simple averages all prices were converted into Canadian dollars. The exchange rate for converting U.S. dollars was determined from the I.W.C. CWRS No.1 (13.5) and (12.5) prices which were listed in both U.S. and Canadian dollars. Australian prices listed in both Australian and U.S. dollars were converted to Canadian dollars using the same procedure. U.S. prices were F.O.B. the Gulf of Mexico and the Pacific Northwest, and Australian prices F.O.B. ports

166 During some quarters of some crop years limited quantities of No.2 CWRS 14.5 percent protein was exported by Canada. However, the number of cargoes and number of times this segregation appeared in the data was very small. This segregation was, therefore, ignored as it does not represent a usual export quality.

167 The linear relationship between protein premiums was assumed from necessity and most likely understates the premium which may be paid for the higher protein wheat.

168 The problem of the lack of the actual selling prices may be solved for later researchers by the Canada Grains Council. The Council has been able to obtain the price information for wheat exported from Canada from the customs declarations. However, the prices for the actual grades and protein segregations only commenced in 1988.

in New South Wales, South Australia and Western Australia.

Calculation of ash correction factors for the various wheats required milling data for each wheat in each quarter. The milling data for all CWRS wheats were not consistently available over time from either the GRL mill or the C.I.G.I. mill. Collection of this type of data was therefore not pursued. Rather, wheats for which milling data were available were used as representative, and the ash correction factors were used throughout the study for all quarters. An ash correction factor was arbitrarily assigned to wheats for which no milling data were available, i.e. U.S. and Australian wheat.

5.9. Shipping Rates

The prices used in this study are based on F.O.B. asking prices at various ports. Variation in transportation costs between the ports of origin and destinations will affect the landed wheat cost to the importing country. Ideally, landed prices for the various cargoes of wheat should be used to determine the lowest cost wheat flours. As landed wheat prices are not available, landed prices for wheat grades can theoretically be determined by adding the relevant ocean shipping charges to the F.O.B. price. However, three problems arise in the determination of landed wheat prices; (i) the F.O.B. prices used are asking prices at export ports and are not actual selling prices, (ii) the shipping rates for grain cargoes are negotiated rates which fluctuate between ports, months, cargoes and other factors and iii) shipping charges are published only for selected origin/destination pairs. Since the price data used for the study are already manufactured, it was thought that developing a landed wheat price may further reduce the accuracy of the price series. However, it must be recognized that ocean freight rates do impact on the price of wheat to the importing country. This section discusses the potential impact of ocean shipping rates on the landed wheat price.

The possible impact of ocean shipping charges on landed wheat prices was analyzed based on ocean shipping rates published in the I.W.C. World Wheat Statistics. Seven import locations and four export locations were chosen for the comparison. The seven import locations were, Eastern Africa, China, Japan, Siberia and three E.C. import locations, the west coast of Italy, the U.K. and Amsterdam/Rotterdam. These seven import locations were chosen as they either represented the markets where CWRS wheat is sold or their locations were closest to foreign markets where French breads are consumed. The four export locations examined were the St. Lawrence, the U.S. Gulf, the Pacific N.W. and the Eastern States of Australia. The ocean shipping costs for the Pacific N.W. are assumed to be representative for export cargoes from the west coast of Canada and the U.S. Pacific Northwest shipments. The eastern States of Australia[169] are assumed to be representative of all ocean shipping costs from Australia[170].

I.W.C. monthly ocean shipping rates were collected over the last 10 crop year quarters in which the U.S., Australia and Canadian CWRS wheats are simultaneously made available for selection in the least cost flour blend analysis. Quarterly average shipping rates[171] were then derived, Table 5.4. The differences between the quarterly

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[169] Eastern states include New South Wales and Queensland.

[170] The relevant Australian ports are only several hundred miles apart.

[171] Caution is advised in comparing ocean rates between destinations. The I.W.C. data publishes shipping charges for several sizes of vessels. The ocean shipping rates selected for <u>each</u> destination in Table 5.4 are for one size vessel which may or may not be of the same size for other destinations. The larger the vessel, the lower the per tonne shipping

average shipping rates between Canadian and competitive export ports for the selected import locations were calculated. The calculated differences in quarterly shipping rates are shown in Table 5.5.

The average freight rate differences shown in Table 5.5, indicate that five Canadian ports/import destinations were more expensive than reported competing export ports. The rate differences ranged from \$0.12/tonne to \$9.38/tonne and averaged \$2.81/tonne. The average rate difference to Pacific destinations such as Japan and China was \$1.52/tonne excluding the St. Lawrence-Australia comparison to China of \$9.38 which is expected to be a last port choice when shipping grain to China.

Freight rates from Canadian export positions were cheaper in nine of the export/destination comparisons. The rate differences ranged from \$0.98/tonne to \$9.00 per tonne, averaging \$4.22/tonne. The average freight rate difference to Atlantic destinations was \$3.95/tonne and \$3.99 to Pacific destinations excluding i) Siberia-Pacific N.W./U.S. Gulf and ii) Japan-Pacific N.W./U.S. Gulf comparisons. The Pacific N.W. shipping rates also include U.S. ports, hence it would be more economical for the United States to ship from Pacific ports than exporting from the Gulf.

A comparison of ocean shipping rates indicates that depending on the port of origin and the destination, the F.O.B. prices used in the study may favour selection of Canadian CWRS wheats while discriminating against Canadian wheats in other circumstances. The potential impact of these differences in ocean freight rate charges

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rate. Hence, the size of the shipment to countries may also affect the landed prices in terms of the size of vessel which can economically be used. Countries which are able to load large vessels may have a competitive advantage in exporting wheat.

Table 5.4 **Quarterly Average Shipping Rates For Selected Desinations From Selected Export Ports ($U.S. per tonne)**

Destination	Export Port	Crop Year 1984-85 First Quarter	Crop Year 1984-85 Second Quarter	Crop Year 1984-85 Third Quarter	Crop Year 1984-85 Fourth Quarter	Crop Year 1985-86 First Quarter	Crop Year 1985-86 Second Quarter	Crop Year 1985-86 Third Quarter	Crop Year 1985-86 Fourth Quarter	Crop Year 1986-87 First Quarter	Crop Year 1986-87 Second Quarter
Eastern Africa	U.S. Gulf	38.00	38.00	38.33	39.00	38.33	37.00	36.67	36.00	32.33	31.00
	Pacific N.W.	38.33	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00
China	Australia	19.17	18.92	18.50	16.83	15.33	15.33	14.33	13.00	12.50	12.33
	St.Lawrence	25.00	25.00	25.00	25.00	17.33	27.75	26.42	25.75	26.08	26.75
	U.S. Gulf	26.60	27.53	29.00	29.00	29.00	29.00	29.00	29.00	27.33	23.75
	Pacific N.W.	16.00	16.83	19.17	19.50	18.83	18.50	19.00	18.67	15.33	14.00
Amsterdam/ Rotterdam	St.Lawrence	10.25	10.50	11.00	11.00	8.00	8.50	9.17	9.50	9.83	10.92
	U.S. Gulf	12.00	12.08	12.42	12.17	11.83	11.00	10.67	10.00	8.83	10.58
Italy	St.Lawrence	15.50	15.67	15.75	15.75	12.75	13.25	13.25	13.25	13.67	14.25
	U.S. Gulf	18.10	18.27	18.52	19.77	17.68	16.85	16.52	15.85	16.18	18.18
	Pacific N.W.	17.33	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75	17.75
United Kingdom	Australia	17.17	19.33	18.83	18.17	16.83	17.50	17.67	17.00	15.00	14.83
	St.Lawrence	9.25	9.28	10.53	10.75	6.60	7.25	7.25	7.25	6.67	7.92
	U.S. Gulf	11.83	11.67	11.58	13.17	10.17	10.00	10.00	8.50	8.33	10.00

Destination	Export Port	Crop Year 1984-85				Crop Year 1985-86				Crop Year 1986-87	
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	First Quarter	Second Quarter
Japan	Australia	19.25	19.17	19.17	19.00	17.75	17.92	17.50	16.75	16.08	16.08
	U.S. Gulf	25.83	26.50	26.00	26.00	24.67	24.67	24.67	24.50	23.33	23.33
	Pacific N.W.	18.50	19.83	19.83	19.50	17.75	17.92	17.50	16.83	16.08	16.25
Siberia	Australia	19.00	19.33	19.00	18.17	16.83	16.83	16.17	14.83	13.00	12.33
	U.S.Gulf	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	18.83	19.50
	Pacific N.W.	16.00	16.00	16.67	17.00	16.33	15.00	15.00	14.67	14.00	14.00

Source: I.W.C. World Wheat Statistics and Authors Calculations

Table 5.5 Differences in Average Quarterly Shipping Rates For Selected Desinations From Selected Export Ports ($U.S. per tonne)

Destination	ExPort Port	Crop Year 1984-85				Crop Year 1985-86				Crop Year 1986-87		Average
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	First Quarter	Second Quarter	
Eastern Africa	Pacific N.W. -U.S. Gulf	.33	1.00	0.67	0.00 *	0.67	2.00	2.33	3.00 *	6.67	8.00	2.47
China	St. Lawrence-Australia	5.83	6.08	6.50	8.17 *	2.00	12.42	12.08	12.75 *	13.58	14.42	9.38
	St. Lawrence-U.S. Gulf	-1.60	-2.53	-4.00	-4.00 *	-11.67	-1.25	-2.58	-3.25 *	-1.25	3.00	-2.66
	Pacific N.W.-Australia	-3.17	-2.08	0.67	2.67 *	3.50	3.17	4.67	5.67 *	2.83	1.67	1.96
	Pacific N.W.-U.S. Gulf	-10.60	-10.70	-9.83	-9.50 *	-10.17	-10.50	-10.00	-10.33 *	-12.00	-9.75	-8.34
Amsterdam Rotterdam	St. Lawrence-U.S. Gulf	-1.75	-1.58	-1.42	-1.17 *	-3.83	-2.50	-1.50	-0.50 *	1.00	0.33	-1.29
Italy	St. Lawrence-U.S. Gulf	-2.60	-2.60	-2.77	-4.02 *	-4.93	-3.60	-3.27	-2.60 *	-2.51	-3.93	-3.28
	Pacific N.W.-U.S. Gulf	-0.77	-0.52	-0.77	-2.02 *	0.07	0.90	1.23	1.90 *	1.57	-0.43	0.12
United Kingdom	St. Lawrence-Australia	- 7.92	-10.05	-8.30	-7.42 *	-10.23	-10.25	-10.42	-9.75 *	-8.33	-6.92	-9.00
	St. Lawrence-U.S. Gulf	-2.58	-2.38	-1.05	-2.42 *	-3.57	-2.75	-2.75	-1.25 *	-1.67	-2.08	-2.25
Japan	Pacific N.W.-Australia	-0.75	0.67	0.67	0.50 *	0.00	0.00	0.00	0.08 *	0.00	0.17	0.13
	Pacific N.W.-U.S. Gulf	-7.33	-6.67	-6.17	-6.50 *	-6.92	-6.75	-7.17	-7.67 *	-7.25	-7.08	-6.95
Siberia	Pacific N. W.-Australia	-3.00	-3.33	-2.33	-1.17 *	-0.50	-1.83	-1.17	0.17 *	1.00	1.67	-0.98
	Pacific N.W.-U.S. Gulf	-3.00	-3.00	-2.33	-2.00 *	-2.67	-4.00	-4.00	-4.33 *	-4.83	-5.50	-3.24

Source: Authors Calculations

will be further explored through parametric analysis of the F.O.B. prices.

5.10. Parametric Programming

The linear programming model used in this study determined the least cost flour blend conforming to a specified set of quality characteristics which could be obtained from a specified set of available wheat flours. The selection of the wheat flours to be blended is affected by the selling prices of the available wheats. The price data used in the research are calculated on the basis of adjustments[172] to listed asking prices[173], as the actual selling prices of wheat are not known.[174]

The CWRS wheats, particularly the No.1 CWRS (14.5) and (13.5) percent protein segregations, have the highest asking prices of the wheats used in the study. The high asking price may adversely affect the selection of the CWRS wheat grades/segregations in some of the flour blends. In addition, the asking prices are F.O.B. prices and not landed prices, hence ocean shipping charges can affect price competitiveness. As shown in Table 5.5, the ocean freight rates from Canadian export ports were both lower and higher than those from competitors ports depending on the import location. Consequently, the ocean rates could either adversely affect or improve the landed price hence CWRS wheats' ability to compete in the international market.

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[172] See Section 5.8 for explaination of the calculation.

[173] Suggested retail prices.

[174] The C.W.B. keeps actual selling prices confidential to preclude competitors undercutting the selling price of CWRS wheat. In addition, exporters sometimes price discriminate as various importing nations have different abilities to pay as well as different reservation prices for quality wheat. Publishing actual selling prices would prevent exporters from extracting a premium from those importers with higher reservation prices.

To determine the impact of price on the selection of the Canadian wheats, parametric testing of the asking prices was undertaken. The starting level for parametric testing was ascertained by calculating the differences between each of No.1 CWRS (14.5) and No.1 CWRS (13.5) and No.2 DNS and APHD14 over the last 10 quarters of the study period. The average difference in asking prices between No. 1 (14.5) and APHD14 was $26.39/tonne, and $22.80/tonne between No.1 (13.5) and APHD14. The average asking price differences between No.1 CWRS (14.5) and (13.5) and No.2 DNS were $30.07 and $26.48 per tonne, respectively. On the basis of these differences in asking price, No. 1 (13.5) prices were adjusted stepwise in increments of $5.00 beginning with a decline in price of $20.00/tonne. New prices for the other CWRS grades/segregations were calculated relative to No.1 (13.5). For example, if the original asking price of No.1 (13.5) was $200/tonne and the asking price for No.1 (14.5) (same quarter and port) $204 tonne, the price of the No.1 (14.5) was 1.02 times the No.1 (13.5) price. If the No.1 (13.5) price is lowered by $25.00/tonne to $175.00 per tonne, the new No.1 (14.5) price would be $175.00 * 1.02 = $178.50. This method of calculating the prices was chosen so that the price relationship between the grades and segregations of CWRS wheat would remain the same during the parametric exercise.

5.11. Summary

CWRS wheat is targeted towards a select market, specifically that of North American style pan breads. However, the question which arises is whether the grading system for CWRS wheat in Canada does an adequate job of ensuring that the grades of CWRS wheat satisfy the demands of the end-user, the miller? There exist a plethora of quality tests for wheat and wheat flour which are performed by various research and quality control laboratories in conjunction with the mills. The efficacy of the grading system for CWRS was evaluated using an existing linear programming least cost flour formulation package. This approach limited the type of quality factors used due to the linearity requirement. Meaningful linear constraints were chosen, however, to determine objectively the effectiveness of the grading system to meet the requirements of particular end use products.

CHAPTER 6. RESULTS: CWRS WHEATS FOR PAN BREAD FLOUR

6.1. Introduction

Red Fife wheat was the first Canadian Hard Red Spring[175] wheat developed for production in western Canada for the pan bread markets of North America and Western Europe. New varieties developed since that time have continued to provide a consistent quality product for these particular markets. During the past two decades exports of CWRS wheats to the Western European nations have declined. This decline is the result of two factors, (i) increased wheat production in the E.C.; and (ii) the introduction of the Chorleywood baking process which allows pan breads to be baked with lower flour protein content. Despite the loss of this large traditional outlet, several opportunities exist for CWRS wheat. During the 1980's the main outlets for CWRS wheat were the domestic and export pan bread market, and the overseas blending market. Canada exports approximately 80 percent of the CWRS wheat produced on the prairies. Therefore, maintaining or increasing its share of the wheat blending markets should be a goal of the grading system.

The domestic market was essentially a captive market as all the wheat used to make bakery products consumed in Canada was Canadian grown[176]. However,

[175] The grade designation or name Canada Western Red Spring (CWRS) only came into use with the passage of the 1971 *Canada Grain Act*. Prior to 1971 there existed other names such as Manitoba, and Northern which identified the wheats which now constitute the CWRS wheats.

[176] In 1991 provisions in the Canada - U.S. Trade Agreement took effect and the domestic wheat market ceased to be a captive market as millers now have access to U.S. wheats.

domestic millers did not necessarily have to use CWRS wheat as there are other domestically produced wheats which are suitable. Wheat produced in Ontario and other Provinces, which are not in the C.W.B. designated area[177], may be used for bread flour. These wheats are not in the CWRS wheat class, as Canada Western grades are only produced in the CWB designated area. CWRS, therefore, must not only compete with wheats from other countries in the export market, but must also compete with other domestic wheats in the pan bread flour market.

Although wheat produced in eastern Canada could conceivably compete with CWRS wheats in domestic markets, these wheats are not used in the analysis. Canada Eastern grades of wheat are not export oriented[178] and therefore are not subject to the same stringent regulatory framework that has been established to ensure quality control in CWRS wheats. For example, quality testing carried out on CWRS wheat is not required for eastern wheats. As a result wheat quality information for these wheats is not available. Consequently, the analysis of the domestic pan bread market included only

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Comparisons of CWRS wheat with U.S. Dark Northern Spring Wheats are presented in Chapter VII.

[177] The Canadian Wheat Board designated area contains all the grain production area west of Thunder Bay, Ontario and east of the Rocky Mountains. Thus the CWB designated area includes the provinces of Manitoba, Saskatchewan, Alberta and the northeastern part of British Columbia. The CWB is the sole buyer and seller of all the wheat and barley for export or domestic human consumption produced in the designated area. The CWB, therefore holds a monopsony/monopoly position in these markets.

[178] Some eastern Canadian wheat is exported, but the major portion is used domestically.

the six segregations of CWRS wheat discussed in Chapters 5[179]. These six segregations were analyzed to determine which grades of CWRS would provide the least cost flour grist which was acceptable for the two types of pan breads identified for the domestic market.

6.2. Discussion of Factors Affecting the Cost of Wheat Flour[180]

Information concerning wheat products in Chapter 5 (Table 5.2) shows that there are essentially two types of pan breads, those produced in large bakeries and those in small bakeries. The major difference between these two types of bread production facilities is that small bakeries require higher protein flour than large bakeries. The protein ranges used in the analysis were 11.8 to 12.5 percent protein for the large bakery pan bread flour and 12.6 to 13.5 percent protein for the small bakery pan bread flour. The two different flour requirements are hereafter referred to as small bakery and large bakery.

The most obvious flour cost determining factors are the grade and protein segregation of the wheat which determine its price on arrival at the mill. During the 26 crop year quarters analyzed, the prices of the different CWRS wheat grades changed substantially: For example, the price of No. 3 CWRS shipped from the West Coast

[179] The six segregations of CWRS wheat used in the study are: 14.5. 13.5 and 12.5 percent protein content for No.1 CWRS wheat, 13.5 and 12.5 percent protein for No. 2 CWRS wheat, and No.3 CWRS wheat.

[180] Wheat flour refers to the flour which is extracted from a particular grade/segregation of wheat. Flour blend refers to the mixture of wheat flours. For example, a large bakery flour blend may comprise any combination of No. 1, No. 2 and No. 3 CWRS wheat flours from the various protein segregations.

ranged from a high of $266.30 per tonne during the second quarter of crop year 1980-81 to a low of $179.82 per tonne during the first quarter of crop year 1986-87, a difference of $86.48/tonne.[181]

Since protein content is a factor in the determination of wheat price, the wheat segregation used in the flour blend should also influence the cost of the flour. Intuitively it would seem flour for small bakery pan breads should be more costly than that for large bakery pan bread. However, intuition may not be completely correct. One of the developers of the Brill Flour Formulation Package (BFFP) indicated that in some cases higher wheat grades may produce less costly flour than the lower grades because sometimes the amount of flour extracted is much greater for the higher grades of CWRS wheat[182]. The possibility that higher grades of wheat may in fact produce lower cost flour blends than lower grades, was one of the reasons the spreadsheet was incorporated into the BFFP. The real (or estimated true) cost of a particular wheat flour as determined by the spreadsheet depends on several factors which may vary between parcels of wheat.

Several quality factors can change between parcels of wheat of the same grade and protein segregation which impact on the cost of the flour produced. These factors include foreign material content, moisture content, the price of millfeed, ash content and

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[181] It should be remembered that these figures are reported in nominal rather than real dollars, therefore the impact of the price decline between 1980-81 and 1986-87 is larger in real terms.

[182] Personal Communication with Mr. Ashok Sarkar, C.I.G.I. Mr. Sarkar provided much of the technical and practical milling experience used in the development of the package.

ash correction factors.

The impact of foreign material content can be illustrated in the following examples. No. 3 CWRS wheat with 1.25 percent foreign material contains only 987.5 kg of usable wheat. At $266.30/tonne, the actual cost per tonne of usable wheat is $266.30/.9875 = $269.67 per tonne, a difference of $3.37/tonne. Conversely No. 1 CWRS with a maximum foreign material tolerance of .4 percent, at the same $266.30/tonne price would cost $267.37/tonne or a difference of only $1.06/tonne.

Information provided in the G.R.L.'s *Quarterly Cargo Bulletins* does not include the average amount of foreign material and dockage in the export cargoes sampled. Thus, the analysis of the CWRS wheats assumed the maximum tolerances for dockage and foreign material in each grade. In other words, the amount of foreign material was assumed to be 0.4 percent for No. 1 CWRS wheat, 0.75 percent for No. 2 CWRS, and 1.25 percent for No. 3 CWRS. Due to regulations which govern the loading out of wheat and other grains at the export terminals, it is unlikely wheat would be exported at the maximum tolerance level[183]. Consequently, using the maximum foreign material tolerances may actually bias the quantity of usable wheat estimated in the spreadsheet downward and hence the gross price of wheat upwards. As a consequence, the customer probably receives more wheat than that estimated in the spreadsheet using maximum

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[183] When the terminal elevators load grain on behalf of the Canadian Wheat Board, or themselves, on to ships, the grain moving out of the terminal is sampled by the Inspection Division of the Canadian Grain Commission. If the product loaded is not of the correct grade or contains excess foreign material or dockage, the terminal may be forced to unload the vessel an reload with proper product. The unload and reload of a vessel is an expensive proposition and most terminals attempt to avoid this possibility by erring on the side of have lower than maximum tolerances for the grain being loaded.

tolerance limits.

Another bias related to foreign material is the value of the usable material which is included in the foreign material category. The foreign material which is removed from the wheat includes kernels of other grains, small seeds, and other usable material which can be added to the millfeed to feed livestock. The spreadsheet, therefore, may actually overestimate the cost of wheat used in the flour as the usable foreign material was not valued and deducted from the initial cost of the wheat. However, this return is offset at least in part by the cost of cleaning prior to milling.

The price and quantity of millfeed also impacts on the cost of the wheat required to produce flour. As the price of millfeed increases, the payback on some of the material which cannot be used in flour increases. The quantity of millfeed also depends on the extraction rate for that wheat. The influence of price and quantity of millfeed on the real cost of wheat to produce flour can be illustrated by the following example. Assume wheat delivered to the mill costs $275/tonne and millfeed $80.00/tonne. Given an extraction rate of 75 percent, the 250 kilograms of millfeed produced[184] has a value of $20/tonne. The net cost of the wheat to be recovered from the price of the flour is $255/tonne. Throughout the analysis, the price of millfeed was held at $80.00/tonne.

The extraction rate also has a large influence on the real cost of the wheat. The extraction rate is related to (i) the ash content level required in the flour for the specific end-use, and (ii) the characteristics of the wheat. CWRS wheat is usually milled at an extraction rate of about 75 percent and an ash content level between .48 and .50 percent.

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[184] For simplicity, the example assumes no moisture or foreign material loss.

If the flour from the wheat has a lower ash content (ie. .45) than required in the end-use product, the rate of extraction can be increased thereby raising the ash content in the flour. The spreadsheet adjusts for different ash content levels using the ash correction factor which in turn indicates the appropriate extraction rate. The effect of a 1 percent increase in the extraction rate on the real cost of flour is illustrated in the following example. Assuming 1) a wheat price of $275/tonne, 2) a millfeed price of $80/tonne, 3) an extraction rate of 75 percent, the real cost of flour would be $340/tonne.

Net wheat price :$275 - $20/tonne of millfeed = $255/tonne

Cost of flour extracted: $255 for 750 kg of flour

Cost of flour/tonne: $340 or $0.34/kg

If the extraction rate was increased to 76 percent, 760 kg of flour would be produced at a wheat cost of $255, resulting in a tonne of flour costing $335.52. The increase in the extraction rate by 1 percent yielded an additional 10 kilograms of flour, reducing the cost per kilogram to $0.335/kg.

Moisture content, as previously stated, can have a substantial impact on the cost of the flour produced from a particular parcel of wheat. The moisture content levels at which wheat is milled are much higher than those acceptable for stored wheat. The miller must add water to temper the wheat and increase the moisture content prior to milling. Although some of the added moisture is lost through evaporation during the milling process, the retained moisture in the flour adds weight and value to the flour[185].

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[185] Millers prefer wheat which is as dry as possible for this reason. Canadian wheat tends to contain higher moisture contents that U.S. and Australian wheat. This has led to some speculation that this disadvantages Canadian wheats in the export market.

Lower moisture content wheat is preferred by millers as adding moisture generally reduces the cost of the wheat by adding weight. For example, wheat costing $275.00 with 12.25 percent moisture is delivered to the mill. The moisture is increased to 16 percent for first break (IBK) and 1.75 percent is subsequently lost during the milling process, leaving a total of 14.25 percent moisture. The moisture content is increased in the wheat by 2 percent or 20 kilograms, lowering the cost of the wheat by $5.50 per tonne.

All wheat used in the study was assumed to have a first break moisture content of 16 percent, and a flour moisture content of 14.25 percent. While milling technologists with C.I.G.I. indicated that different mills tend to have slightly different operating parameters, a 16 percent first break and 14.25 percent flour moisture content is believed to be representative of the industry.

6.3. Availability of CWRS Grades/Segregations by Ports

The only grades/segregations available at both export port locations for all 26 quarters of the study period, from 1980/81 to 1986/87, were No.1 CWRS (13.5) and No.3 CWRS. The small sample size makes it difficult to make a definitive statement, but the information in Table 6.1 suggests two possible trends in product availability; (i) CWRS (12.5) was available at the Pacific ports more often than at the Atlantic ports[186], and (ii) No.1 and 2 (14.5) was more often available at the Atlantic ports. During the

[186] Of a total of 52 possible export opportunities for wheat with 12.5 percent protein (No.1 CWRS 12.5 and No.2 CWRS 12.5) through each location, only twice was there no 12.5 percent protein exported through the Pacific ports while there were 15 times none was shipped through the Atlantic ports.

study period, all 19 shipments of No. 2 (14.5) CWRS were through the Atlantic ports. While information concerning the direction of No. 1. CWRS shipments is not as striking[187], there appears to be a tendency to access customers for CWRS (14.5) through the Atlantic Ports. Evidence of directional differences in protein requirements is further supported by the fact that the only shipments of No. 1 (11.5) CWRS during the study period were through the west coast ports[188].

Table 6.1. Number of Quarters CWRS Grade/Segregation Were Available by Port

GRADE	Pacific Coast	Atlantic Coast
No. 1 14.5	20	25
No. 1 13.5	26	26
No. 1 12.5	24	21
No. 2 13.5	22	23
No. 2 12.5	26	16
No. 3	26	26
Total	144	137

Source: Calculated from C.G.C. Canadian Wheat Cargoes Quarterly Bulletin, Various Issues and C.G.C. Quality of Canadian Grain Exports: Red Spring Wheat Quarterly Bulletin, Various Issues.

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187 Only once during the study period was No. 1 (14.5) not shipped through Atlantic ports. Conversely there were six crop year quarters when No. 1 (14.5) was not shipped through Pacific ports.

188 During the first quarter of 1983/84, 7 cargoes of No.1 11.5 weighing 27,400 tonnes were shipped through the Pacific ports. As indicated previously, there were very few quarters when No. 1 11.5 and No.2 14.5 CWRS were exported. As both the occurrences and volumes were small these segregations were not included in the main body of the research.

6.4. Ash Content Profile of CWRS

The original ash contents as reported by the GRL[189] for the 26 quarters ranged from .42 to .54 percent ash. The frequency with which each particular ash level occurred are shown in Table 6.2. Approximately 38.4 percent (106 of 276) ash contents were in the .48 to .50 percent allowable ash range for pan style breads. Over 51 percent (141 of 276) of the original ash contents were lower than .48 whereas less than 11 percent (29 of 276) were above the .50 percent ash level. In total, 89.5 percent of the samples were below the .50 percent allowable ash level. Thus it appears that CWRS wheats tend to have lower ash contents than is necessary to produce pan bread flour.

The distribution of the original ash contents appear to be related to both grade and crop year. The distribution of the average ash contents for all cargoes of a particular grade and protein segregation sampled over the study period are shown on Table 6.3. It appears that the higher "quality" CWRS grades/segregations have lower ash contents. For example, the percent of each grade which had less than .48 percent ash are as follows: 26 percent No. 3 (12/52), 43.9 percent No. 2 (36/82) and 65.5 percent No. 1 (93/142). Conversely, the percentage of each grade that had ash content above .50 percent ash were: 21.2 percent No. 3 (11/52), 11 percent No. 2 (9/82), and 6.3 percent No. 1 (9/142). As the ash contents reported in the Quarterly Cargo Bulletins are averages of a large number of cargoes they should be fairly representative of the wheat which was exported during the particular quarter. Consequently, there appears to

[189] Canadian Grain Commission, Grain Research Laboratory, *Quality of Canadian Grain Exports, Red Spring Wheat Quarterly Bulletin.*, Winnipeg: GRL. Various Issues.

be a loose inverse relationship between Grade number and ash content.

Table 6.2. Frequency of Original Ash Content.

Ash Content	Frequency	Percent
.42	1	0.36
.43	8	2.9
.44	12	4.35
.45	25	9.05
.46	50	18.12
.47	45	16.3
.48	49	17.75
.49	36	13.05
.50	21	7.6
.51	11	3.99
.52	11	3.99
.53	5	1.82
.54	2	0.72
Total	276*	100

*The 276 samples were for the two ports, six grade/segregations for 26 quarters.

Source: Calculated from C.G.C. Canadian Wheat Cargoes Quarterly Bulletin, Various Issues and C.G.C. Quality of Canadian Grain Exports: Red Spring Wheat Quarterly Bulletin, Various Issues.

Wheats which have lower than .48 to .50 percent ash content can be milled at a higher extraction rate if they are to attain flour with an allowable ash content between .48 and .5. However, increasing the extraction rate reduces the cost of the flour as more is obtained for a unit of wheat. Therefore, millers, should be willing to pay more for a wheat which has a lower ash content given the same initial extraction rate of .75.

Table 6.3. Distribution of Grades/Segregations by Ash Content Range

	Ash Content Range[1]			
Grade/Segregation	Less than .48	.48 -.50	More than .50	Total
CWRS No. 1 (14.5)	30	14	2	46
CWRS No. 1 (13.5)	38	10	4	52
CWRS No. 1 (12.5)	25	16	3	44
CWRS No. 2 (13.5)	18	21	1	40
CWRS No. 2 (12.5)	18	16	8	42
CWRS No. 3	12	29	11	52
Total	141	106	29	276

1. Assumes 75 percent extraction rate.

Source: Calculated from C.G.C. Canadian Wheat Cargoes Quarterly Bulletin, Various Issues and C.G.C. Quality of Canadian Grain Exports: Red Spring Wheat Quarterly Bulletin, Various Issues.

Inconsistency in ash content between crop years was observed. Within any crop year and any quarter, No. 2 CWRS wheats may have a lower ash content than the No.1 CWRS wheats in another quarter. During the study period, there were three crops years where no samples contained ash in excess of .50 percent. Also the ash content for the same grade and protein segregation in the same quarter of a crop year may differ between export locations.

This variability of ash content mitigates against using ash content as a selling feature for CWRS wheat. If ash contents were consistent within a grade over time, the CWB would be able to extract premiums. For example, if No. 1 (13.5) always had an ash content between .44 and .46 percent at a 75 percent extraction rate, a premium could be charged as the miller would be able to extract more wheat flour.

6.5. Spreadsheet Analysis

The results of the spreadsheet analysis are presented in Appendix 1 and Appendix 2 in Tables A1 to A7 and B1 to B6, respectively. The spreadsheet analysis shows the impact of correcting for ash content in the wheat on the cost of the wheat flour to the miller. The allowable ash content in the flour was set at .50 percent in this part of the analyses. Each is organized as follows:

- The Wheat Number is presented in the first column.
- The second column indicates the ash content of the wheat flour as reported in the quarterly cargo bulletins[190].
- The third column shows the estimated selling price of the wheat.
- The fourth column presents the calculated cost of the wheat flour uncorrected for the allowable ash content.
- The fifth column shows the corrected cost of the wheat flour using the ash correction factor[191].
- Columns six shows the differences in cost between the selling price of the wheat and the cost of flour uncorrected for the ash content. The difference in the selling price of wheat (column 3) and the uncorrected flour cost (column 4) is attributable to initial moisture content, foreign material content, exaction rate and

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[190] Canadian Grain Commission, Grain Research Laboratory, *Quality of Canadian Grain Exports, Red Spring Wheat Quarterly Bulletin*, Winnipeg: GRL, Various Issues.

[191] In this part of the analysis all wheats were corrected to a standard ash content of .50 percent ash using the following ash correction factors: No.1 CWRS wheats: .38; No.2 CWRS wheats:.48; and No. 3 CWRS wheat:.50.

the millfeed price.

- Column seven shows the difference in cost between the selling price of the wheat and the cost of flour corrected for ash content.
- Column eight shows the difference in the cost of flour to the miller due to the ash correction.

Tables A1 to A7 in Appendix 1 are organized on a crop year basis starting with Crop Year 1980/81 and ending with the first half of crop year 1986-87. Tables B1 to B6 in Appendix 2 contain the same information as in Appendix 1, but are organized on the basis of grade and protein segregation.

6.5.1. CWRS Wheat Information Identification

The CWRS wheat data used in the research covered 26 crop year quarters, two export ports, three grades and six protein segregations. To simplify the identification of the data, the following identification system was used[192]. The Wheat Number listed in the tables indicates the export location, year, quarter, and grade of wheat. The first column of the Wheat Number indicates the port; Pacific coast samples start with the number 8 and Atlantic port export samples with number 9. The second column of the Wheat Number indicates the crop year of the sample, the number corresponds to the latter year denoted in the crop year. For example, the number 1 indicates crop year 1980-81. The third column of the wheat number indicates the quarter within the crop year the numbers 1,2,3,& 4, corresponding to the first, second, third and fourth quarters respectively. The fourth, and last column in the wheat number indicates the grade and protein segretations as follows:

[192] The same system was used for the U.S. DNS and the three Australian wheats. The codes which relate to these other wheats will be outlined in a later chapter.

Number 1 = No.1 CWRS 14.5 percent protein

Number 2 = No.1 CWRS 13.5 percent protein

Number 3 = No.1 CWRS 12.5 percent protein

Number 4 = No.2 CWRS 13.5 percent protein

Number 5 = No.2 CWRS 12.5 percent protein

Number 6 = No.3 CWRS, No protein segregation

Wheat No. 8214 indicates a No.2 CWRS (13.5) exported from the Pacific ports during the first quarter of Crop Year 1981/82.

6.5.2. Wheat Flour Costs by CWRS Grade/Segregations

The real cost of wheat to the miller, for each grade, at each port during each quarter it was available, is listed in Appendix A, Tables A1-A7. The wheat selling price, the uncorrected flour cost associated with each sample is also listed. For example during the first quarter of crop year 1980/81 (Table A1), the selling prices of No.1 CWRS 13.5 (Wheat No. 8112) and No.3 CWRS (Wheat No. 8117) were $269.00/tonne and $254.47/tonne, respectively, a difference of $14.53/tonne. However, when the real costs of these wheats to the miller are determined, the prices are $312.96 for the No.1 and $310.93 for the No. 3 CWRS wheat, a difference in cost of $2.03 or a reduction in the price spread of $12.5/tonne. This narrowing in the price spread is not suprising as lower grades of CWRS wheat contain more foreign material and usually have higher moisture content than the higher grades.

The results listed in Appendices B are summarized in Table 6.4. The average wheat selling price, corrected and uncorrected flour costs are listed for each grade by port over the 26 quarters of the study period. With the exception of No. 2 CWRS (13.5), the wheat selling prices decline with protein segregation and with grade. The uncorrected flour costs also decline with the protein level and the grade. This was expected as the price of the corresponding wheat used was also less. The trend toward declining flour costs by protein segregation and grade continued for corrected flour costs at the Pacific coast but the progression was not as smooth. However, this tendency was not exhibited for Atlantic blends. In fact the real cost of No. 1 (14.5) $268.66 approximated that of CWRS No. 3., $267.22. This anomoly can be more easily explained if the differences between the selling price of wheat and the uncorrected and corrected flour costs are analyzed.

The spread between the wheat selling price and the uncorrected flour costs (S-U;column 6) increases as the grade decreases. The S-U spread ranged from $44.85 for No. 1 (14.5) in the Pacific to to $48.432 for No. 3. Similarly, the S-U spread was $41.48 for No.1 (14.5) versus $46.88 for No. 3. This is not unexpected as the moisture and foreign material content increases as the grade decreases, reducing the usable quantity of wheat per tonne purchased hence increasing the cost of flour. Consequently, lower grades may cost less but their cost advantage is somewhat eroded as indicated by the uncorrected flour costs.

As indicated previously, 89 percent of the CWRS wheats analyzed over the study period had ash contents below .50. Consequently, once the ash content of the wheat is considered in the costing, a lower corrected flour cost (C) is derived. The S-C spread

Table 6.4. Average CWRS Wheat And Flour Cost Differences

CWRS GRADE NO.	ASH	WHEAT SELLING PRICE	UNCORR. COST FLOUR	CORR COST FLOUR	SELLING MINUS UNCORR.	SELLING MINUS CORR.	DIFFER.
WEST							
ONE 14.5	0.46	252.37	297.22	292.88	44.85	40.51	4.35
ONE 13.5	0.46	244.87	287.85	283.75	42.98	38.88	4.10
ONE 12.5	0.48	241.07	283.44	280.39	42.37	39.33	3.04
TWO 13.5	0.47	235.63	280.64	276.77	45.01	41.14	3.87
TWO 12.5	0.48	237.23	282.81	279.70	45.59	42.47	3.12
NO. 3	0.50	229.64	278.08	277.06	48.43	47.42	1.02
EAST							
ONE 14.5	0.47	241.55	283.13	268.66	41.58	37.89	3.69
ONE 13.5	0.47	238.40	280.61	277.16	42.21	38.76	3.45

GRADE NO.	ASH	WHEAT SELLING PRICE	UNCORR. COST FLOUR	CORR COST FLOUR	SELLING MINUS UNCORR.	SELLING MINUS CORR.	DIFFER.
ONE 12.5	0.48	233.73	275.50	272.88	41.77	39.15	2.62
TWO 13.5	0.48	236.70	281.96	278.53	45.27	41.84	3.43
TWO 12.5	0.49	225.72	269.03	267.04	43.31	41.32	1.99
NO. 3	0.49	222.67	269.56	267.22	46.88	44.55	2.34

Source: Derived from the spreadsheet.

also shows that the S-C spread increases as the protein and grade drop but that the range in the spread is larger, Table 6.5. This trend can be attributed to

Table 6.5. Wheat Selling Price and Flour Cost Spreads

Spreads	Pacific Blends	Atlantic Blends
	$	$
S-U	3.58	5.3
S-C	6.9	6.6

Source: Author's calculation.

the ash content. The ash contents are lower for the higher grades/protein segregations consequently the extraction rate to make .48-.50 ash pan bread flours would be greater yielding a higher percent of flour. As No. 3 CWRS had the highest average ash content, one would expect two results. First, the difference between the S-U and S-C spread are smaller for No. 3 than for No. 1 (14.5), as the allowable ash content in CWRS No. 3 is close to pan bread flour requirements reducing possible changes in flour cost, Column 8, Table 6.3. Secondly, the range between the average No. 1 (14.5) and No. 3 S-C spread (Column 7) would be wider than the S-U spread (Column 6) for the same grades. For example, the range in the S-C spread for Pacific coast blends lay between $40.51 and $47.42, a difference of $6.90. The difference in the S-U range was $3.58.

The wheat selling price, the uncorrected flour and corrected flour costs were less expensive for Atlantic coast blends than Pacific coast blends with the exception of No.

2 (13.5). The S-U and S-C spreads were also less, again with the exception of No. 2 (13.5). These spreads were smaller partially due to the fact that the financial gain associated with cheaper initial wheat prices are not fully passed down to the flour; extraction rates are only around 75 percent. The extent to which flour costs were adjusted was also smaller for Atlantic coast blends. No. 1 (14.5), No. 1 (13.5), No 2 (13.5) and No. 2 (12.5) had higher ash contents on average than the same grades at the Pacific coast, accounting for smaller corrections in the flour costs. Conversely, No. 3 at the Pacific Coast had a higher average ash content hence the correction to flour costs was greater than at the Atlantic coast. The higher ash contents in wheats delivered to the Atlantic coast may be the result of different environmental and soil conditions in the eastern versus the western parts of the Canadian Prairies.

6.6. Least Cost Flour Blends Analysis

Linear Programming is a deterministic method of quantitative analysis in which an objective function is either maximised or minimized within a predetermined set of constraints. The solution to a linear programming problem shows which inputs and specific quantities of these inputs, would be used in order produce the end product and satisfy the constraints to either maximize or minimize the objective function. In the flour blending problem, the objective function was to minimize the cost of producing a specific flour that conformed to a specified set of quality constraints. Assuming that millers have no biases toward any specific segregation of CWRS wheat, the segregations selected by the model for a specific grist should be used in the miller's optimal flour blend. The basic number of observations used in this section of the study was 52, that is 26 crop year quarters times two ports. If three ash contents were used, the number of observations becomes 156. When the results are reported on the basis of the two protein content levels as well as the three ash content levels the number of observations was 312.

6.6.1. Composition of Least Cost Pan Flour Bread

The number of times a particular segregation is included in a flour blend is shown on Tables 6.6 and 6.7 A to F. Each table shows the results for a particular grade and segregation, for all the crop years for both small bakery (12.6 to 13.5 percent protein) and large bakery (11.8 to 12.5 percent protein) flours.

Not unexpectedly, Table 6.6A indicates that small bakery flours utilized a higher proportion of No.1 CWRS (14.5) than did larger bakery flours. No.1 (14.5) was present in 43.7 percent of the small bakery flour blends. In approximately 76 percent of the small bakery blends, No.1 (14.5) constituted less than 25 percent of the blend. The remaining 24 percent of the time, No.1 (14.5), it constituted between 25 and 50 percent of the wheat mix.

For the large bakery flours, No.1 (14.5) was selected only twice out of a possible 135 large flour blends and both times comprised less than 25 percent of the flour blend[193]. The low occurrence of No.1 CWRS (14.5) wheat in large bakery flours was expected, as the protein level in the wheat is much higher than required.

The number of times No.1 CWRS (13.5) was selected in the two flours is shown on Table 6.6B. The small bakery flour has a high enough protein content range to mill

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[193] The actual contribution of No.1 CWRS 14.5 to these two blends were 6.919 percent and 10 percent. In addition, both of these were individual instances resulting from changes in the ash content.

Table 6.6A Occurrence of Segregations In Blends, NO.1 CWRS 14.5 Wheats: Small Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	18	6	33.33	3	3			
1981-82	24	6	25.00	6				
1982-83	18	8	44.44	8				
1983-84	21	12	57.10	12				
1984-85	24	7	29.10	3	4			
1985-86	24	14	58.30	10	4			
1986-87	6	6	100.00	3	3			
TOTAL	135	59	43.70	45	14			
PERCENT	OF	USED		76.27	23.73			

Source: Author's calculations based on linear programming results.

Table 6.6B Occurrence of Segregations in Blends, NO.1 CWRS 13.5 Wheats: Small Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	24	9	37.50	3	3	3		
1981-82	24	12	50.00	3	6	3		
1982-83	24	4	16.67	1	2			1
1983-84	24	12	50.00	5	2	3	2	
1984-85	24	12	50.00	7	5			
1985-86	24	3	12.50	3				
1986-87	12	0						
TOTAL	156	52	33.33	15	20	14	2	1
PERCENT OF USED				28.85	38.46	26.92	3.85	1.92

Source: Author's calculations based on linear programming results.

Table 6.6C Occurrence of Segregations In Blends, NO.1 CWRS 12.5 Wheats: Small Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	21	9	42.80	4	3	2		
1981-82	24	15	62.50		9	6		
1982-83	24	7	29.10	4	3			
1983-84	24	11	52.30	4	4	3		
1984-85	12	9	75.00	3		6		
1985-86	7	0						
1986-87	12	3	25.00	3				
TOTAL	135	54	40.00	18	16	20		
PERCENT	OF	USED		28.85	38.46	26.92	3.85	1.92

Source: Author's calculations based on linear programming results.

Table 6.6D Occurrence of Segregations In Blends, NO.2 CWRS 13.5 Wheats: Small Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	12	9	0.75	4	3	2		
1981-82	24	0						
1982-83	24	8	33.33	3	5			
1983-84	24	0						
1984-85	18	2	11.11	2				
1985-86	21	9	42.80	5	4			
1986-87	12	6	50.00		3	3		
TOTAL	135	34	17.77	14	15	5		
PERCENT	OF	USED		41.18	44.12	14.70		

Source: Author's calculations based on linear programming results.

Table 6.6E Occurrence Of Segregations In Blends, NO.2 CWRS 12.5 Wheats: Small Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	15	12	80.00	3		3	3	3
1981-82	18	3	16.67			3		
1982-83	21	13	61.90	2	3	5	3	
1983-84	18	7	38.88	4			3	
1984-85	18	6	33.33		3		3	
1985-86	24	15	62.50	3			9	3
1986-87	12	3	25.00			3		
TOTAL	126	56	44.44	12	6.00	11.00	21.00	6.00
PERCENT	OF	USED		21.42	10.71	19.64	37.50	10.72

Source: Author's calculations based on linear programming results.

Table 6.6F Occurrence of Segregations In Blends, NO.2 12.5 CWRS Wheats: Small Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	24	12	50.00	3	6	3	3	
1981-82	24	21	87.50	3	9	9		
1982-83	24	17	70.83	4	2	3	5	3
1983-84	24	20	83.33	4	3	5	2	3
1984-85	24	21	87.50	5	10	3	3	
1985-86	24	15	62.50	3		11	1	
1986-87	12	9	75.00		3	3	3	
TOTAL	156	118	75.64	25	33	37	17	6
PERCENT	OF	USED		21.19	27.97	31.36	14.40	5.08

Source: Author's calculations based on linear programming results.

Table 6.7A Occurrence of Segregations In Blends, NO.1 14.5 CWRS Wheats: Large Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	18	0						
1981-82	24	0						
1982-83	18	0						
1983-84	21	0						
1984-85	21*	1	4.76	1				
1985-86	24	1	4.17	1				
1986-87	6	0						
TOTAL	135	2	1.48	2				
PERCENT OF USED				100.00				

Source: Author's calculations based on linear programming results.

Table 6.7B Occurrence of Segregations In Blends, NO.1 13.5 CWRS Wheats: Large Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	24	6	25.00		6			
1981-82	24	7	29.17	1	3	3		
1982-83	24	3	12.50	3				
1983-84	24	2	8.33		2			
1984-85	21	5	23.81	2	3			
1985-86	24	0						
1986-87	12	3	25.00		3			
TOTAL	153.00	26.00	16.99	6	17	3		
PERCENT	OF	USED		23.08	65.38	11.54		

Source: Author's calculations based on linear programming results.

Table 6.7C Occurrence of Segregations In Blends, NO.1 12.5 CWRS Wheats: Large Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	21	15	71.43	3	9		3	
1981-82	24	23	95.83		9	11	3	
1982-83	24	3	8.33			3		
1983-84	21	14	66.67	8	1	5		
1984-85	9	6	66.67			3		3
1985-86	21	6	28.57	5		1		
1986-87	12	3	25.00	3				
TOTAL	135	70	51.85	19	19	23	6	3
PERCENT	OF	USED		27.14	27.14	32.87	8.57	4.28

Source: Author's calculations based on linear programming results.

Table 6.7D Occurrence of Segregations In Blends, NO.2 13.5 CWRS Wheats: Large Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	12	3	25.00	3				
1981-82	24	0						
1982-83	24	3	12.50	3				
1983-84	24	0						
1984-85	18	3	16.67	3				
1985-86	21	0						
1986-87	12	0						
TOTAL	135	9	6.67	9				
PERCENT OF USED				100.00				

Source: Author's calculations based on linear programming results.

Table 6.7E Occurrence of Segregations In Blends, NO.2 12.5 CWRS Wheats: Large Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	15	12	80.00	3		3	3	3
1981-82	18	6	33.33	3	3			
1982-83	21	18	85.71	3			6	9
1983-84	18	10	55.56		1	3	3	3
1984-85	18	9	50.00			6	3	
1985-86	24	15	62.50		7		3	5
1986-87	12	0						
TOTAL	126	70	55.56	16	4	12	16	20
PERCENT OF USED				22.86	5.71	17.14	25.72	28.57

Source: Author's calculations based on linear programming results.

Table 6.7F Occurrence of Segregations In Blends, NO.3 CWRS Wheats: Large Bakery

CROP YEAR	POSSIBLE USE	ACTUAL USE	PERCENT OF POSSIBLE	ONE	TWO	THREE	FOUR	FIVE
1980-81	24	16	66.67	7	3	3		3
1981-82	24	24	100.00	9	14		1	
1982-83	24	12	50.00	6			3	3
1983-84	24	21	87.50	3	6	6		6
1984-85	21	18	85.71	6	6	3		3
1985-86	24	19	79.17	3	1	3	4	8
1986-87	12	12	100.00			3		9
TOTAL	153	122	79.74	34	30	18	8	32
PERCENT	OF	USED		27.87	24.59	14.75	6.55	26.23

Source: Author's calculations based on linear programming results.

flour exclusively from No.1 (13.5). However, in only one case was flour exclusively milled from No.1 CWRS (13.5), and twice where the segregation constituted more than 75 percent of the flour blend. In total, No. 1 (13.5) CWRS was used in only 33 percent of the blends for small bakery flours[194]. Suprisingly, CWRS No 1. (14.5) was used more frequently in small bakery blends (43.7 percent) than No.1 (13.5) wheat (33.3 percent), albeit CWRS No.1 (14.5) comprised a smaller proportion of the total segregation.

No.1 (13.5) was used in large bakery flour blends 16.99 percent of the time. Only in three cases, did No. 1 CWRS (13.5) contribute more than 50 percent of the wheat for a blend. These three occurred in the same crop year and were shipped from the same export port.

The contributions of No.1 CWRS (12.5) to the small and large bakery flours are shown on Table 6.6C. The total use ratio, as expected, is higher for the large bakery flour than for the small bakery flour. However, small bakery flour blends utilized CWRS No 1 (12.5) more frequently than CWRS No. 1 (13.5). CWRS No.1 (12.5) was used in 40 percent of the blends and CWRS No. 1 (13.5) in 33 percent. It would seem that least cost small bakery flours are better achieved by blending 12.5 and 14.5 percent protein wheat than 13. 5 exclusively, particularly at the higher allowable protein range of the flour. For both flour blends, the amount of No. 1 CWRS (12.5) used in the blend

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[194] It should be noted, as stated previously, for each blend an additional run was carried out with the upper limit of the protein range for small bakery flours being increased to 13.8 percent. The increase in the upper limit of protein was carried out to test whether this would change the results of the blends. No change was seen and most of the small bakery blends tended to have protein towards the lower end of the range.

is less than 50 percent in more than half the cases.

The incidence of No.2 CWRS (13.5) wheat used in the two flour blends are shown on Table 6.6D. This segregation is used in fewer cases and has a lower use ratio for each pan flour than any other segregation used in the study. Based on least cost solutions, No. 1. (13.5) was selected 10 percent more often than No.2 (13.5) for both pan flours. In only 5 of a potential 270 cases (1.85 percent), did No. 2.(13.5) account for more than 50 percent of a flour blend, even though this segregation is a lower cost segregation than the No.1 (13.5) CWRS wheat.

The No.2 CWRS (12.5) wheat results are presented on Table 6.6E. While No. 1 (13.5) was more often selected over No 2.(13.5), the reverse was true for No. 1 and No.2 (12.5). No. 2 (12.5) was used in 44 percent of small bakery blends as compared to 40 percent No. 1 (12.5). Similarly, No. 2 (12.5) was used in 55 percent of the large bakery blends and No.1.(12.5) in 51.5 percent of the possible blends. Not only was No.2 (12.5) used in more blends, it also contributed a larger portion of the wheat mix among the small bakery flour blends when it was used; No. 1 (12.5) constituted over 50 percent of the wheat used in 37 percent of the blends, whereas No. 2.(12.5) constituted over 50 percent of the wheat in 67 percent of the blends. An increased use of No. 2 (12.5) in large pan flour was also visible; No.2 (12.5) constituted 50 percent of the wheat mix in 71 percent of the blends as compared to 45.7 percent for No.1 (12.5). In 28.6 percent of the blends No.2 (12.5) constituted 100 percent of the wheat used in the large bakery flour blend.

The results for No.3 CWRS wheat are shown in Table 6.6F. CWRS No.3 was used more frequently in flour blends than any other grade or segregation. This grade had a total use ratio of 75.6 and 79.4 for small bakery and large bakery flours, respectively. No.3 was used exclusively in six cases of small bakery flours. In 51 percent of the small bakery flour blends produced, No.3 constituted more than 50 percent of the wheat in the mix. This emphasizes that although the grading system down graded the wheat to No. 3, the protein content and other factors were of sufficient quality to produce small bakery flour.

For large bakery flour, the table shows No. 3 CWRS was used exclusively 32 percent of the time. This indicates that the lowest quality No. 3 CWRS wheat is frequently of sufficient quality to produce acceptable pan bread flour. In the large bakery flours, No. 3 constituted more than 50 percent of the mix 47.5 percent of the time, slightly less than the small bakeries. One would expect the reverse to be true with respect to No. 3 CWRS. Overall, the fact that No.3 occurred in so many flour blends indicates that this particular grade is more competitive in the pan bread flour market than the other grades and segregations.

6.6.2. Grade and Protein Range Analysis

The preceding section discussed the results of blending the six grade/segregations of CWRS wheat to produce two pan bread flours on a free choice basis, i.e. the package was not restricted to specific grades. The analysis indicated that No. 3 CWRS was used in wheat blends more than any other grade. A hypothetical third flour blend with a protein range, 11.3 to 12.0 percent, was added to this analysis to determine the potential use for a CWRS wheat mix in a lower protein flour. Also to determine the impact of specific segregations, the grades/segregations available were restricted.

The first set of the three flour blends was restricted to selecting from the three protein segregations 14.5. 13.5 and 12.5 for No. 1 CWRS. The second set of simulated flour blends was then restricted to all protein segregations of No. 1 and No. 2 CWRS wheats. The third set utilized all three grades of CWRS wheats.

The results of the formulations restricted to using No. 1 CWRS wheats are presented on Table 6.8. The first three columns of the Table show the number of times a feasible solution occurred for each of the various end-use flours. Of the 26 quarters and two ports for which wheat sample characteristics were provided, there were only two instances where a feasible solution was reached for the hypothetical flour blend. Protein content was the major constraint in all infeasible solutions for the hypothetical flour blends. As the designation 13.5 and 12.5 percent protein are minimum guaranteed protein levels, the level is too high for a feasible solution to be reached.

Out of 52 possible large bakery flour blends, there were only 24 feasible solutions. This is particularly interesting as No.1 CWRS wheat is primarily a pan bread wheat. Thus in more than 50 percent of the cases, No. 1 CWRS does not conform to the flour specification for the major target market. More suprising there were only 18 feasible solutions for small bakery blends out of a possible 52, a 34.6 percent feasibility rate. Protein was not the primary reason for the poor feasiblility rate among small bakery blends relative to large bakery blends. Rather the level of other wheat qualities constrained the solutions as they did not conform to the constraints. In many cases the level of the characteristics were "better than required for the small bakery bread, but they

Table 6.8. Separate Grade Blending Results, Number One Wheats Only

CROP YEAR	FEASIBLE SOLUTIONS VARIABLE PROTEIN			SEGREGATIONS USED OUT OF POSSIBLE			CONSTRAINTS PREVENTING FEASILITY
	LOW	MED.	HIGH	ONE 14.5	ONE 13.5	ONE 12.5	TYPES & NUMBER
80-81	1	2	2	0/2	2/4	3/4	G-11,T-6, S-12, P-2
81-82	1	4	7	4/12	4/12	12/12	P-3, L-1, S-3
82-83	0	3	2	0/3	4/5	5/5	G-10, P-3, V-1
83-84	0	7	4	2/10	4/11	11/11	P-3, G-1
84-85	0	2	0	0/2	0/2	2/2	G-11,S-11,T-11, H-2
85-86	0	3	3	3/6	3/6	5/6	G-9, P-3
86-87	0	3	0	0/3	0/3	3/3	P-4, S-2, G-2, H-1

Source: Results from linear programming runs.

did not fall into the required range of acceptable characteristic levels. Using an analogy, a Cadillac is perceived to be "better" than a Honda Civic but if it cannot fit into a parking space it is not as useful as a car that can.

The constraints which prevented solutions for the small and large bakery flours are listed in the far right column of the table and are abbreviated as follows:

P = Protein Content,	H = Water Absorption,
T = Thousand Kernel Weight,	L = Liquefaction Number,
G = Wet Gluten,	S = Starch Damage,
V = Amylograph Peak Viscosity (modified)	W = Alveograph W.

Wet Gluten, which is closely associated with protein content, appeared more often as a barrier to feasibility than any other constraint. However, in many cases wet gluten was not the only constraint appearing in the infeasible solutions. In these cases a feasible solution was unattainable due to a combination of two or more constraints not being satisfied.

It is apparent from the number of feasible solutions, that No.1 CWRS wheats are less suitable for producing pan bread flours than for which the class was intended. In only two crop years, 1981/82 and 1983/84, were feasible solutions achieved more than 50 percent of the time.

The "Segregations Used out of Possible" column shows the number of times the particular segregation was used in a feasible solution and the number of possible times the segregation could have been used in the solution[195]. The total use and possible use number and the subsequent percentages are shown at the bottom of the Table. These figures are useful to compare to Table 6.6 and 6.7A-F presented earlier and Table 6.9 which is discussed later. The No.1 CWRS (12.5) is the most commonly included segregation of this particular grade. The most probable reason for the frequent inclusion of No.1 (12.5) is it is lower priced due to lower protein content. The low number of feasible solutions for the small bakery blend (12.6 - 13.8 percent)[196] casts some doubt upon Canada's emphasis on producing higher protein wheats, at least in the pan bread markets.

The least cost solutions for the three flour blends when No.2 CWRS wheats were included in the selection are shown in Table 6.9. Out of the 52 possible occasions, No. 1 and No. 2 CWRS can be used to produce the hypothetical low protein product only four times. This suggests that No. 1 and No.2 CWRS wheats alone have limited potential for the production of low protein wheat flours. However, the number of feasible solutions for the large and small bakery flours increased substantially when No. 2 CWRS wheat was included in the wheat choices available. The percent feasible solutions for small bakery blends increased from 34.6 percent when only No. 1 CWRS was available, to 64 percent when No. 2 wheats were added. Similarly, large bakery

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[195] In some crop year quarters a particular segregation was not exported through a port thus quality data was unavailable for use in the study and consequently for inclusion in a flour blend.

[196] During this section of the analysis the top level of the protein content range was increased to 13.8 percent in order to attempt to include more of the higher protein segregations in the feasible flour blends.

Table 6.9. Separate Grade Blending Results, Number One And Two Wheats Only

CROP YEAR	FEASIBLE SOLUTIONS VARIABLE PROTEIN LOW	MED.	HIGH	SEGREGATIONS USED OUT OF POSSIBLE ONE 14.5	ONE 13.5	ONE 12.5	TWO 13.5	TWO 12.5	CONSTRAINTS PREVENTING FEASIBILITY TYPES & NUMBER
80-81	2	4	6	2/6	3/12	5/10	4/7	8/9	G-6, S-8, P-2, T-6
81-82	1	5	7	2/16	5/13	10/13	1/13	7/11	P-2, W-1
82-83	1	5	2	0/5	2/8	2/8	1/8	7/8	H-1, G-4, P-3, V-1
83-84	0	7	7	2/12	5/14	14/14	1/14	6/9	NONE LISTED
84-85	0	5	4	1/9	5/9	4/6	1/7	6/7	G-6, H-4, T-2, S-1
85-86	0	6	6	6/13	2/13	3/12	5/13	9/13	H-1, G-3
86-87	0	4	0	0/2	0/4	1/4	0/4	3/4	P-4, S-2, G-1

Source: Calculated by author.

flour feasible solutions increased from 46.2 percent to 72 percent.[197]

These results indicate that No.2 CWRS is necessary for producing pan bread flour as No. 1 CWRS segregations cannot fulfill the requirements alone. The information also suggests No. 2 (12.5) is a substitute for No. 1 (12.5) as No. 1 (12.5) use in the feasible solutions declined from 95.3 percent to 56.7 percent. No. 2 (12.5) was used in 75.4 percent of the feasible solutions. The replacement of No.1 (12.5) by No.2 (12.5) indicates that the less expensive and lower "quality" wheat appears to be better suited to the market.

Despite a reduced use of No. 1. (12.5), both (No.1 and No.2 12.5) percent protein segregations individually constitute the two largest contributions to the blends. One reason 12.5 percent segregations are often selected is the minimum protein content guarantee. Guaranteeing a minimum protein content of 12.5 means the resulting flour can also have a protein content close to 12.5 percent. Wheat with 12.5 percent protein can technically be the sole contributor to large bakery flours and a major contributor to small bakery flour.

The addition of No. 2. (13.5) to the selection of available wheats, did not replace No. 1 (13.5) use. Rather No. 1 (13.5) was used more frequently than No.2 (13.5); No. 1 (13.5) being used in 31.3 percent of possible cases and No. 2 (13.5) in 19.7 percent.

[197] The percentage increase figures actually understate the impact of the No. 2 CWRS wheats on the increase in the number of feasible solutions as neither No.2 13.5 or 12.5 was available in two quarters of 1984-85 through the Atlantic ports. The results from the formulation for the No.1 CWRS wheats for these two quarters were infeasible, thus the No.2 results are understated in the percent total on Table 6.9

There are several possible explanations why No. 2 (13.5) was used relatively less. No.2 (13.5) is higher priced than No. 2 (12.5) but it's quality characteristics are similar to those of No. 2 (12.5). The lack of No. 1 CWRS attributes in No. 2 CWRS combined with higher protein may also result in a segregation where market niches are difficult to determine.

The 13.5 percent protein wheats could be the sole input in the upper range small bakery flour, but their protein content is too high for the large bakery flour. In addition, for the 13.5 percent protein wheats to be blended with 12.5 percent wheat, the protein levels in the 12.5 must be near 12.5. The same holds for the 14.5 percent protein segregation which needs to be blended with low protein wheats in order to produce an acceptable protein level in the flour.

The inclusion of No.2 CWRS segregations in the potential formulation choices, changed the number and sometimes type of the constraints which prevented feasible solutions. The only constraint which increased in frequency was water Absorption (H) in 1984/85 and 1985/86. Wet Gluten (G) and Starch Damage (S) continued to be the predominant constraints preventing feasibility albeit less frequently. The number of formulations during Crop Year 1980/81 in which Thousand Kernel Weight was a constraint to feasibility did not change with the addition of the No.2 CWRS wheat to the selection. The consistency in the number of times Thousand Kernel prevented feasible solutions indicates that the CWRS wheat was lighter than normal during this crop year.

The addition of No. 3 CWRS wheats to the inputs matrix increased the number of feasible solutions for the hypothetical flour blend to 11 out of a potential 52 possible blends. This was a feasibility ratio of 21.15 percent. Six of the 11 hypothetical blends were the same as the large bakery blends indicating that the large bakery blends were formulated towards the low end of their protein range and the hypothetical blend towards the high end of its range.

The five remaining feasible low protein blends present an interesting case in that four of the five resulted in a higher cost flour than the large bakery flour. The average amount by which the cost of the hypothetical blends exceeded the large bakery blends was $5.87. These ranged from a high during the third quarter 1983-84 at Pacific ports of $16.99 to a low of $0.17 for Atlantic ports shipments in the second quarter of 1982-83. The only feasible hypothetical blend which cost less than the large bakery blend was $0.34 less expensive.

These five low protein solutions were more expensive than the large bakery flours and contained No. 3 CWRS exclusively. The quality of No. 3 fluctuates between quarters, ports and crop years more than any other grade. No. 3 also contains more foreign material than the other grades and often has higher ash and moisture contents. Thus the actual cost of flour from No. 3 may be higher in some instances than other grades.

6.6.3. Comparison of Small and Large Bakery Blend Costs

Protein content is one of the major determinants in the price of wheat sold. In general the higher the protein content, *ceteris paribus*, the higher the price of the wheat. Flours which require higher protein wheat in their grist should therefore cost more than those which require a lower level of protein, the difference in cost being partially attributable to the higher protein. Intuitively, small bakery flour, which requires higher protein content than large bakery flour, should be the higher cost flour. However, higher protein flour blends sometimes cost less or the same as lower protein blends.

The frequency which small bakery high protein blends cost less than large bakery low protein blends is presented by crop year in Table 6.10. Price fluctuations in the world wheat market mitigate between crop year comparisons concerning the effect of ash content level on flour costs. As CWB payments to producers were used to determine CWRS wheat prices, within crop year comparisons can be made concerning the patterns and trends between the different grades/segregations.

Forty-six cases occurred where the cost of the higher protein blend was lower than for the lower protein blends. In three instances, the costs of the flour was exactly the same for both blends. Consequently, almost 30 percent of the time there was no cost advantage to using lower protein wheats. One reason for this occurrence was a limited choice of available grades/segregations for lower protein wheat. Another reason may be that the lower ash higher grade wheats were able to be extracted at higher rates hence reducing the costs of small bakery blends.

Infeasible solutions occurred in only three instances. The infeasibilities all occurred due to the lack of choices for flour blends in the Atlantic shipments during the third quarter of 1984/85. The grades/protein segregations which were available did not possess the level of quality characteristics which would result in a feasible solution. Feasible solutions could have been produced by changing the levels of the constraints. However, changing the constraints creates different conditions hence flour costs which are not comparable with the other flours.

Table 6.10. Frequency with which Small Bakery Blends Cost Less than Large Bakery Blends.

CROP YEAR	NUMBER OF SAMPLES LOWER OR SAME PRICE	TOTAL SAMPLES[1]	PERCENT
1980-81	8	24	33.37
1981-82	15	25	62.40
1982-83	6+	24	25.00
1983-84	3	24	12.50
1984-85	12(3)*	21(3)*	57.14
1985-86	2+	24	8.33
1986-87	0	12	0.0
Totals	46	153(3)*	30.07

+ Denotes that the large and small bakery flours costs were identical on one occassion.

* The number in parentheses indicates an infeasible solution for large bakery flours due to a limited number of potential input wheats from which to choose.

1. For each crop year there were 12 samples for each product representing the four quarters and the three ash levels.

Source: Author's calculations.

6.6.4. The Effect of Allowable Ash Content

As was discussed earlier in the chapter the cost of producing wheat flour varies with wheat ash content level and ash correction factors. Therefore, ash content may impact on the selection of the particular segregations utilized in a flour formulation during a crop year quarter. The number of times during each crop year a change in ash content changed the CWRS wheat segregations selected for the two pan flour blends are shown on Table 6.11.

Table 6.11. Changes in Segregation Selection Based on Ash Content Level

Crop Year	Large Bakery	Small Bakery
1980/81	3	3
1981/82	1	0
1982/83	1	4
1983/84	3	4
1984/85	1	0
1985/86	3	2
1986/87	0	0
TOTAL CHANGES	12	13
TOTAL SETS*	51	52
PERCENT OF POSSIBILITIES	23.5**	25.00

* Based on 26 quarters for both ports.

** Due the limited segregations available through the Atlantic ports during the third quarter of crop year 1984-85, the Large Bakery flour was not included. Thus for the Large Bakery flour there were a total of 51 sets of flour blends with the different ash levels.

Source: Author's calculations.

Approximately 25 percent of the original cost minimizing solution selections were changed when the allowable ash content was raised from .48 to .52. Lower quality[198]

[198] The term quality in this case is pejorative in that its use follows " conventional wisdom" in Canada in that No.1 CWRS 14.5 is of higher "quality" than is No.3 CWRS wheat.

wheat was generally selected when the allowable ash content in the flour blend was increased .52 percent ash. In 96 percent (24) of the selections which changed, No. 2 and/or No. 3 CWRS wheats were chosen over No. 1. Only in one case did the change in ash content result in the selection of a higher "quality" grade or segregation in the blend.

An inverse relationship exists between protein content and crop yield and also between crop yield and grade in the production of CWRS wheat[199]. In general, higher protein and higher grade wheats are lower yielding. Higher grades and protein segregations of CWRS wheat generally have low ash content as well. Consequently, low ash wheats ultimately receive premium prices[200]. As the acceptable level of ash in pan breads increases, lower quality wheats can be utilized. This could result in greater production of lower protein and higher yielding wheat varieties which could raise farm incomes. However, these wheats are currently discounted.

In this section, the impact of ash content on the cost of the two pan bread flours is also examined. The three ash content levels used in the analysis were .48, .50, and .52 percent ash. These three ash content levels were chosen to reflect the trend towards increased ash contents in pan bread flour.

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[199] Loyns,R.M.A., C.A.Carter,M.Kraut, W.Bushuk, J.R.Jeffrey, and Z.Ahmadi- Esfahani, *Institutional Constraints to Biotechnological Developments in Canadian Grains with Special Reference to Licensing of Varieties*, Research Bulletin No.85-1, Department of Agricultural Economics and Farm Management, Faculty of Agriculture, University of Manitoba, Winnipeg, March 1985.

[200] If there were consistency in ash content from grade to grade and year to year, the premiums that may be justified on the basis extraction rates can be increased and flour costs reduced.

The ash content in the flour did not appear to affect the number of times small bakery flours were less expensive than large bakery blends. As was indicated in Table 6.10, the cost of small bakery flours was less or the same as large bakery flours approximately 30 percent of the time regardless of the level of ash content. As mentioned previously this may be related to a trade-off in grade prices and the extraction rates that can be achieved with lower ash content wheat.

6.6.5. Binding Constraints

One of the advantages of using a linear programming model is that the constraints which prevent lower cost solutions can be identified. These binding constraints have shadow prices which are the amount that the feasible solution could be reduced had the constraint been changed by one unit. In a cost minimizing model such as one used in the study, a negative shadow price indicates that the cost of the flour could be reduced if the level of the constraint was allowed to decrease. Similarly, positive shadow prices indicate that if the constraint was increased, the cost of the flour could be reduced. For example, a negative shadow price for protein would indicate that the price of the flour could be reduced if the lower limit of the allowable protein range was reduced. Conversely, a positive shadow price for protein on the same flour blend would indicate that the flour cost could be reduced it the upper protein level were increased above 13.5 percent[201].

[201] In general, upper and lower boundaries were placed on protein levels to delineate the two pan bread flour types. As higher protein content flour is generally more expensive than lower protein flour, millers would be unwilling to produce flours with higher than requested protein contents. Also if customers were to receive flour from the mill with more protein than requested for the same price, they may continue to expect to receive

Protein, as expected, was the most frequent binding constraint for both the large and small bakery flours at all three ash content levels. Of the 103 feasible least cost flour blends at the .50 percent ash content level[202], protein was a binding constraint in 43 or 41.7 percent of the blends. There were no significant differences between the export ports for protein as a binding constraint[203]. However, there were many more instances where protein was a binding constraint for small bakery blends than for large bakery flours. Small bakery flours generally had negative shadow prices and the large bakery flour blends positive shadow prices. For the .50 percent ash content level there were a total of 52 feasible solutions for the small bakery blends, of which a lower protein content could have lowered the flour costs for 26 of these blends. In 66 percent (34 of 51) of the large bakery feasible solutions, a small increase in the protein content would not change the wheat flours utilized in the least cost blends.

The constraint which was second to protein in the number of times it appeared as a binding constraint was Wet Gluten as can be seen in Table 6.12. A total of 71 flour blends (22.98 percent) had Wet Gluten as a binding constraint. Unlike protein, the direction of the constraint did not change when the bakery size changed as all shadow

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flour with higher protein. Hence, the upper bound for flour protein is a cost rather than technically inspired constraint.

[202] Due to the lack of choices for flour blends in the Atlantic shipments during the third quarter of 1984/85, there was one infeasible solution at each ash content level which was not included for this part of the analysis. The total number of least cost runs carried out for this section at .50 percent ash was 104. The total for all three ash content levels was 312 of which 309 were feasible solutions.

[203] In the large bakery flour blends protein was binding in 21 western blends and 28 eastern blends. For the small bakery flours the occurrences for protein being binding were 41 for the west and 40 for the east.

prices were positive indicating that a higher allowable wet gluten level would have resulted in lower cost flour. However, in two of the seven crop year groups, this constraint was not binding for any of the blends, an indication of the between year variability of the quality of the wheats. Although not shown in Table 6.12, a perusal of the raw results revealed no discernable trend with respect to wet gluten being binding and export port[204]. The wheat destined for specific export locations does not have a propensity to have higher or lower wet gluten standards than the other port. The rest of the binding constraints were relatively evenly distributed and reflect the vagaries of weather and other factors rather than a problem with the grading sytem.

Liquefaction Number, the linearization of Falling Number, was binding in 15 cases. This may cause some concern because alpha-amylase content is an important factor in bread making. However, in 14 of the 15 times in which Liquefaction Number was binding, it was binding at the lower limit. A low liquefaction number can be easily remedied by adding malt to increase the enzyme activity in the flour. This low enzyme activity in CWRS wheats while being desirable in pan breads, may be a disadvantage in other flour product markets which require higher enzyme activity and less expensive wheats.

The majority of instances in which Alveograph W was binding occurred during the first two crop years of the study period. The incidence of Alveograph W being

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[204] There were 31 Pacific port blends with wet gluten binding and 40 Atlantic blends with wet gluten as a binding constraint.

Table 6.12. Frequency Quality Factors Were Binding Constraints at .5 Ash Content

Factor/ Direction[1]	WEST Large Bakery	WEST Small Bakery	EAST Large Bakery	EAST Small Bakery	TOTAL Large Bakery	TOTAL Small Bakery
Protein						
+	8	-	9	-	17	-
-	-	14	-	12	-	26
Water Absorption						
+	2	-	1	1	3	1
-	3	1	1	6	4	7
Liquefaction No.						
+	3	4	-	5	3	9
-	1	-	-	1	1	1
Thousand Kernel Wt						
+	-	-	-	-	-	-
-	4	3	-	-	4	3
Alveograph						
+	-	-	-	-	-	-
-	6	5	2	1	8	6
Starch Damage						
+	6	3	1		7	3
-	3	-	-	-	3	-
Wet Gluten						
+	3	8	6	5	9	13
-	-	-	-	-	-	-

[1] += positive shadow price; - = negative shadow prices.
Source: Results of linear programming runs.

binding then drops off with no incidence appearing during the last two crop years. This reduction may be due to changes in the varieties of CWRS wheats available during the study period, ie. producers changing from older to newer varieties during the seven or more growing seasons of the study period[205].

Of the 17 instances when Thousand Kernel weight was binding, 14 (82.4 percent) occurred in Pacific Coast least cost formulations and 12 of the 17 (70.59) in large bakery blends. The apparent trend towards the majority of the Thousand Kernel Weight constrained blends being from the Pacific Coast flours is likely due to environmental factors in the Western part of the Prairies. In addition, as large bakery flours require lower protein levels than small bakery, there is a greater tendency for No. 3 CWRS wheats which may have been down graded on the basis of the kernel weight to conform more closely with the requirements for small rather than large bakery protein and other specifications[206].

6.7. Discussion with Millers

Representatives of five flour milling companies were contacted after the research had been completed to determine if the assumptions used in the research were relevant to the flour industry. In addition it was hoped that the millers could affirm the practicability and relevancy of the research results. The millers responses to questions

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[205] Due to the possibility of carryover stocks on farms from previous crop years it is quite possible that during crop year 1980/81 and even 1981/82 there was wheat in the system produced prior to the study period.

[206] The expectation would be that No. 3 CWRS would contain shrunken kernels with a relatively high protein content.

supported the assumptions made with respect to protein level and ash contents for pan bread flours as being realistic. The discussion revealed that for pan bread flours, protein content can range from 11 to 13.5 percent depending on customer requirements, but the majority of the flour produced contains between 12 and 13 percent protein. Two of the millers stated that the trend was towards a lower protein content in flour, but one miller indicated that his/her customers preferred flour with a protein content above 13 percent.

The consensus was that ash contents in pan bread flours tended to be in the .50 to .52 percent range. However, one miller indicated that his/her customers had requested ash contents in flour as low as .46 percent. Some of the other millers said they had milled flour with ash contents as high as .53 percent. The high ash content flours, .52 and .53 percent, are produced solely for large commercial bakeries. One miller indicated that the impact of the ash content depends on what part of the kernel the ash comes from, the bran or the mineral content of the endosperm[207]. Most of the millers also indicated that over the past few years the allowable ash content in pan bread flours has increased slightly.

The responses to questions about grades of wheat used to produce pan bread flours were varied. One miller stated emphatically that they try to use No.1 CWRS exclusively. The other four millers indicated that they normally use a blend of No.1 and No.2 CWRS. The amount of the respective grades and protein levels used in the flour depends on several factors. The two major factors which dictate the relative use of the

[207] The location of the ash has an impact on the ability of the miller to increase the extraction rate.

No.1 and No.2 CWRS are (i) availability of No.2 CWRS, and, (ii) the price-quality relationship between the two grades. Some millers said that often there is not enough of the correct protein level No.2 CWRS available so they are forced to use the corresponding protein level of No.1 in their grists. One miller indicated that his/her mill would prefer to use No.1 as much as possible but cannot afford to be higher priced than other mills. Two millers said that their use of No.2 depends on the downgrading factors[208], but if the protein content and Falling Number are within acceptable ranges, they use as much No.2 as possible because it is less expensive than No.1. One miller indicated when the price difference between No.1 and No.2 is very small, they will use more No.1 in their pan bread grists.

The millers were asked whether or not they used No.3 CWRS in their grists. All millers indicated that they sometimes use No.3 CWRS, but the amount each miller uses varies between grists and years. Some millers seemed less apprehensive about using No.3 and consequently used more of that grade than others. The consensus was that 10 to 20 percent of the wheat used in pan bread flour could be No.3 CWRS. One miller indicated a willingness to use as much No.3 as possible due to the economic advantages of using this lower cost grade, and they sometimes have used 30 percent No. 3 CWRS in their grist.

The use of No.3 depends on the downgrading factors in particular the falling number, Figures 6.1 and 6.2. If a parcel of No.3 has a protein content close to 13

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[208] Downgrading factors are factors that cause grain to be downgraded to lower grade levels, ie. weathering.

percent and has a high falling number (liquefaction) indicating lower alpha-amylase activity, a miller will tend to use more No.3 in his/her grists. Two millers expressed the opinion that one of the biggest problems with No.3 CWRS was that it is not segregated by protein and if the grade was protein segregated they may be able to increase their use of the grade. All the millers said that one of the major problems with trying to use No.3 CWRS is the variability in the quality of the wheat, Figure 6.3.

The millers were asked (i) if it would be useful to know the ash content prior to purchasing the wheats and, (ii) if they would be willing to pay a higher price for wheat with a low ash content. There was no consensus to either question. However, all the millers said that if more information was available *ex ante* they would be able to make better informed purchasing decisions. One miller indicated that he/she would be willing to pay a slight premium for lower ash content wheat but the other millers were non-committal about their willingness to pay a premium for lower ash content wheat.

All millers said that because they are in a very competitive industry, they need to use any advantage to stay in business. Thus they must strive to keep their costs as low a possible while maintaining the quality desired by their customers. The answers given by the millers support the research results presented in this chapter. The miller answers also verify that the protein and ash content ranges used in the study reflect the current and future trend in the industry.

Figure 6.1 Liquefaction Numbers
No.1 (13.5) & No. 3 CWRS West Coast

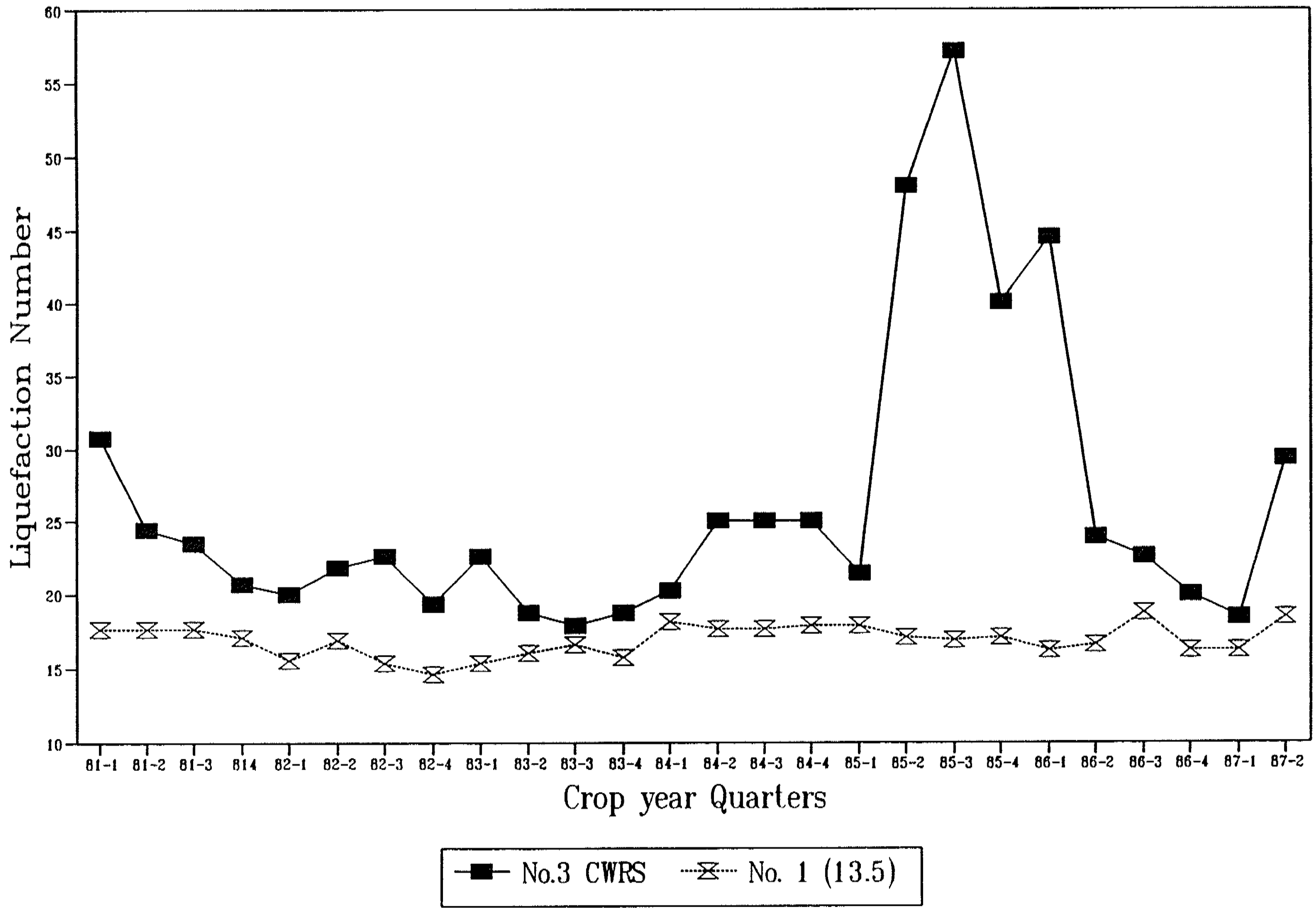


Figure 6.2 Liquefaction Numbers
No.1 (13.5) & No. 3 CWRS East Coast

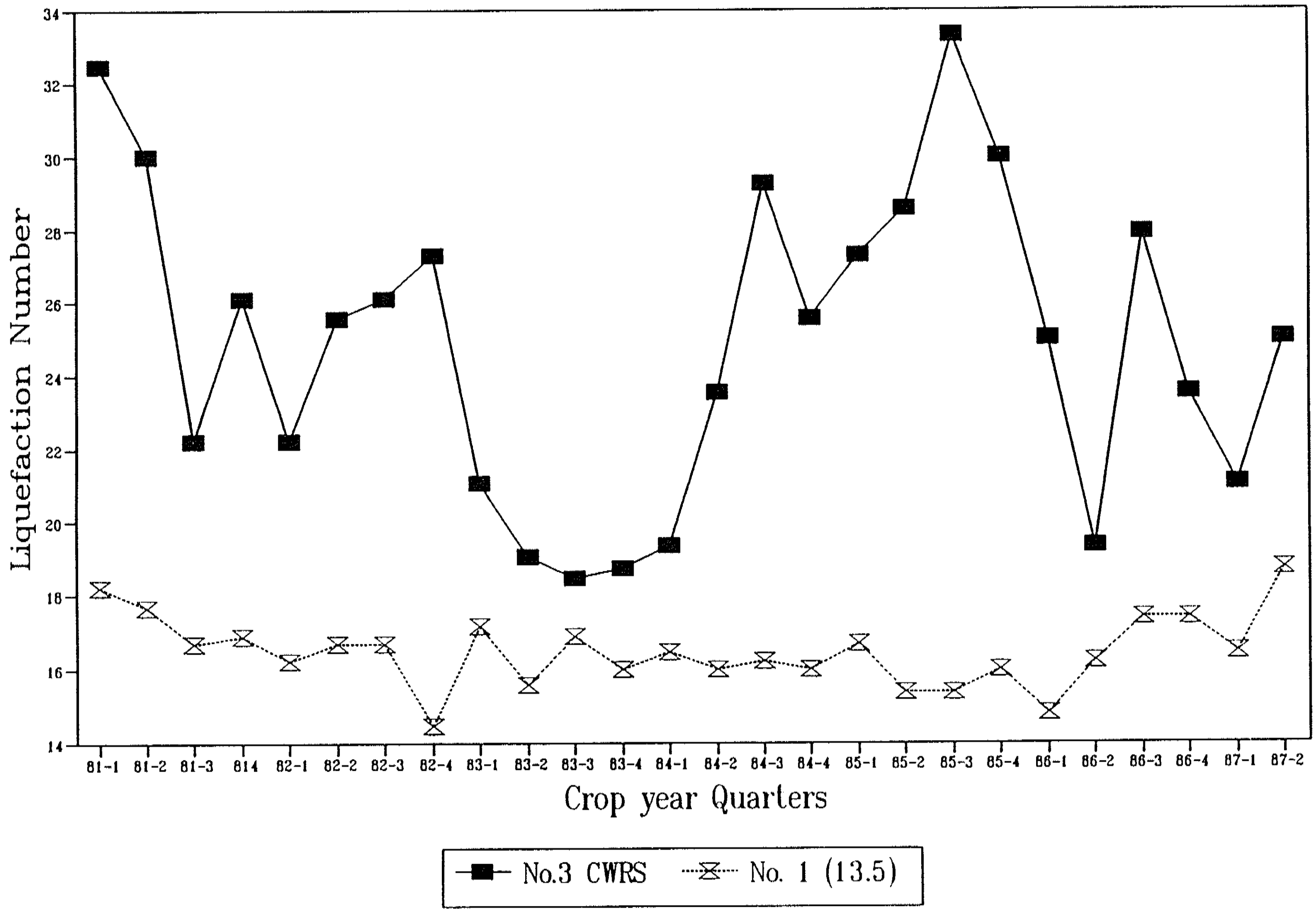
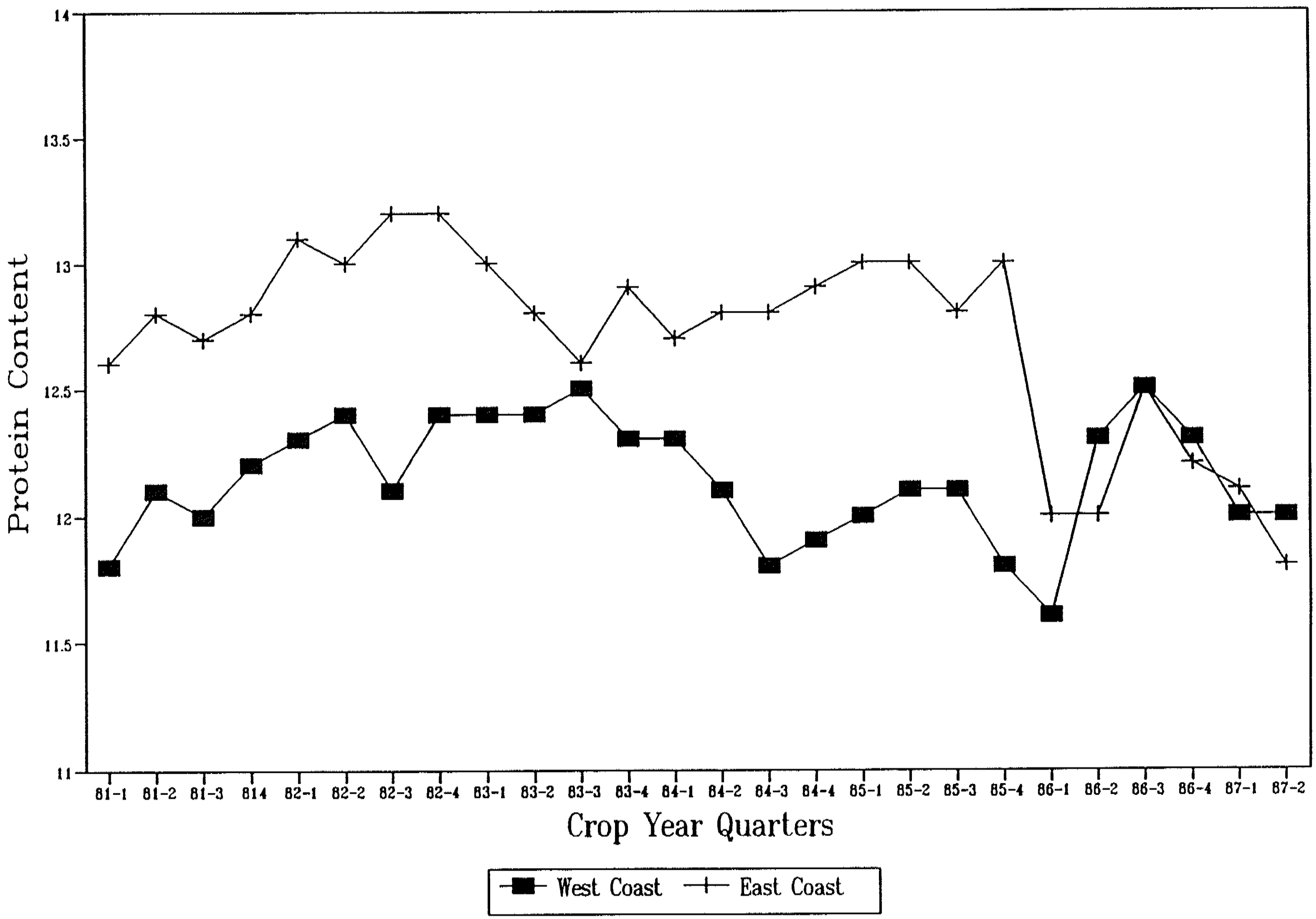


Figure 6.3 No.3 CWRS Protein
Comparison Between West and East Coast



6.8. Summary

The CWRS wheats chosen to produce flour for two types of pan breads were reviewed in this chapter. This review involved simulation of the situation prevailing in the Canadian milling industry during the mid 1980's prior to the Free Trade Agreement between Canada and the U.S. Canadian millers were essentially restricted to using wheat grown in Canada to produce flours suitable for their customers, the bakers.

The analysis also examined the factors which affect the cost of flour blends, in particular protein level, the wheat ash content and allowable flour ash content. One of the major findings in this part of the analysis is that higher protein contents in the No.1 grades of CWRS wheat are often excluded from the production of a least cost flour even for the higher protein content small bakery flours. The three protein segregations of No.1 CWRS appeared to contain higher or "better" than necessary levels of some quality characteristics which prevented them from producing feasible soloutions in the absence of the No.2 and No.3 CWRS wheats. In addition, the standards by which CWRS wheat is graded appear to downgrade CWRS No. 2 (12.5) and may downgrade No. 3 CWRS, both suitable for milling into pan bread flour. This may result in lost farm income as the higher the protein content in a CWRS wheat, the lower the crop yield, *ceteris paribus*. The analysis also shows that the most economic grades/segregations of CWRS wheat are No.2 (12.5) and No.3. CWRS.

It must be emphasized that the selection of the wheats making up flour blends analyzed in this study was based on full knowledge of the level of the various wheat quality factors. Discussions with the millers indicated that if No. 3 CWRS protein content and falling numbers were within acceptable ranges, more No. 3 would be used, if this information were known *ex ante*. Incomplete knowledge of wheat quality factors important to millers is exacerbated by the inconsistency of quality within the No. 3 CWRS grade. Increased quality information availabilty concerning No. 3 CWRS would enhance millers acceptance of the grade.

CHAPTER 7. PAN BREAD RESULTS USING WHEATS FROM CANADA, UNITED STATES AND AUSTRALIA

7.1. Introduction

Chapter 6 presented the results of the pan bread flour analysis under the assumption that Canadian millers had to choose from the six CWRS grades and protein segregations. This approximates the situation which faced Canadian millers until 1991. Quarterly quality data for each of the CWRS grades and segregation were collected for both the east and west coast ports between 1980/81 and 1986/87. Based on the quality data and the specified quality standards for the end-use products, wheats were selected to produce the lowest cost flour.

As a result of technological and economic developments, Canadian millers are no longer restricted to using CWRS and eastern Canadian wheats. Canadian millers can now also import wheat as the Canada-U.S. Trade Agreement (CUSTA) opened the border in May 1991. Millers in Canada will be able to select from several U.S. wheats to produce their grists.

The development of new red and white wheat varieties in the Canadian Prairie Spring (CPS) class may be another factor which impacts on the Canadian milling industry in the near future. The development of Genesis wheat (HY355)[209] could also usher in a new era of wheat production in Canada. Domestic millers may follow the lead of overseas millers and blend lower priced wheat with CWRS wheat to produce a lower cost

[209] Genesis wheat is a high yielding medium quality wheat

flour. The impact of increasing the miller's available wheat choices to produce a least cost pan bread flour is the subject of this chapter[210].

The analysis in this chapter continues to be based on the large and small bakery pan bread flours. However, the miller is able to choose from four additional wheats including; two classes of Australian wheat from three export locations and one grade of U.S. Dark Northern Spring (DNS) wheat from two export locations. Australian Standard White (ASW) is included in the wheat choices to provide some insight as to the possible impact of a medium protein white wheat such as CPS on the milling industry in Canada.

There are a limited number of wheats from other countries for which data are available to test CWRS's competitiveness in production of Canadian pan bread flour. This is because few countries publicly fund and publish wheat quality information[211]. In the U.S., wheat quality testing by public institutions is a recent phenomenon. Wheat quality data for DNS is limited to export wheat as there is less control of domestically purchased wheat, and wheat which is purchased by U.S. mills may not be of the same quality as that which is exported[212].

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[210] White wheats have higher extraction rates than red wheats as the particles of the bran do not discolour the flour. Higher extraction rates lower the cost of the wheat to the miller on a per tonne of flour basis. Therefore, if the new white CPS wheats are of milling quality, Canadian millers may decide to include some of these wheats in their grist.

[211] Most commercial mills test the quality of the wheat they receive to determine their most cost effective blends. The laboratory results from private mills are generally not available as this information contributes to the mills' competitiveness.

[212] Flour mills in the U.S. purchase flour from specific producing areas of the U.S. depending upon the growing conditions in that particular year. In addition, it is not uncommon for the U.S. miller to specify the quality characteristics which must be present in the wheat purchase contract. The reason for contracting quality characteristics by U.S. mills is the lack of varietal control for new seed releases. In Canada, new

The three Australian wheats used are 14 percent protein Australian Prime Hard (APHD14) from New South Wales, Australian Standard White Wheat (ASW) from South Australia (ASWSA) and Western Australia (ASWWA). Although two of the wheats are in the same class, noticeable quality differences exist between the ASW wheats produced in Western Australia (ASWWA) and South Australia (ASWSA). Thus the wheats from the two export origins were treated as different wheats and hence both may be used in the same flour blend. This inconsistency in grade quality differs from North America where the grading system strives to maintain the same quality within a grade, irrespective of the export location.

In addition to quality differences between States, the cost of wheat at each export position will also affect the wheat choices in the least cost flour formulations. Although changes in technology have reduced shipping costs there are shipping cost differences related to the destination of the cargo. For example, wheat exported to the U.K. from the east coast of North America would have a slight cost advantage over shipments from the west coast. Conversely, the west coast ports have a distinct locational advantage over Canada's Atlantic ports for wheat shipments to Pacific Rim countries. Australian ports appear to lack the locational advantages or disadvantages that North American ports have with respect to export destination as their ports are only several hundred miles apart.

In Australia, the grain transportation system helps to maintain the locational integrity of the wheat. The railways are owned by each individual state and tend to run from inland areas to coastal areas within the state. Wheat which is produced in a

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varieties must conform to type in order to be released as a new variety.

particular state is generally exported through a terminal located in that state. Australia, therefore, does not have comingling of wheats produced in different areas which occurs in Canada. This lack of comingling may also be perceived as a disadvantage as the comingling of parcels of CWRS wheat is thought to be one of the strengths of the Canadian system. It is partially due to the comingling of parcels of wheat from different production areas of the prairies which assists in maintaining the consistent quality of CWRS wheat throughout a crop year and between crop years.

Conversely, the Australian grain collection system may have some advantages over the Canadian system, as all wheat in Australia is delivered to agents of the Australian Wheat Board (AWB) at harvest. The AWB, therefore has full information of the quality and characteristics of the wheat at harvest. Conversely, the CWB in Canada must rely on surveys and open delivery quota to call forward wheat during the crop year. Hence, less information concerning the characteristics of the various wheat grades are available throughout the crop year. Consequently, the Australian system may have an advantage over the Canadian system which relies on the comingling of parcels of wheat to ensure consistency of product characteristics.

The quality information for the U.S. No. 2 DNS was obtained from North Dakota State University and is limited to two and a half crop years, or 10 crop year quarters. The Australian quality data used in the study covered five and a half crop years or 22 crop year quarters. When all wheats from all three countries are available for selection, the analysis is limited to the period corresponding to the U.S. data. Correspondingly, when the CWRS and Australian wheats were used together, the study period is expanded to the 22 crop year quarters of the Australian data.

The chapter begins with an analysis of the cost differences between pan bread flours which contain solely CWRS wheats and those flours which are blends of CWRS and other wheats. This section is followed by an analysis of the composition of the pan bread flours which have the least cost solutions. Discussion of the results completes the chapter.

7.2. Cost Comparison of CWRS Flours and Other Flour Blends

CWRS wheat is a hard red spring wheat suitable for the production of pan bread flours. However, CWRS must compete with other wheats in the world market. According to some researchers (eg. Wilson 1989), CWRS wheat receives a premium in the world market. Conversely, Veeman in 1987 indicated that Australian wheat received a premium over CWRS and U.S. wheats. Assuming Wilson is correct, Western Canadian producers presumably receive a higher return for wheat sold in the world market than producers in other countries. However, there may be a down side to this premium which Canada purportedly asks for her CWRS wheats. If the cost of using CWRS wheat is substantially higher that the costs of using other wheats, the amount of CWRS wheat used in world markets may decline. Thus, premiums are justified if and only if the costs of the characteristics provided by CWRS wheat cannot be provided at a lower cost by other wheats.

Throughout the analysis in this section four wheat choices sets will be analyzed. These choices sets are:

Canadian (CDN) - uses only CWRS wheats,

North American (NOR) - uses only No. 2 DNS and CWRS wheats,

Commonwealth (COM) - uses only CWRS and Australian wheats,

ALL - CWRS, U.S. No.2 DNS and the Australian wheats are available.

The cost of producing least cost pan bread flours from these sets are also compared for three different ash content levels, 0.48, 0.50, and 0.52 percent ash. These are the same ash content levels which were used in Chapter 6.

Table 7.1 and Table 7.2 summarize the cost differences between flour blends produced using the CDN choice set and the other choice sets for small and large bakery blends, respectively. The average deviations indicate how much cheaper flour costs are relative to flour products from CWRS wheats. For example, the large bakery COM flours blends at western ports were on average $29.61, $26.51 and $28.92 per tonne less expensive to produce for 0.48, 0.50 and 0.52 percent ash, respectively than flour blends produced from Canadian (CDN) wheats exclusively. Similarly, the per tonne flour cost differences for the eastern ports blends with ash contents of 0.48, 0.50 and 0.52 percent, were $20.23, $20.34, and $21.83, respectively.

The results show that the CAN choice set (i.e. CWRS wheats alone) produced the most expensive flour blends. The least expensive flours were generally produced by the ALL choice set wheats. The COM (Commonwealth CWRS and Australian wheats) choice set flour blends tended to be lower priced than the NOR (CWRS and DNS) flour blends but were often slightly more expensive than the blends produced using the All choice set.

Table 7.1 Differences in Flour Costs For Varying Ash Levels And Various Wheat Combinations: Large Bakery

	WEST COAST PORTS			EASTERN PORTS		
	ASH CONTENT LEVEL			**ASH CONTENT**		
	.48 ASH	.50 ASH	.52 ASH	.48 ASH	.50 ASH	.52
	dollars per tonne					
CANADIAN AND AUSTRALIAN WHEATS						
AVERAGE	29.607	26.509	28.922	20.228	20.335	21.829
STD DEV	6.875	6.242	7.770	11.825	11.844	11.139
CANADIAN AND U.S.WHEATS						
AVERAGE	4.445	1.238	4.332	2.127	6.051	3.882
STD. DEV	3.124	9.470	3.222	9.286	6.705	4.155
CANADIAN U.S. AND AUSTRALIAN WHEATS						
AVERAGE	33.487	30.061	32.713	26.373	29.619	29.629
STD.DEV	4.694	7.935	4.733	19.587	18.451	18.290

Source: Author's calculations.

Table 7.2. Differences In Flour Costs For Varying Ash Levels And Various Wheat Combinations: Small Bakery

	WEST COAST PORTS			EASTERN PORTS		
	ASH CONTENT LEVEL			ASH CONTENT LEVEL		
	.48 ASH	.50 ASH	.52 ASH	.48 ASH	.50 ASH	.52
	dollars per tonne					
CANADIAN AND AUSTRALIAN WHEATS						
AVERAGE	19.737	18.754	19.290	13.365	13.018	12.885
STD. DEV	5.404	4.619	5.427	8.931	8.684	9.438
CANADIAN AND U.S. WHEATS						
AVERAGE	13.796	13.293	13.502	15.469	15.505	15.078
STD.DEV	5.249	5.490	5.157	14.354	14.278	14.871
CANADIAN U.S. AND AUSTRALIAN WHEATS						
AVERAGE	22.439	22.364	24.961	21.311	22.021	23.073
STD.DEV	4.914	4.446	4.622	16.472	15.098	15.430

Source: Author's calculations.

Examining Tables 7.1 to 7.2 reveals that for both large and small bakery flour, the eastern ports tended to have smaller between blend price differences than the flour blends from the western ports[213]. While blends from eastern ports showed less variation between sets, Western port blends tended to be cheaper than its eastern counterpart for large bakery flours. One other noticeable trend was that there appeared to be very little cost difference between the CAN and NOR choice wheat blends for large bakery flours. The small difference in cost between the CAN and NOR choice sets for producing large bakery flours may not support the thesis of Gibson et al when transportation costs for Canada are considered[214].

With the exception of NOR wheats, the small bakery flour results illustrated in Tables 7.2 indicate that western port blends are also less expensive than eastern blends. Also there was a tendency for COM blends to be higher cost than NOR blends on the east coast but not on the west. One could expect that as the protein range in small bakery flour is higher than large bakery flour, the cost advantage of Australian wheat is diminished. The data supports this as differences between NOR and COM wheats for either port is narrower for small bakery flours.

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[213] There may be several reasons why these differences between the eastern and western ports exist. Included in these reasons could be the differences in the CWB asking prices and regional production differences between the eastern and western prairies.

[214] Recent research by Gibson, Faminow and Jeffrey related to the location of North American milling following the CUSTA indicated that Canadian millers may switch to using U.S. wheats from CWRS and other Canadian wheats as U.S. wheats may be less expensive.

The variability of costs within choice sets for the large bakery flour blends appears to be greater for the eastern port wheat than for west coast wheat. The standard deviations of these differences are also shown in Table 7.1. The standard deviations of the differences between the CAN and COM choice set blends ranged between $11.14 and $11.85 a tonne for the eastern port flours, and between $6.24 and $7.70 per tonne for the western port flours. Thus the variations at eastern ports were $4 to $5 per tonne greater than at western ports. Similarly, standard deviations for the ALL choice set ranged between $4.69 and $7.93 at western ports and $18.29 and $19.59 at eastern ports, a difference in variation of $11-14 per tonne. Also the standard deviations for the COM and ALL choice sets are the greatest. This perhaps points to inconsistent quality in the Australian grades.

The standard deviations for small bakery flours are shown in Table 7.2. The results reveal a similar pattern with respect to export port, the within set variability being greatest for eastern ports. However, the range in variability between ports for within set comparisons is less for the small bakery flours. Increasing the protein content to produce small bakery flours changed the choice set which had the largest between port cost differences. The NOR and ALL choice sets have the largest differences in standard deviation for between ports small bakery flours, whereas the ALL and COM choice sets had large between port costs differences for the large bakery flours. This switch between the COM and NOR choice set is the result of the higher protein requirement for small bakery flours. Due to the flour protein content, the between port differences in the higher protein CWRS and No. 2 DNS prices will have a greater impact on the overall cost of the small bakery flour blends.

In general, the ash content level appears to have had little impact on the variability of the cost differences within a choice set and the level of costs between the CDN choice set flours and the other choice set flours. One exception where the ash content level did impact on the variability of cost was in the large bakery flour blends from the eastern ports. In the eastern port flour blends, the standard deviation declined as the allowable ash content was increased. This decline in standard deviation indicates that variability in flour cost differences decreased as allowable ash content increased. The same declining variability trend was not exhibited by the eastern port small bakery flours.

7.3. CWRS Wheat Grades Used in Pan Bread Blends

The previous section discussed the differences in the cost of producing flour when different wheats are available. Part of Canada's wheat marketing strategy has been to provide wheat of consistent quality which is high in those characteristics which are desirable for the production of pan bread flours. Extensive use of CWRS wheat grades within each of the choice sets would indicate that this is a viable strategy. This section examines CWRS as a blending wheat for producing pan bread flours.

The appearance of CWRS grades in the three choice set flour blends for both pan breads are shown in Table 7.3 through to Table 7.5. These tables show the average composition of each wheat in the blends that are actually used.

Table 7.3. Average Percent And Number Of Appearances Of Various Wheats Appearing In Pan Bread Blends: COM Choice Set

LARGE BAKERY PAN BREADS

ASH CONTENT	ONE CWRS 14.5	ONE CWRS 12.5	TWO CWRS 13.5	TWO CWRS 12.5	THREE CWRS	APHD14	ASWSA	ASWWA
WEST COAST PORTS								
.48	44.74	0	1.37	0	2.04	56.97	40.34	17.72
	7	0	1	0	6	16	21	8
.50	46.19	0	0	0	2.96	55.79	41.23	15.51
	8	0	0	0	7	15	21	7
.52	46.19	0	0	2.96	57.09	40.38	15.51	
	8	0	0	0	6	15	21	7
EASTERN PORTS								
.48	43.22	1.71	0	0	45.38	55.38	40.67	24.44
	8	2	0	0	9	9	20	5
.50	43.22	0	0	1.71	41.99	54.06	41.19	19.18
	8	0	0	2	8	11	20	5
.52	41.50	0	0	1.71	43.58	48.96	42.72	20.91
	7	0	0	2	9	9	19	6

SMALL BAKERY PAN BREADS

ASH CONTENT	ONE CWRS 14.5	ONE CWRS 12.5	TWO CWRS 13.5	TWO CWRS 12.5	THREE CWRS	APHD14	ASWSA	ASWWA
			WEST COAST PORTS					
.48	41.91	12.35	0	6.65	71.28	26.05	24.88	
	12	2	0	10	16	15	3	
.50	42.98	0	6.43	0	7.53	73.08	22.57	22.60
	12	0	2	0	10	16	13	6
.52	42.28	0	6.43	0	0	7.94	72.13	24.30
24.31								
	12	0	2	0	0	16	14	5
			EASTERN PORTS					
.48	38.95	53.81	8.04	0	38.48	60.88	27.30	22.83
	11	3	2	0	13	11	15	3
.50	37.26	0	8.04	21.48	35.65	57.50	28.73	22.83
	12	0	2	2	11	14	14	3
.52	32.00	0	8.04	41.04	44.14	61.74	21.54	17.73
	12	0	2	3	12	11	14	4

Source: Author's calculations.

7.4. The COM Choice Set in Pan Bread Blends

The number of times a grade or segregation was actually selected and the average amount of its contribution per selection is shown on Table 7.3. The scenario in this choice set was that the miller could choose between the six grades and segregation of CWRS and the three Australian wheats. The most surprising result in this section was that No.1 CWRS (13.5) was not selected for any of the blends in the choice set. No.1 CWRS (13.5) tends to be one of the most popular CWRS grade/segregations and is the major focus of the CWRS breeding program, yet in this analysis the segregation was not selected even once. The most commonly selected CWRS segregation for both pan bread types and all three ash contents was No.1 CWRS (14.5) which is also surprising as this is generally the most expensive CWRS segregation. At eastern ports No. 3 CWRS was as large or larger a contributor to the average blend than No. 1 CWRS (14.5).

It is interesting to note that the two extremes of the perceived quality spectrum of CWRS, No.1 (14.5) and No.3 CWRS are the CWRS grade/segregations most commonly used in the COM choice set blends. This may be partially due to No. 3 CWRS being the lowest price CWRS wheat which results in it often being selected over the other CWRS grades/segregations. Another reason may be the seemingly apparent inverse relationship between high protein content and low ash content in No.1 CWRS 14.5 which allows the higher protein No.1 CWRS wheat to be milled at a higher extraction rates than the other segregations. The higher extraction rate decreases the cost of flour produced per tonne wheat purchased. For the eastern port blends, No. 1 (14.5) had a higher average contribution to the blends than No. 3 CWRS at the .50 percent ash content level. This may indicate that there may be a point where increasing the extraction rates associated with the more expensive higher protein grain offsets the lower priced higher ash content grade CWRS No.3.

Use of No. 1 (12.5), No. 2 (13.5) and No. 2 (12.5) was negligible. However, they were used more frequently in small bakery flours (Table 7.5). The low use of the No. 2 CWRS wheats for the large bakery flour blends is odd given that 12.5 percent protein is in the allowable protein range for the blend. The only exceptions to the low use rate for No. 2 (12.5) CWRS segregation occurred in port flour blends at .52 allowable ash content. In this particular set of flour blends, No. 2 CWRS (12.5) averaged 41.04 percent of the blend. Although No. 2 (12.5) had a high contribution rate when it was used in this particular blend, it was used only 3 times whereas it was available at the eastern ports in 15 of the 22 quarters of the study period.

On average No 1 CWRS (14.5) was not the largest wheat contributor to the COM choice set as APD14 and ASWSA were incorporated more frequently and used in as great or greater proportion. The results appear to indicate that given the particular set of circumstances under which these analyses were done, CWRS No. 1 and No. 2 wheat grade/segregations have difficulty competing with Australian wheats. However, since No.1 CWRS (14.5) was more frequently selected for small bakery flours than large bakery flours this suggests that Canada No. 1 wheat performs better when higher protein flour is required. The selection of No. 3 CWRS more frequently than any other CWRS wheat

Table 7.4. Average Percent And Number Of Appearances Of Various Wheats Appearing In Pan Bread Blends: NOR Choice Set

ASH CONTENT	ONE CWRS 14.5	ONE CWRS 13.5	ONE CWRS 12.5	TWO CWRS 13.5	TWO CWRS 12.5	THREE CWRS	DNS
LARGE BAKERY PAN BREADS							
WEST COAST PORTS							
.48	0	34.14	31.58	0	50.57	38.64	30.92
	0	1	2	0	5	8	8
.50	0	34.14	40.37	0	40.10	39.13	32.45
	0	1	3	0	5	9	9
.52	0	34.14	31.58	0	40.10	40.89	30.26
	0	1	2	0	5	9	10
EASTERN PORTS							
.48	0	0	38.13	0	45.34	68.60	27.11
	0	0	3	0	3	8	6
.50	0	0	54.55	0	26.99	67.05	24.82
	0	0	3	0	3	9	6
.52	0	0	38.13	0	34.01	68.60	27.11
	0	0	3	0	3	8	6

SMALL BAKERY PAN BREADS

ASH CONTENT	ONE 14.5	13.5	CWRS 12.5	TWO 13.5	CWRS 12.5	THREE CWRS	DNS
				WEST COAST PORTS			
.48	0	0	43.27	0	44.88	46.13	82.25
	0	0	2	0	1	1	10
.50	29.17	0	43.27	0	16.22	46.13	82.19
	1	0	2	0	1	1	10
.52	0	0	43.27	0	44.88	46.13	82.25
	0	0	2	0	1	1	1
				EASTERN PORTS			
.48	15.90	30.00	7.98 0	38.47	52.97	69.63	
	2	1	1	0	1	5	9
.50	3.74 0	17.55	12.61	38.44	60.01	66.33	0.00
	2	0	1	2	1	5	9
.52	9.91 0	17.56	12.60	38.47	56.14	74.93	
	2	0	1	2	1	4	9

Source: Author's calculations.

Figure 7.1 Wheat Usage - Large Bakery
NOR Choice Set West Coast .5% Ash

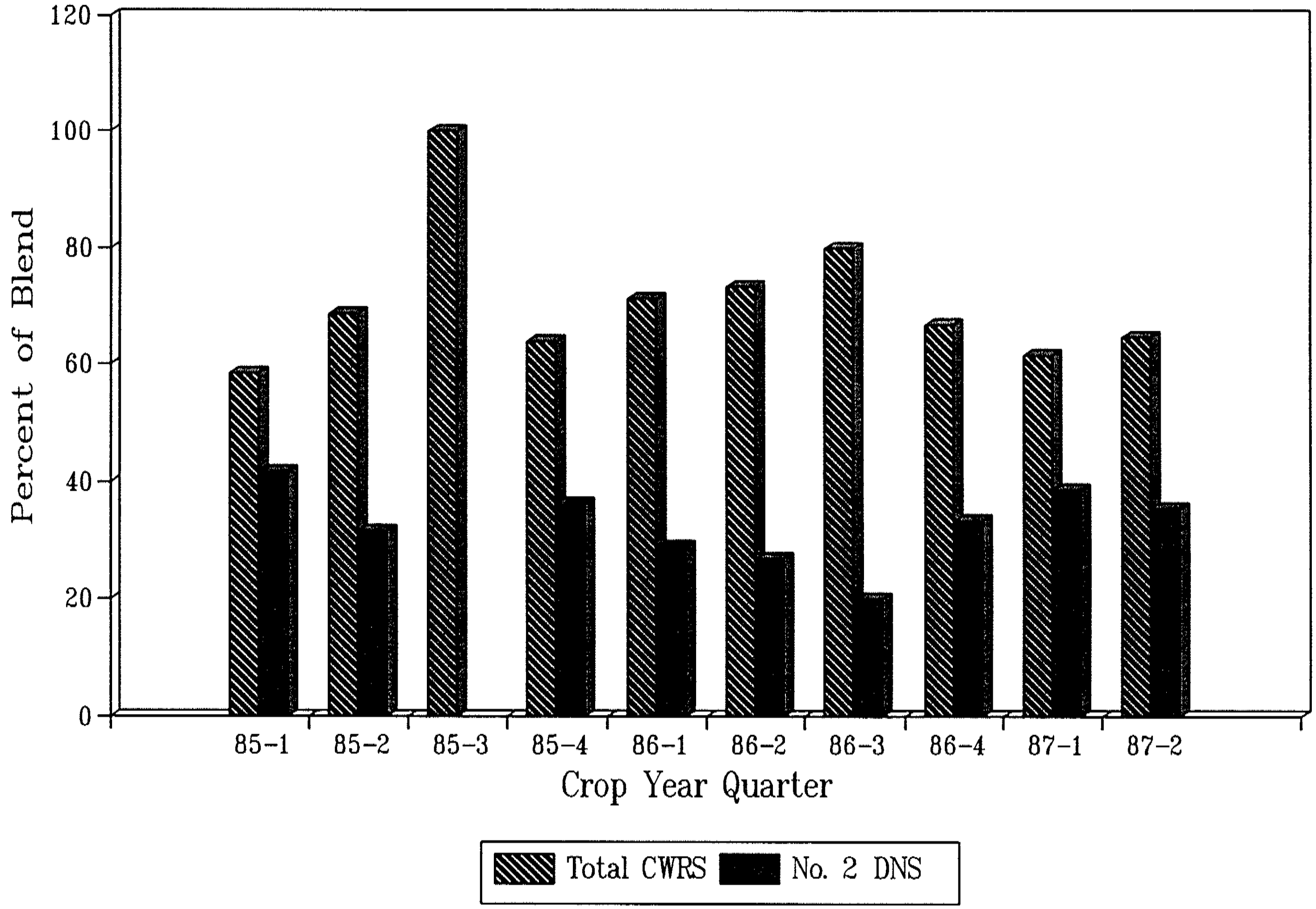


Figure 7.2 Wheat Usage - Large Bakery
NOR Choice Set East Coast .5% Ash

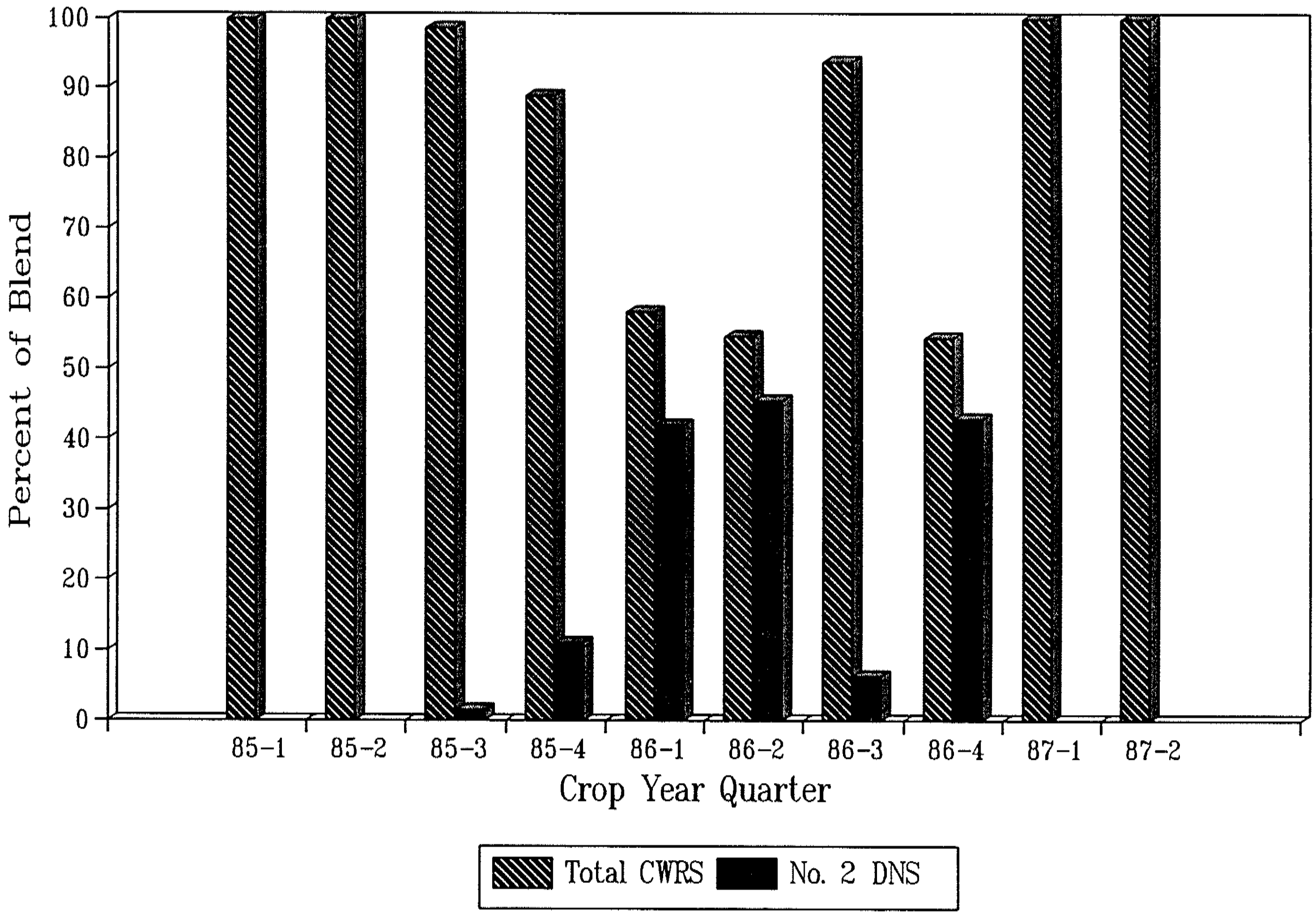


Figure 7.3 Wheat Usage Small Bakery
NOR Choice Set West Coast .5% Ash

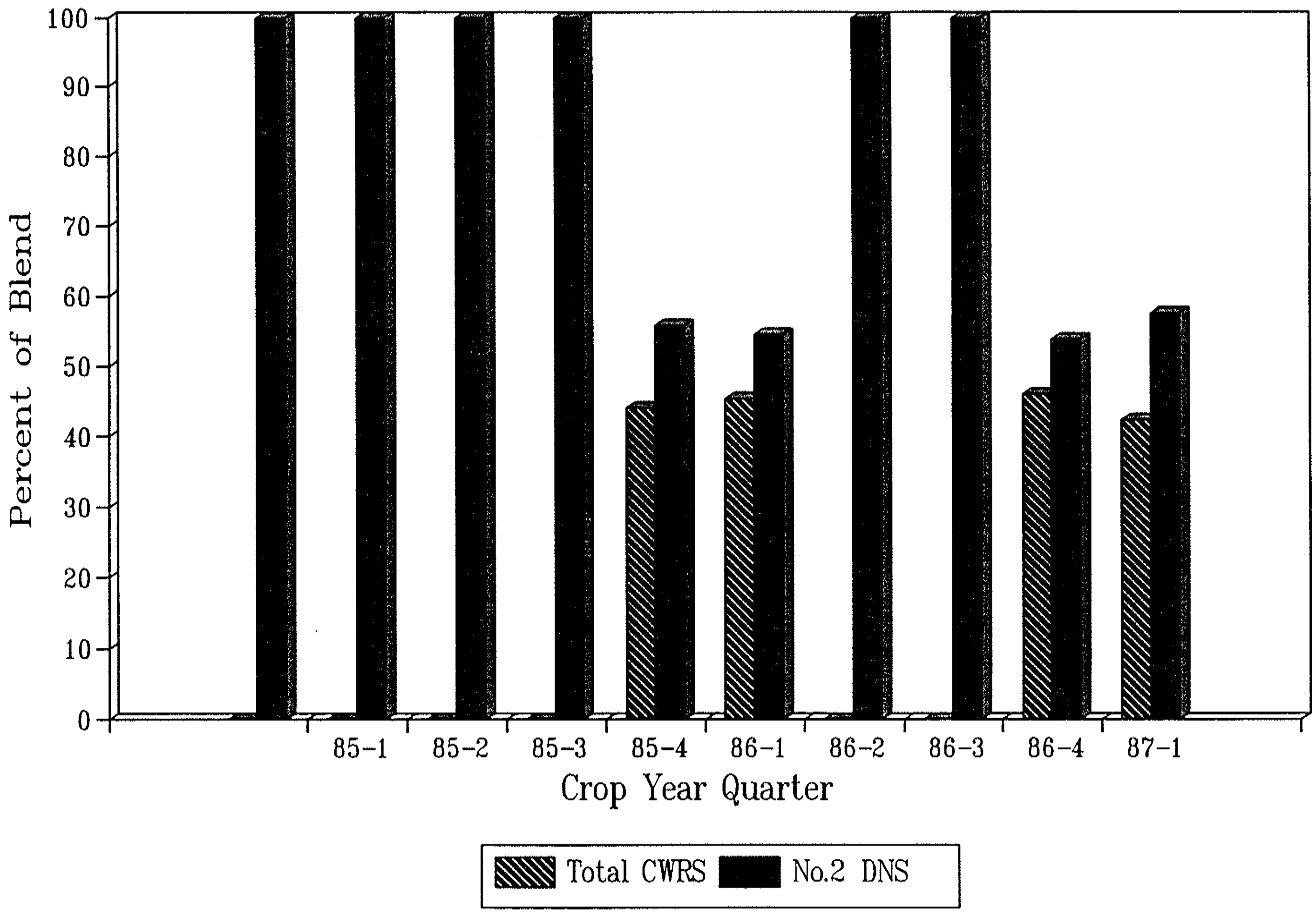
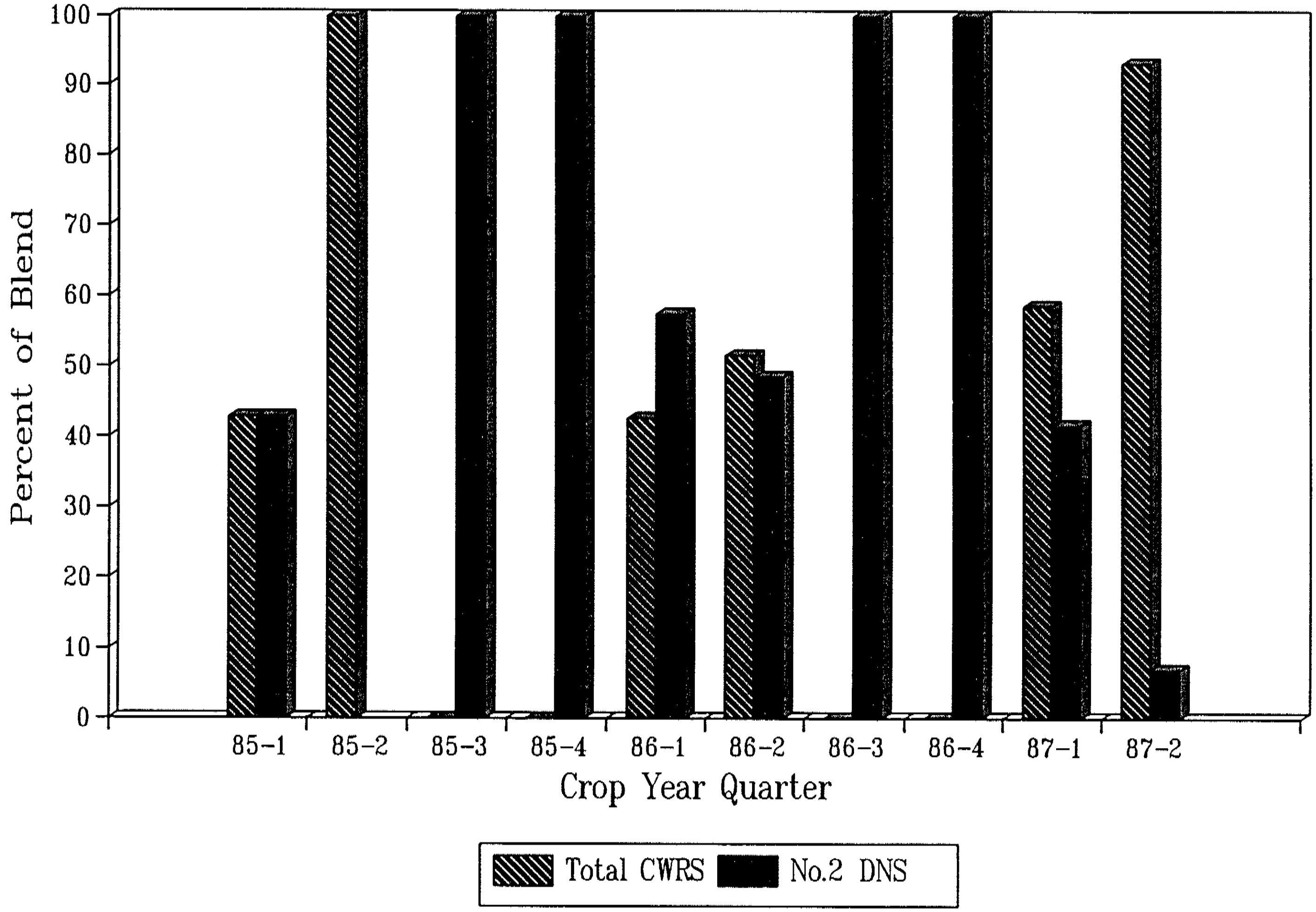


Figure 7.4 Wheat Usage Small Bakery
NOR Choice Set East Coast 0.5% Ash



in the large bakery flours appears to indicate that the price of No. 3 CWRS may be an important factor in it's selection and it may be complementary with APHD14.

7.5. NOR Choice Set Used in Pan Bread Blends

The wheat use results of the NOR Choice set are shown in Table 7-4. This scenario is the one which most closely approximates the impact of an open border for wheat between Canada and the U.S. In this choice set the miller can choose from the six grades and segregation of CWRS and No. 2 DNS from the U.S. Total CWRS and DNS contribution within each blend is illustrated in Figures 7.1, 7.2, 7.3 and 7.4 for large and small pan bread flours on each coast.

The CWRS grades/segregation exhibited different patterns of selection in the NOR choice set than in the COM choice set. One major difference is the absence or near absence of No.1 CWRS (14.5) in the large bakery and small bakery blends, respectively. The low use of this segregation is not surprising as No.2 DNS had a protein content close to 14 percent. The high protein content of the lower cost DNS precluded No.1 CWRS 14.5 from being selected on the basis of protein alone.

The next "best" CWRS grade/segregation No. 1 CWRS (13.5) was used even less than No.1 (14.5). However, when selected No.1 CWRS (13.5) did make a significant contribution to the blend. Conversely, No.2 DNS was selected most frequently for the small bakery flours and was "neck in neck" with No. 3 CWRS wheats in the large bakery blends.

The lower protein and quality CWRS wheats tended to be more compatible with DNS that did the two "top" segregations. No. 1 CWRS (12.5) contributed between 30 and 40 percent of the wheat in blends when it was selected but was only chosen in 20 percent of the possible periods.[215]

The CWRS grades No.2 (12.5) and No. 3 CWRS were most often used in the flour blends. In general, No. 2 CWRS (12.5) outperformed No.1 CWRS (12.5). No. 2 (12.5) was used in between 30 and 50 percent of the blends and comprised between 35 and 50 percent of the wheat mix in large bakery blends; it was chosen only 10 percent of the time in the small bakery blends.

Examination of the results in Table 7-4 showed that No. 3 CWRS was the most competitive of the CWRS wheats and was complementary to No.2 DNS. No. 3 CWRS is the major Canadian grade/segregation selected for use in large bakery flour blends being selected 80 to 90 percent of the time and contributing between 40 and 68 percent of the wheat mix.

The location of export also appeared to influence the amount of No. 3 CWRS used in small bakery blends. The results show that for eastern port flours, No. 3 CWRS competed directly with No. 2 DNS as the dominant wheat in the blend. Some competition also appeared to exist between No. 3 CWRS and No. 2 DNS in the western port blends for the small bakery flours. However, these two wheats appeared to be complementary in the large bakery west costs blends. As No. 3 CWRS is not segregated on a protein basis, the protein in this grade of wheat may have varied from quarter to quarter which resulted in its sporadic use in the flour blends. No. 3 CWRS is generally

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[215] Least cost blends were calculated for 10 periods therefore as the segregation was not available for some quarters the use rate of No. 1 (12.5) may be better than it appears.

priced lower than other CWRS grade/segregations and may have been better able to compete with DNS than the other CWRS grade/segregations. The other grades/segregations of CWRS were only used when they could offer the miller lower cost protein or other qualities. This appeared to be an infrequent occurrence.

7.6. ALL Choice Set Used in Pan Bread Blends

The results for the various grade/segregations which were selected for the ALL choice set are presented on Table 7.5. In this choice set, the miller could choose from six CWRS grade/segregations, three Australian wheats and No.2 DNS from the U.S. Among these wheats, the miller could choose from several high protein wheats and two medium protein wheats to produce the lowest cost flour for the two bakery types. The most noticeable change from the COM and NOR choice set blends was that only two CWRS grade/segregations were used in any of the least cost flours. No. 1 CWRS (14.5) is the only CWRS grade/segregation which appeared at least once in each possible blend situation. The No.3 CWRS grade was only present in the eastern port flour blends and even then it was only used in one of the ten possible grists.

The wheats which contributed the most to the flour blends in this segment of the analysis were the No. 2 DNS from the U.S., and the Australian Standard White wheat from South Australia (ASWSA), Figures 7.5 and 7.6. Examination of Table 7-5 reveals that No. 2 DNS contributed over 60 percent of the wheat mix in 90 percent of the blends; the contribution of DNS being somewhat larger for small bakery pan breads than for large bakery flours blends. As DNS tended to have a protein content which was close to 14 percent, the larger contribution to the higher protein flour blends was not

Table 7.5. Percent And Number Of Appearances Of Various Wheats Appearing In Pan Bread Blends: ALL Choice Set

LARGE BAKERY PAN BREADS

ASH CONTENT	ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	NO.2 DNS
			WEST COAST PORTS			
.48	26.85 2	0 0	54.17 2	39.93 9	53.19 1	60.77 7
.50	26.85 2	0 0	27.56 2	38.92 5	53.19 1	54.18 9
.50	6.79 2	0 0	27.56 2	38.92 9	39.43 1	60.17 9
			EASTERN PORTS			
.48	3.69 2	62.50 1	0.96 2	37.37 9	38.68 1	61.47 9
.50	3.69 2	62.50 1	0.96 2	37.37 9	38.68 1	61.47 9
.50	3.69 2	62.50 1	0.96 2	37.37 9	38.68 1	61.47 9

SMALL BAKERY PAN BREADS

ASH CONTENT	ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	NO.2 DNS
			WEST COAST PORTS			
.48	38.40	0	70.26	19.02	36.17	61.77
	3	0	2	8	1	9
.50	23.51	0	43.38	16.36	22.36	68.03
	2	0	2	10	1	10
.52	17.18	0	37.55	19.62	27.19	67.92
	2	0	2	8	2	10
			EASTERN PORTS			
.48	20.88	68.57	49.88	15.92	19.69	64.12
	2	1	3	9	1	9
.50	20.88	65.11	28.14	20.27	19.69	67.39
	2	1	3	9	1	9
.52	15.39	68.57	14.60	20.73	19.69	72.30
	2	1	3	9	1	9

Source: Author's calculations.

unexpected. For the large bakery flour blends, ASWSA contributed about one third of the wheat in the grists whereas its contribution to the small bakery flour blends was significantly less, approximately 20 percent less. In the small bakery flours the lower contribution of ASWSA was replaced by an increase in the amount of DNS or APHD14 in the blend. The other higher protein wheat which competed with CWRS was APHD14. APHD14 was used only 20 percent of the time as was No. 1 (14.5). However, the contribution of APHD14 to the blends tended to be much greater than No.1 (14.5). The contribution of APHD14 to the blends tended to increase for the small bakery flours over the large bakery flours. The high use of ASWSA in the blends indicates the importance of having a reasonably priced medium quality wheat available for blending. The two medium protein content wheats from Australia ASWSA and ASWWA were significant contributors to both the large and small bakery blends. Except for two quarters, ASWSA was included in 90 percent of the blends. The use of these medium quality wheats may have economic implications for CWRS wheat exports.

7.7. Parametric Analysis

The wheat prices used in the aforementioned analyses were F.O.B. asking prices and not landed prices, hence differences in ocean shipping charges can affect price competitiveness. To determine the impact of price on the selection of Canadian wheat, parametric testing of the asking prices was undertaken. Six separate analyses[216] were

[216] The sample size for the parametric analysis was 20 observation, 10 quarters at 2 ports and one ash content, .5 percent ash.

Figure 7.5 Wheat Use - Large Bakery
All Choice Set; .5 Ash

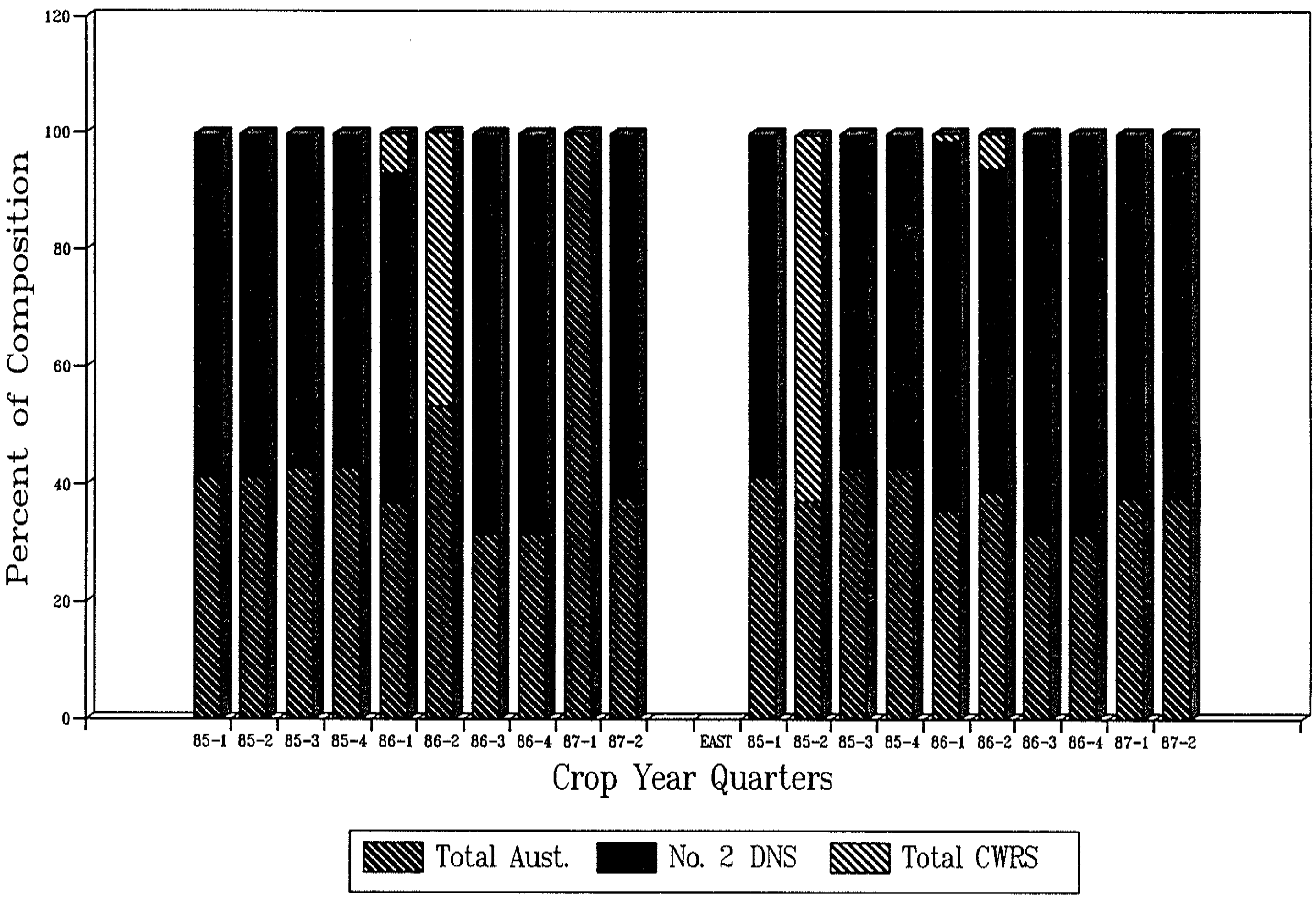
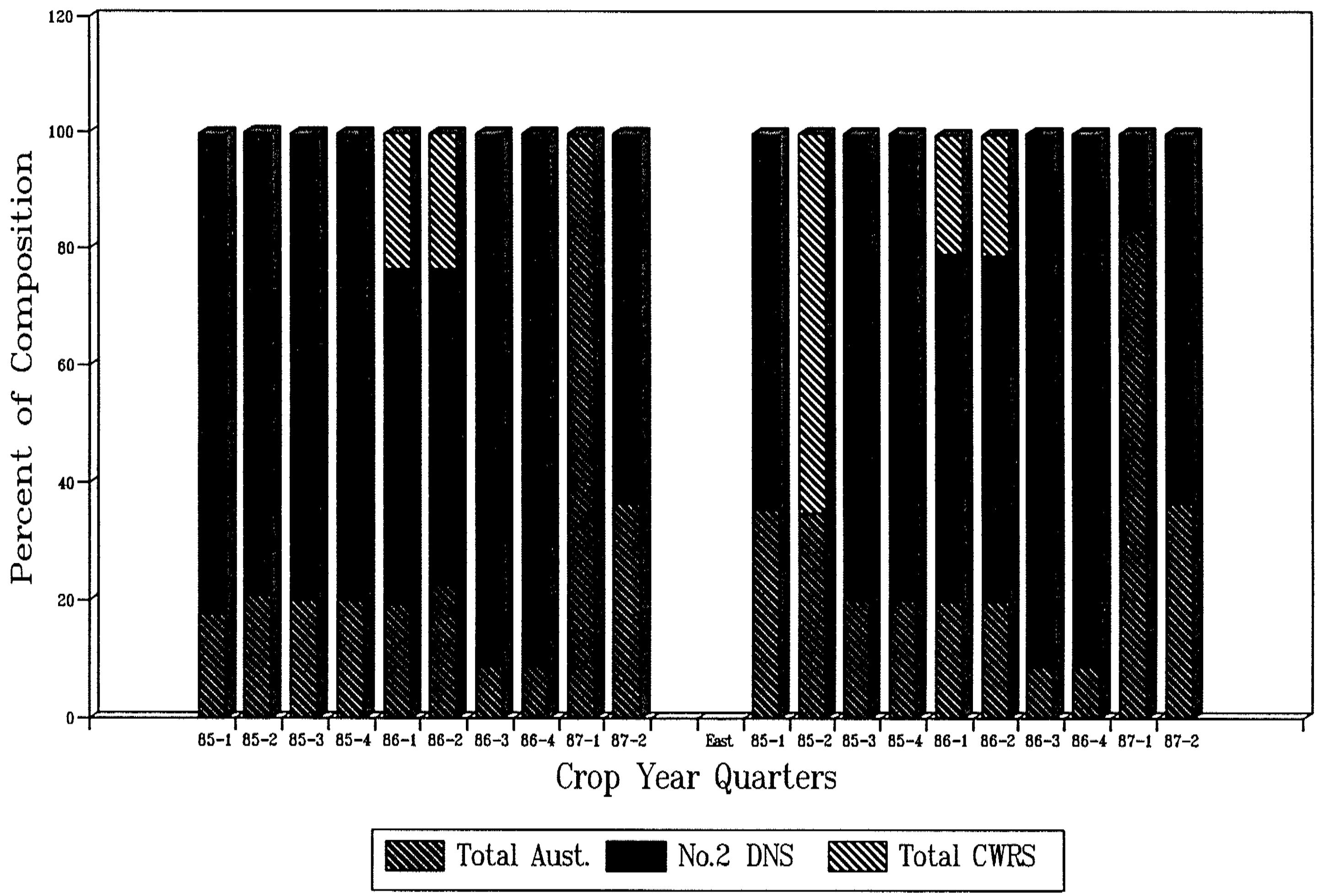


Figure 7.6 Wheat Usage - Small Bakery
All Choice Set - .5 % Ash



undertaken, the first adjusting No. 1 (13.5) prices downward $5.00/tonne, then in $5.00 increments to $30.00/tonne. New prices for the other CWRS grades/segregations were calculated relative to their original price relationship with No. 1 (13.5). The analyses also assume an ash content of .50 percent and pertained to the ALL choice set, to determine the impact of price in the selection of CWRS wheats vis-a-vis Australian and U.S. wheats.

7.7.1. Large Bakery Flours

The results of the six incremental analyses are presented in Tables 7.6, 7.7, 7.8, 7.9, 7.10 and 7.11. Table 7.6 shows that results of lowering No.1 (13.5) prices $5.00/tonne and the other CWRS wheat grades/segregations an amount reflecting the original price relationships between CWRS wheats. A comparison of Tables 7.5 and 7.6 indicates that reducing CWRS prices approximately $5.00/tonne, would increase the frequency of use from five to nine selections, and the average contribution in the mixes would almost double increasing from 24.7 to 47.2 percent. The increase in frequency of use was primarily due to the selection of No. 3 CWRS which comprised on average 78.7 percent of the wheat mix in the four blends for which it was selected. The increasesin CWRS use was at the expense of No. 2 DNS.

The results of reducing the CWRS asking prices by $10.00/tonne are shown in Table 7.7. The only impact of the second $5.00/tonne price reduction was a slight increase in the frequency and use of No.1 CWRS (14.5) for the west coast ports. No.1 (14.5) selections increased to 7 from 5 and the average contribution per selection increased from 22.1 to 35.1 percent. The increased use of No.1 (14.5) replaced

Table 7.6. Results of Parametric Analysis: Large Bakery Flour Blends, CWRS Prices Reduced Approximately $5.00/Tonne

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	259.58							58.82		41.18	
85-2W	255.30							58.82		41.18	
85-3W	257.18							57.14		42.86	
85-4W	247.08							57.14		42.86	
85-1E	248.15						62.50			37.50	
85-2E	246.41						62.50			37.50	
85-3E	253.41							57.14		42.86	
85-4E	235.20							57.14		42.86	
86-1W	237.20	6.90						56.29		36.81	
86-2W	256.11	46.81									53.19
86-3W	262.09	44.65						8.61		46.74	
86-4W	212.26							68.57		31.43	
86-1E	228.29	6.09						56.96		36.95	
86-2E	254.68	5.96						55.37			38.67
86-3E	253.00							68.57		31.43	
86-4E	208.43							68.57		31.43	
87-1W	185.98								54.17	45.83	
87-2W	191.19							62.29	0.96	36.75	
87-1E	182.53						89.65			10.35	
87-2E	184.45						100.00				

Source: Linear programming results.

Table 7.7. Results of Parametric Analysis: Large Bakery Flour Blends, CWRS Prices Reduced Approximately $10.00/Tonne.

Quarter	Price	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	258.34	43.83						4.68	51.49		
85-2W	255.30							58.83		41.17	
85-3W	257.18							57.14		42.86	
85-4W	247.08							57.14		42.86	
85-1E	244.25						62.50			37.50	
85-2E	242.63						62.50			37.50	
85-3E	253.41							57.14		42.86	
85-4E	235.20							57.14		42.86	
86-1W	235.10	52.17								47.83	
86-2W	253.20	46.81								53.19	
86-3W	259.30	44.65						8.61		46.74	
86-4W	210.01	46.15								53.85	
86-1E	227.91	6.09						56.96		36.95	
86-2E	254.35	5.96						55.37			38.67
86-3E	252.99							68.57		31.43	
86-4E	208.43							68.57		31.43	
87-1W	185.98								54.17	45.83	
87-2W	191.19							62.29	0.96	36.75	
87-1E	177.36						89.66			10.34	
87-2E	178.69						100.00				

Source: Linear programming results.

Table 7.8. Results of Parametric Analysis: Large Bakery Flour Blends, CWRS Prices Reduced Approximately $15.00/Tonne

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	255.55	45.45							3.38	51.17	
85-2W	252.71	46.51								53.49	
85-3W	257.18							57.14		42.86	
85-4W	244.77	45.45								54.55	
85-1E	240.36						62.50			37.50	
85-2E	238.84						62.50			37.50	
85-3E	251.68	39.21					6.26	2.48		52.05	
85-4E	235.20							57.14		42.85	
86-1W	231.81	52.17								47.83	
86-2W	250.21	46.81									53.19
86-3W	256.44	44.65						8.61		46.74	
86-4W	207.06	46.15								53.85	
86-1E	227.44				7.72			56.11		36.17	
86-2E	253.97	5.96						55.67			38.67
86-3E	251.88	43.17						9.36		47.46	
86-4E	208.43							6.57			
87-1W	185.90							54.17		45.83	
87-2W	191.18							62.29	0.96	36.75	
87-1E	172.19						89.66			10.34	
87-2E	172.98						100.00				

Source: Linear programming results.

Table 7.9. Results of Parametric Analysis; Large Bakery Flour Blends, .5 Percent Ash, CWRS Prices Reduced Approximately $20.00/Tonne.

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	252.67	45.45							3.37	51.18	
85-2W	249.74	35.98	12.74				0.30			50.98	
85-3W	253.94				66.67					33.33	
85-4W	241.85	45.45								54.55	
85-1E	236.46						62.79			37.21	
85-2E	234.76						64.79			35.71	
85-3E	248.65	39.21					6.26	2.48		52.05	
85-4E	233.63	42.01					4.73			53.25	
86-1W	228.24				58.54					41.46	
86-2W	247.16	46.81									53.19
86-3W	253.53	44.65						8.61		46.74	
86-4W	204.05	46.15								53.85	
86-1E	225.16	50.00								50.00	
86-2E	251.51	50.00									50.00
86-3E	248.84	43.17						9.36		47.46	
86-4E	208.43							68.57		31.43	
87-1W	185.98								54.17	45.83	
87-2W	188.68	69.6							13.56	16.83	
87-1E	167.03						89.66			10.34	
87-2E	167.59						100.00				

Source: Linear programming results.

Table 7.10. Results of Parametric Analysis; Large Bakery Flour Blends, .50 Percent Ash, CWRS Prices Reduced by Approximately $25.00/Tonne.

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	249.59	37.34		13.93						48.73	
85-2W	246.75	42.50					7.50			50.00	
85-3W	251.15	48.78								51.22	
85-4W	238.92	45.45								54.55	
85-1E	232.17						77.78				22.22
85-2E	231.10						78.88				21.12
85-3E	245.82	39.21					6.26	2.48		52.05	
85-4E	230.66	42.01					4.73			53.25	
86-1W	224.60				58.54					41.46	
86-2W	244.09	46.81									53.19
86-3W	250.27	50.23								30.17	19.60
86-4W	201.30	46.15								53.85	
86-1E	220.58				57.14					42.86	
86-2E	248.24	50.00									50.00
86-3E	246.28	43.17						9.36		47.46	
86-4E	208.43							68.57		31.23	
87-1W	180.55						92.86			7.14	
87-2W	184.42		21.16				64.14			14.70	
87-1E	161.86						89.66			10.34	
87-2E	161.46						100.00				

Source: Linear programming results.

Table 7.11. Results of Parametric Analysis: Large Bakery Flour Blends, .50 Percent Ash, CWRS Prices Reduced Approximately $30.00/Tonne.

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	246.63	37.33		13.93						48.73	
85-2W	243.43		31.27		28.30					40.43	
85-3W	247.04					66.67				33.33	
85-4W	236.00	45.45								54.55	
85-1E	228.17						77.78				22.22
85-2E	226.63					27.07	66.68				6.25
85-3E	246.48		51.05						9.79	39.16	
85-4E	227.73	42.01					4.73			53.25	
86-1W	220.97				58.54					41.46	
86-2W	241.07	46.81									53.19
86-3W	247.03	50.23								30.19	19.60
86-4W	198.33	46.15								53.85	
86-1E	218.13				57.14					42.86	
86-2E	245.17	50.00									50.00
86-3E	246.39	43.17						9.36		47.46	
86-4E	207.73	41.79						10.07		48.14	
87-1W	175.08						92.86			7.14	
87-2W	179.05		21.16				64.14			14.70	
87-1E	157.30						100.00				
87-2E	157.71						100.00				

Source: Linear programming results.

contributions by No. 2 DNS. The impact of lowering CWRS prices by approximately $10.00/tonne had no impact on the selection of No.3 CWRS. The average contribution of all CWRS grade/segregations increased from 47.2 to 50.9 percent.

The results of lowering the price of CWRS wheats by approximately $15.00/tonne are shown in Table 7.8. The principal result of the additional $5.00/tonne price decrease was an increase in the frequency of use of No.1 (14.5) from seven to ten appearances and an increase in the average contribution from 35.1 to 41.5. Also as a result of the price decrease, a small amount of No. 2 (13.5) was also selected once. Overall, when the price of the CWRS wheat was reduced by $15.00 tonne, the frequency of use increased from 11 to 15 selections but average contribution of CWRS grades/segregations declined slightly to 49.6 percent down from 50.9 percent. The additional appearance of No. 3 CWRS in one of the blends contributed only 6.3 percent of the wheat mix thus lowering the overall average contribution of CWRS wheats in the blends for which they were selected.

Table 7.9 shows the results of lowering No. 1 (13.5) prices $20.00/tonne. The results show that by reducing the price of CWRS wheat there was an increase in the use of CWRS grades/segregations, particularly No. 1 (14.5) which increased in both the frequency of use and the percent used in a blend. No. 1 (14.5) was selected 12 times up from ten appearances. The average percent used in the blends it was selected also increased from 41.5 to 46.5 percent. Lower prices did not improve the competitiveness of No. 3. One additional appearance each of No. 1 (13.5) and No. 2 (13.5) occurred when prices declined \$20.00/tonne. In 18 of the 20 periods, CWRS grades/segregations contributed on average 56.9 percent of the wheat required to produce the flour blend.

In general, dropping the CWRS asking prices approximately \$20.00/tonne resulted in No. 1 (14.5) substituting for U.S. No. 2 DNS. Table 7.8 shows that 10 of the 20 large bakery blends contained No. 2 DNS when CWRS prices were reduced \$15.00/ tonne, and the average contribution of No. 2 DNS was approximately 36.9 percent in the selected blends. When CWRS prices were lowered by \$20.00/tonne, No. 2 DNS was selected only 4 times yielding an average contribution of 22.3 percent. Only in one in one instance did the wheat contribute a substantial amount to the blend, 68.6 percent, as the contribution in the other three blends ranged between 2.5 and 8.6 percent. Lowering CWRS wheat prices by \$20/tonne appears to have had a minimal impact on the frequency of use and average contribution of Australian wheats to the blends.

Table 7.10 shows the results of lowering the asking prices of CWRS wheats by approximately \$25.00/tonne. The primary impact of the additional \$5.00/tonne price reduction was to increase the average contribution of No. 3 CWRS from 46.9 to 58.0 percent and an increase in frequency of use from seven to nine appearances. There were also minor changes in the use of No. 1 (13.5), No. 1 (12.5) and No. 2 (13.5). CWRS grades/segregations contributed on average 61.2 percent of the wheat required to produce the flour blend, up from 56.9 percent when prices were lowered \$20.00/tonne.

The incremental decrease of \$5.00/tonne impacted primarily on the use of Australian wheats changing not only the frequency of the Australian wheats chosen, but the mix of wheats. For example, APHD14 was not selected at all when Canadian wheat prices declined \$25.00/tonne, the average contribution of ASWSA dropped slightly and was selected in 15 blends down from 17, and ASWWA was selected 5 times, up from 2 selections. This change in mix of Australian wheats is primarily the result of the increased average contribution of No. 3 CWRS in the blends.

The results of reducing the CWRS asking prices by \$30.00/tonne are shown in Table 7.11. The most obvious result is that all six CWRS grades/segregations were selected at least once. No. 1 (13.5) was selected two more times than in the \$25.00 scenario, No. 2 (13.5) one more time and No. 2 (12.5) two more times. The selection of these wheats was largely at the expense of the Australian ASWSA, No. 1 (14.5) CWRS, No. 2 DNS and to some extent No. 3 CWRS, which were either replaced or their contribution reduced. CWRS grades/segregations were included in all 20 blends and contributed 63.1 percent of the wheat on average.

In summary, as CWRS prices were reduced, both the frequency of use and average contribution of No. 2 DNS declined as No. 1 (14.5) use and contribution increased. Australia APHD14 also declined in use but the average contribution increased slightly. The selection of medium quality Australian wheats increased, but average contribution increased then decreased as the average contribution by No. 3 increased, Figures 7.7 and 7.8.

7.7.2. Small Bakery Flours

The results of the small bakery pan bread parametric analyses are presented in Tables 7.12, 7.13, 7.14, 7,15, 7.16 and 7.17. The result of decreasing the price of

Figure 7.7 Large Bakery Flour .5% Ash
Frequency of Wheat Selections

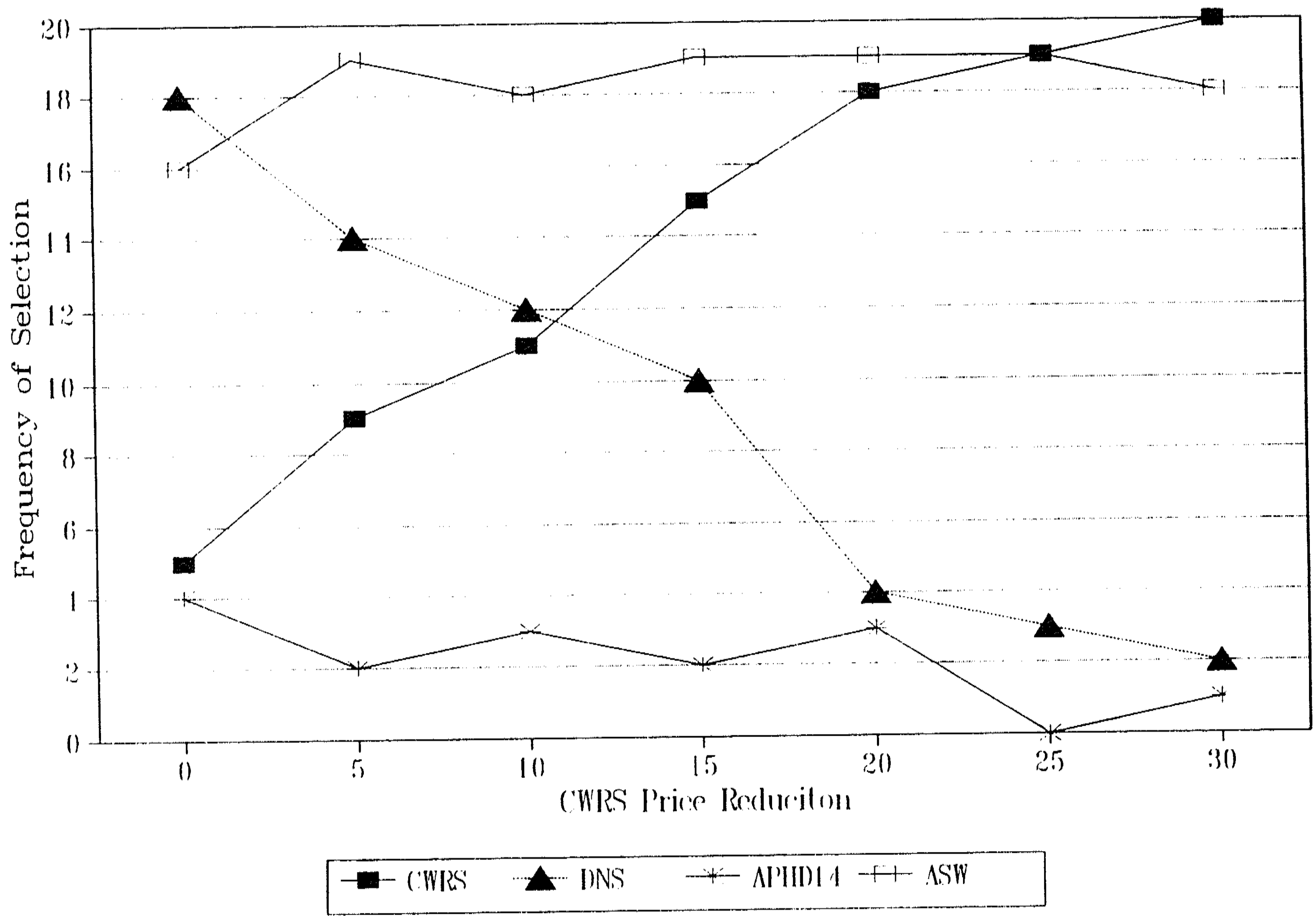


Figure 7.8 Large Bakery Flour .5% Ash
Contribtion of Wheats When Selected

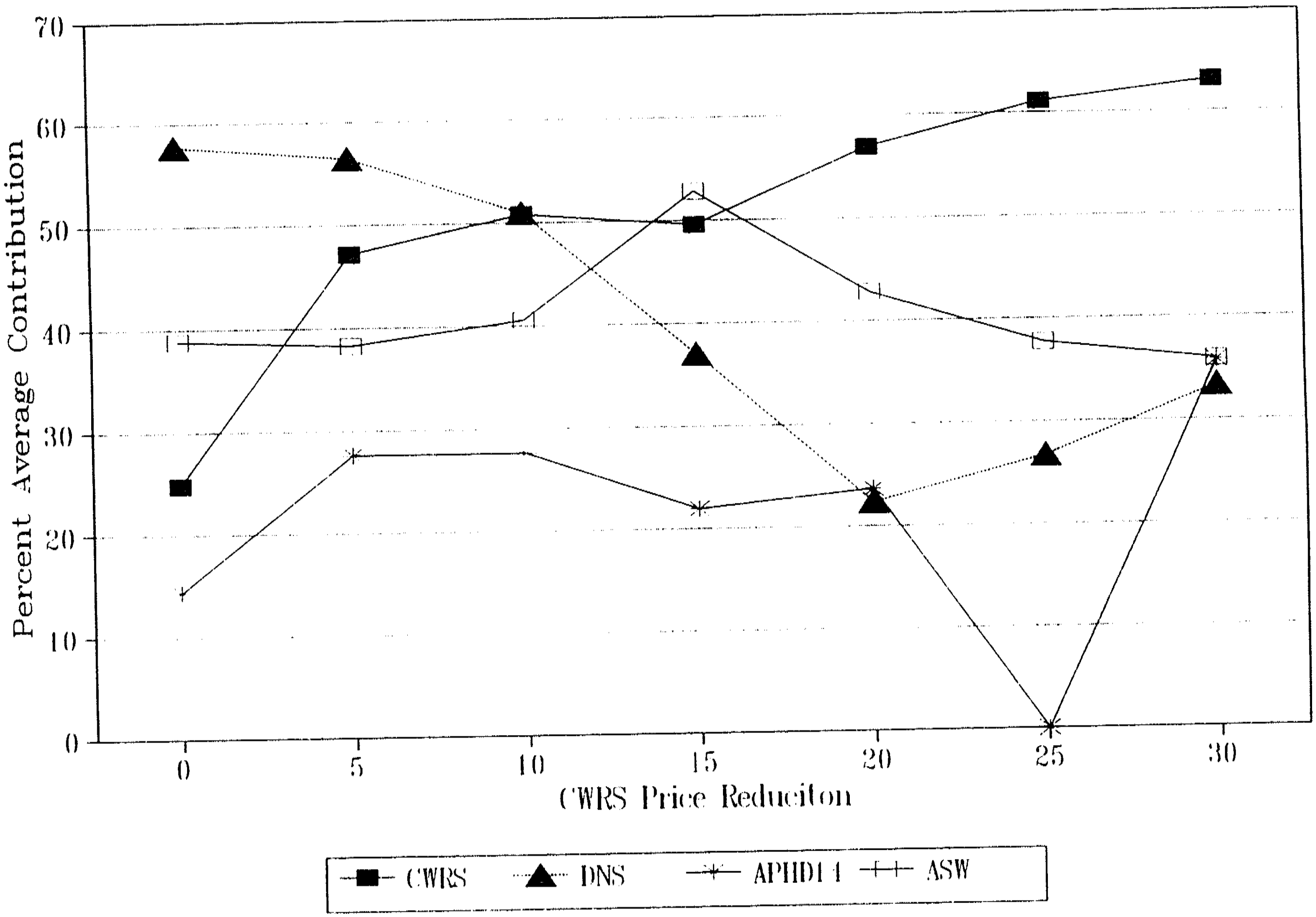


Table 7.12. Results of Parametric Analysis: Small Bakery Flour Blends, CWRS Prices Reduced Approximately $5.00/tonne

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	268.63							82.35		17.65	
85-2W	263.23							82.35		17.65	
85-3W	264.99							80.00		20.00	
85-4W	258.41							80.00		20.00	
85-1E	254.53						50.72	34.62		14.66	
85-2E	255.72						68.57		22.40	8.99	
85-3E	259.71							80.00		20.00	
85-4E	241.77							80.00		20.00	
86-1W	249.49	23.46						57.32		19.22	
86-2W	272.35	63.83									36.17
86-3W	278.37	68.09								31.92	
86-4W	225.43							91.43		8.57	
86-1E	239.00	20.73						59.59		19.68	
86-2E	272.26	21.03						59.27			19.69
86-3E	266.48							91.43		8.57	
86-4E	220.32							91.43		8.57	
87-1W	193.49							0.67	70.26	29.07	
87-2W	198.47							63.60	16.50	19.90	
87-1E	190.04						58.41	41.45	0.14		
87-2E	192.66	16.44					56.53	27.03			

Source: Linear programming results.

Table 7.13. Results of Parametric Analysis: Small Bakery Flours, CWRS Prices Reduced by Approximately $10.00/Tonne.

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	267.63	35.32						38.72	25.96		
85-2W	263.23							82.35		17.65	
85-3W	264.99							80.00		20.00	
85-4W	258.41							80.00		20.00	
85-1E	251.24						60.38	28.48		11.14	
85-2E	250.02					34.46	63.35				2.19
85-3E	259.71							80.00		20.00	
85-4E	241.77							80.00		20.00	
86-1W	246.31	62.95						7.42		29.63	
86-2W	268.71	63.83									36.17
86-3W	274.13	68.09								31.91	
86-4W	222.42	61.54								38.46	
86-1E	237.70	20.73						59.59		19.68	
86-2E	271.08	21.03						59.72			19.69
86-3E	266.48							91.43		8.57	
86-4E	220.32							91.43		8.57	
87-1W	193.49							0.67	70.26	29.07	
87-2W	198.47							63.61	16.50	19.89	
87-1E	184.99	26.32					73.68				
87-2E	187.01	33.33					66.67				

Source: Linear programming results.

Table 7.14. Results of Parmetric Analysis; Small Bakery Flour Blends, CWRS Prices Reduced $15.00/Tonne

Quarter	PRICE	ONE 14.5 CWRS	ONE 135 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	265.27	48.73							27.91	23.36	
85-2W	261.14	37.53						34.88	27.58		
85-3W	264.98							80.00		20.00	
85-4W	255.50	57.37						7.87		34.75	
85-1E	247.48						60.37	28.49			11.14
85-2E	244.05					34.50	63.32				2.18
85-3E	257.98	11.55					41.50	29.91		17.04	
85-4E	241.77							80.00		20.00	
86-1W	241.88	62.95			7.42					29.63	
86-2W	264.29	63.83									36.17
86-3W	269.77	68.09								31.91	
86-4W	218.49	61.54								38.46	
86-1E	236.11				26.25			56.69		17.06	
86-2E	269.75	21.03						59.27			19.69
86-3E	264.90	58.90						10.64		30.45	
86-4E	220.32							91.43		8.57	
87-1W	193.49							0.67	70.26	29.07	
87-2W	198.47							63.61	16.50	19.89	
87-1E	179.09	26.32					73.68				
87-2E	174.80	33.33					66.67				

Source: Linear Programming results.

Table 7.15. Results of Parametric Analysis: Small Bakery Flour Blends, .50 Percent Ash, CWRS Prices Reduced by Approximately $20.00/Tonne.

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	262.81	48.73							27.91	23.37	
85-2W	256.96	41.59					30.71	8.98		18.72	
85-3W	261.18					78.35		12.84		8.81	
85-4W	251.81	57.37						7.87		34.75	
85-1E	243.72						60.37	28.49			11.14
85-2E	236.21					35.88	61.71			2.41	
85-3E	254.19	11.55					41.50	29.91		17.05	
85-4E	238.9	39.05					27.61	5.66		27.68	
86-1W	237.11				78.05					21.95	
86-2W	260.13	63.83									36.17
86-3W	265.32	68.09								31.91	
86-4W	214.48	61.54								38.46	
86-1E	232.97	66.67								33.33	
86-2E	266.38	61.59						8.28			30.12
86-3E	260.82	58.91						10.64		30.45	
86-4E	220.32							91.43		8.57	
87-1W	193.49							0.67	70.06	29.07	
87-2W	195.96						70.00		30.00		
87-1E	173.47	26.31					73.68				
87-2E	175.51	33.33					66.67				

Source: Linear programming results.

Table 7.16. Results of Parametric Analysis: Small Bakery Flour Blends, .50 Percent Ash, CWRS Prices Reduced Approximately $25.00/Tonne.

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	257.85			83.67					7.64	8.67	
85-2W	252.44	41.59					30.71	8.98		18.72	
85-3W	258.00					78.35		12.84		8.81	
85-4W	247.97	65.33								26.41	8.26
85-1E	239.48						71.58		21.26		7.16
85-2E	232.14					34.50	63.32				2.18
85-3E	251.30	11.55					41.50	29.91		17.04	
85-4E	234.75	39.05					27.61	5.67		27.68	
86-1W	232.26				78.05					21.95	
86-2W	255.94	63.83									36.17
86-3W	260.83	68.09								31.91	
86-4W	210.81	61.54								38.46	
86-1E	226.89				76.19					23.81	
86-2E	262.47	61.60						8.28			30.12
86-3E	257.32	58.91						10.64		30.45	
86-4E	220.32							91.43		8.57	
87-1W	189.39						70.00		30.00		
87-2W	191.47		20.37		36.03		43.60				
87-1E	167.38	26.32					73.68				
87-2E	169.27	33.33					66.67				

Source: Linear programming results.

Table 7.17. Results of Parametric Analysis; Small Bakery Flour Blends, .50 Percent Ash, CWRS Prices Reduced Approximately $30.00/Tonne.

QUARTER	PRICE	ONE 14.5 CWRS	ONE 13.5 CWRS	ONE 12.5 CWRS	TWO 13.5 CWRS	TWO 12.5 CWRS	THREE CWRS	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	252.24			65.58			32.46		1.96		
85-2W	247.23	19.87	30.22				30.48		6.92	12.51	
85-3W	252.36					89.98			5.30		4.72
85-4W	243.76	65.33								26.41	8.27
85-1E	235.80						71.58		21.26		7.16
85-2E	226.55					38.47	61.53				
85-3E	248.04		14.27				57.31		22.06	6.36	
85-4E	230.82	39.05					27.61	5.67		27.68	
86-1W	227.42				78.05					21.95	
86-2W	251.84	63.83									36.17
86-3W	256.44	68.09								31.92	
86-4W	206.84	61.54								38.46	
86-1E	223.62				76.19					23.81	
86-2E	258.28	62.67			7.35						29.98
86-3E	252.80	59.93			8.74					31.33	
86-4E	219.27	62.43						4.02		33.54	
87-1W	185.26						70.00		30.00		
87-2W	185.87		20.37		36.03		43.60				
87-1E	162.32	26.32					73.68				
87-2E	164.62	33.33					66.67				

Source: Linear programming results.

CWRS wheat by approximately $5.00/tonne is shown in Table 7.12. Comparing Table 7.12 with Table 7.5 reveals that the frequency with which CWRS wheat would be selected almost doubled, increasing from 5 to 10 selections, and the average contribution in the mixes would increase from 30.8 to 49.9 percent. No.1 (14.5) would be selected in two additional blends and the average contribution would increase to 35.6 percent of the blends in which it was selected. No.3 CWRS was selected three additional times contributing to 58.6 percent of the wheat mix. The decrease in the CWRS price would reduce No.2 DNS selections by two and reduce the average DNS contribution in the blends by three percent.

Table 7.13 shows the results of lowering the price of CWRS wheats by approximately $10.00/tonne. The primary impact of the price reduction was an increase in the frequency of No.1 (14.5) from six to nine and an increase in the expected use from 35.6 to 43.7 percent. The $10.00 price reduction also indicated No.2 (12.5) would be selected in one blend and a slight increase in the average use of No.3 from 58.6 to 66.0 percent. The impact of the additional $5.00/tonne CWRS price decrease was to reduce the number of blends in which No.2 DNS would be selected (-3), and reduce its average contribution 4.7 percent to 60.2 percent. The Australian wheats APHD14 and ASWSA were also selected less frequently, (-1) and (-2) respectively, whereas the contribution of APHD14 and ASWSA increased 16.0 and 3.5 percent, respectively, to 43.4 and 21.8 percent.

The wheat selections which would result from a decrease in CWRS prices of approximately $15.00/tonne are shown on Table 7.14. The primary result of the incremental $5.00/tonne price decrease was an additional increase in the use of No.1 (14.5) from nine to 12 and a slight increase in average contribution use by 2.2 to 45.9 percent. No.2 (13.5) was also selected twice and No.3 CWRS selections increased by one. The total contribution of all CWRS grade/segregations decreased slightly from 62.9 to 61.7 percent because the average contribution of No. 3 CWRS decreased by approximately 5 percent.

The $15.00/tonne reduction in the price of CWRS wheats continued to reduce the frequency with which No. 2 DNS was selected and its average contribution. No.2 DNS was selected in two less blends down from 14 and its average contribution declined approximately 15 percent to 45.3. The effect on Australian wheats was mixed. Both the APHD14 and ASWWA were each selected in one additional blend but their average contribution declined 5.2 and 3.0 percent, respectively. Conversely, the average contribution of ASWSA increased to 49.8 percent but it was selected in one less blend.

Table 7.15 shows the results of lowering CWRS prices approximately $20.00/tonne. No. 1 (14.5) was selected 13 times up one from the $15.00/ tonne price reduction and the average contribution increased 3.2 percent to 49.1 percent. The frequency and percent contribution of No. 1 (14.5) to small pan flour blends was slightly higher than for the large bakery flours when the CWRS prices were lowered by $20.00/tonne. This is as expected as the protein content in the small bakery flours is greater. The $20.00/tonne price decrease also increased the frequency of use of No. 3 CWRS from 5 to 8 selections. Again, the average contribution dropped a few percentage points from 61.0 to 54 percent of the wheat mixes in the blends, as the two additional

No.3 CWRS selections contributed lower levels than the previous selections. No. 2 (13.5) and No. 2. (12.5) were also selected one and two times, respectively. In 18 of the 20 periods, CWRS grades/segregations contributed on average 70.2 percent of the wheat required to produce the flour blend, up from 61.7 percent at the $15.00/tonne price reduction level and up 39.4 percent from the 30.7 percent contributed using original asking prices.

The major impact on non-CWRS wheats was a reduction in the frequency of use of No. 2 DNS from 12 to 10, and a substantial reduction in average contribution from 45.3 percent to 20.5 percent. Lower CWRS prices also impacted on Australian wheats but to a lesser degree; both APHD14 and ASWWA wheat frequencies declined by one selection, but ASWSA wheat increased by one and its average contribution decreased to 23.3 percent. Conversely, the contributions of APHD14 and ASWWA increased to 42.7 (+4.44) and 25.81 (+8.51) percent, respectively.

Table 7.16 shows the results of lowering CWRS asking prices $25.00/tonne. The major impact on the CWRS grades/segregations was a reduction in the use of No. 1 (14.5) and an increase in the frequency of use and contribution of No. 3 CWRS. Lower prices of approximately $20.00/tonne did not improve to competitive positions of No. 1 (13.5) and (12.5) as they were not selected in any blend but each were selected once when prices were lowered $25.00/tonne contributing 20.4 and 83.7 percent, respectively of the wheat mix. Use of No. 2 (13.5) increased from one to three selections contributing 76.2 and 36.0 percent of the wheat in the two additional blend selections.

In 18 of the 20 selections, CWRS grades/segregations contributed on average 74.6 percent of the wheat required to produce the flour blend.

The increase in the average percent contribution of CWRS wheats to the blends resulted in a decrease in the use of No. 2 DNS and APHD14. The frequency of ASWWA, however, increased from 3 to 5 appearances but its contribution in the additional 3 blends was small averaging 5.9 percent.

The results of reducing the asking price of the CWRS wheats by a total of $30/tonne are indicated in Table 7.17. CWRS wheats were used in all 20 blend situations and the average contribution increased to 78.1 percent of the wheat mix. Similar to the large bakery pan flours results, as the CWRS prices were lowered the use of No. 1 and No. 2 (13.5) and (12.5) wheat increased. However, No. 2 (13.5), the third most frequently selected segregation was selected in only 5 of 20 blends and its contribution varied widely ranging between 7.35 and 78.05 percent. Excluding No. 1 (14.5) and No. 3, the increase in the other CWRS segregations displaced No. 2 DNS and ASWSA. However, the frequency of APHD14 use increased from 3 to 6 selections when No. 1 (14.5) use was displaced by No. 1 and No. 2 (13.5) and (12.5) wheats in the blend.

In summary, lowering the price of CWRS wheats improved their ability to compete with foreign export wheats, thereby increasing the frequency and the contribution of CWRS wheats to the theoretical pan bread flour blends. The extent to which the average contribution increased with each incremental drop in the CWRS prices is indicated in Table 7.18. The impact was greatest in the small bakery blends as there tended to be a greater displacement of higher protein No. 2 DNS and APHD14 by No. 1 (14.5), Figures 7.9 and 7.10. The Australian medium quality wheats at first increased as No. 1 (14.5) selections increased but gradually decreased as the contribution of No. 3 CWRS increased, displacing to some extent these medium quality wheats. Note that the impacts of declining CWRS prices on the contribution of APHD14 in the large and small bakery flours were reversed. In the large bakery flours, the average contribution of APHD14 increased as CWRS prices fell and APHD14 contribution declined as CWRS prices fell in small bakery flours. This is due to the higher proportion of CWRS wheats

Table 7.18. Average Percent Contribution and Frequency of Use in Small and Large Bakery Blends When CWRS Prices Reduced.

Price Adjustment	**Small Bakery**		**Large Bakery**	
	Frequency Selected #	Average Contrib %	Frequency Selected #	Average Contrib %
Original Series	4	30.8	5	24.7
$ 5.00/tonne	9	49.8	9	47.2
$10.00/tonne	11	62.9	11	50.9
$15.00/tonne	15	61.7	15	49.6
$20.00/tonne	18	70.2	18	56.9
$25.00/tonne	18	74.6	19	61.2
$30.00/tonne	20	78.1	20	63.1

Source: Author's calculations.

Figure 7.9 Small Bakery Flour .5% Ash
Frequency of Wheat Selections

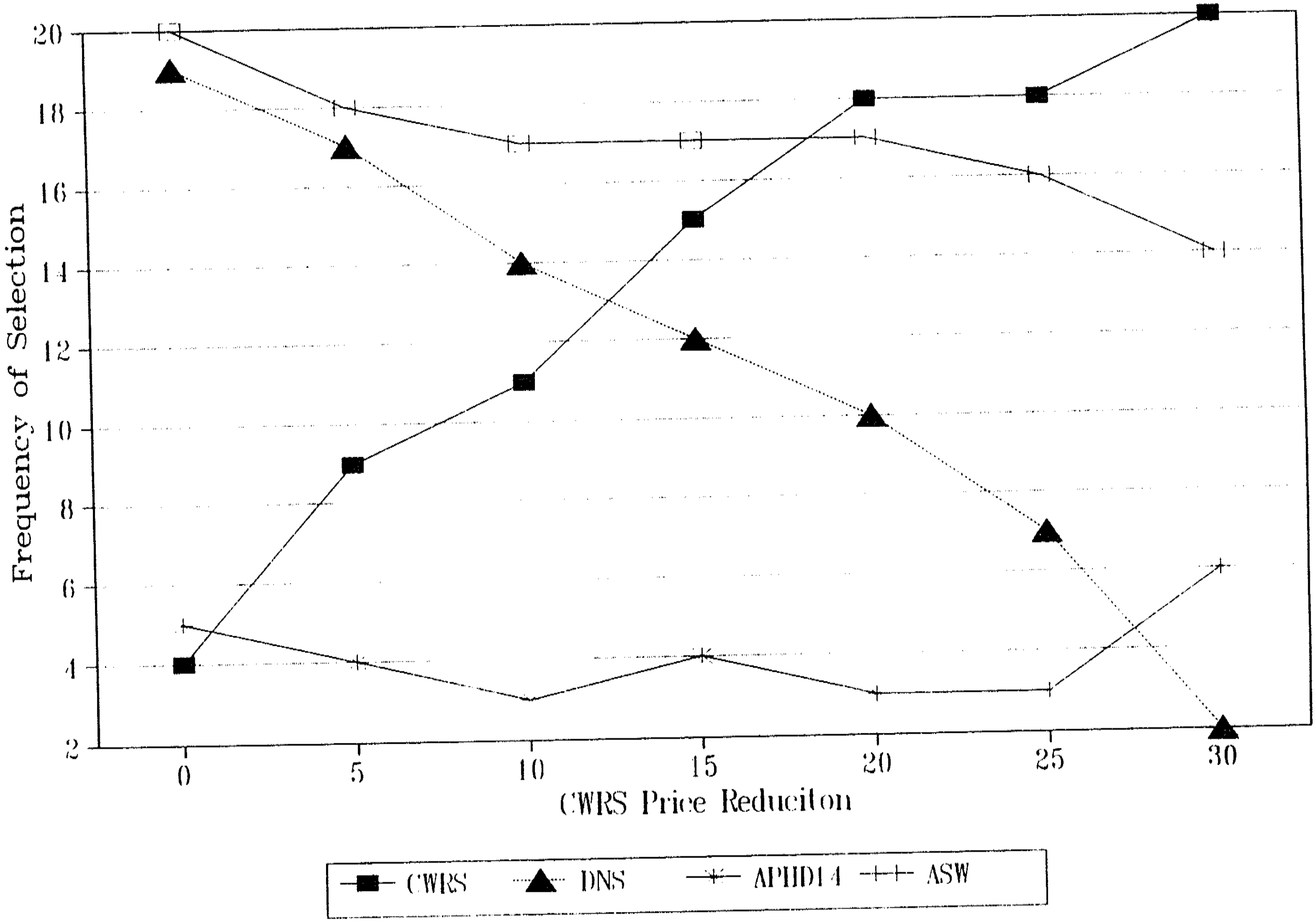
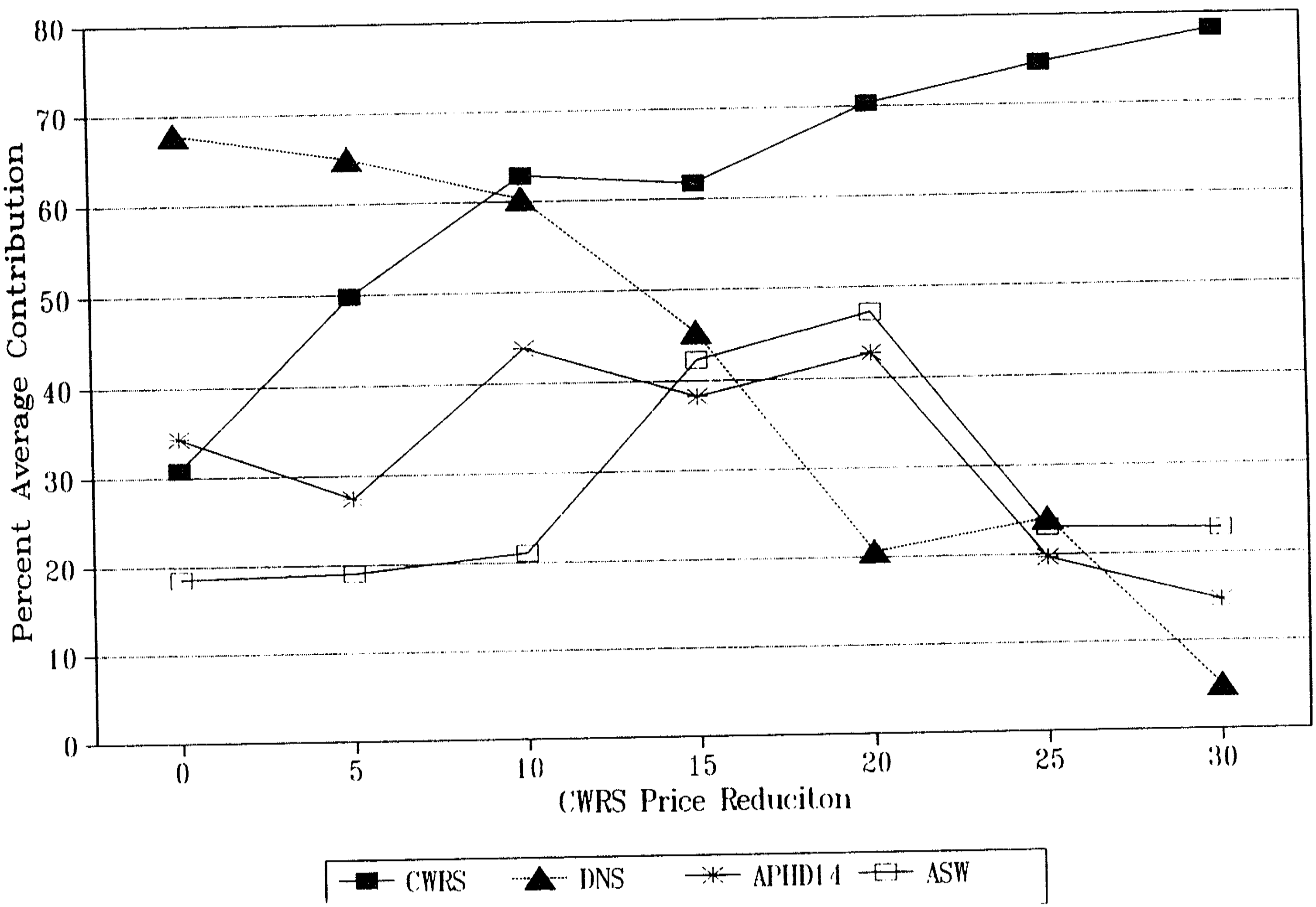


Figure 7.10 Small Bakery Flour .5% Ash
Contriblion of Wheats When Selected



in the mix for small bakery flours.

7.7.3. Elasticities

The effect of price reductions on the quantity of CWRS wheat selected are illustrated in Figure 7.11 and Figure 7.12 for the large and small pan breads, respectively. The quantity of CWRS utilized on average was determined by multiplying the frequency of use by the average contribution of CWRS wheats found in Table 7.18. For example, six selections with an average contribution of 50 percent (.5 tonnes)[217] is equated to three tonnes. The maximum amount that can be selected of any wheat is 20 tonnes. The base price was $235.96/tonne, the average No.1 (13.5) price for the 20 situations used in the parametric analysis. The elasticities with respec to price for these two wheats were calculated where the percentage change in price and quantity are determined relative to the previous price and quantity in the series.

The estimated elasticities are shown in Table 7.19 and 7.20. The results indicate that for both pan bread flours, CWRS wheat is very price elastic over the range of price reductions used. It is also clear from the results that CWRS use becomes less elastic as the price of CWRS wheat is reduced. CWRS wheats in small pan bakery flours appear to be more elastic than in large bakery flours[218].

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[217] To derive quantity estimates it is assumed that only one tonne of grain is purchased within each quarter and port situation. Therefore, the amount of any specific wheat used in any one selection would be the average contribution multiplied by one tonne. For example, if an average CWRS contribution of 42 percent were indicated, then 420 kilograms of CWRS wheats would be selected in each tonne of the wheat mix.

[218] Elasticities were also calculated with respect to the base price and quantity to determine the relative change which occurs with larger price increases. The results of these calculations are not shown as the magnitude of the elasticities was extremely high.

Figure 7.11 Large Bakery Flour

Parametric Price Quanity Relationship

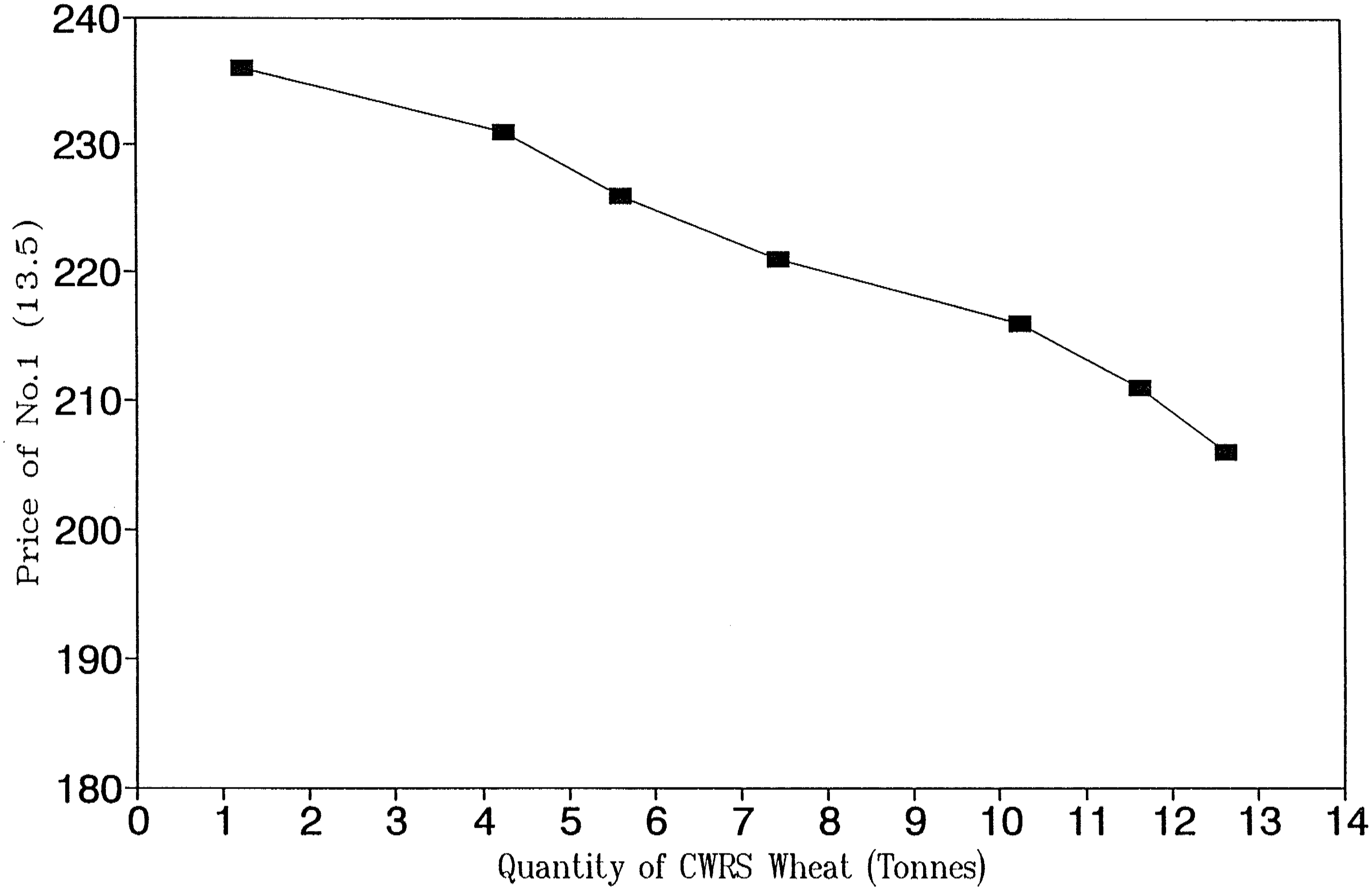

Figure 7.12 Small Bakery Flour
Parametric Price–Quantity Relationship

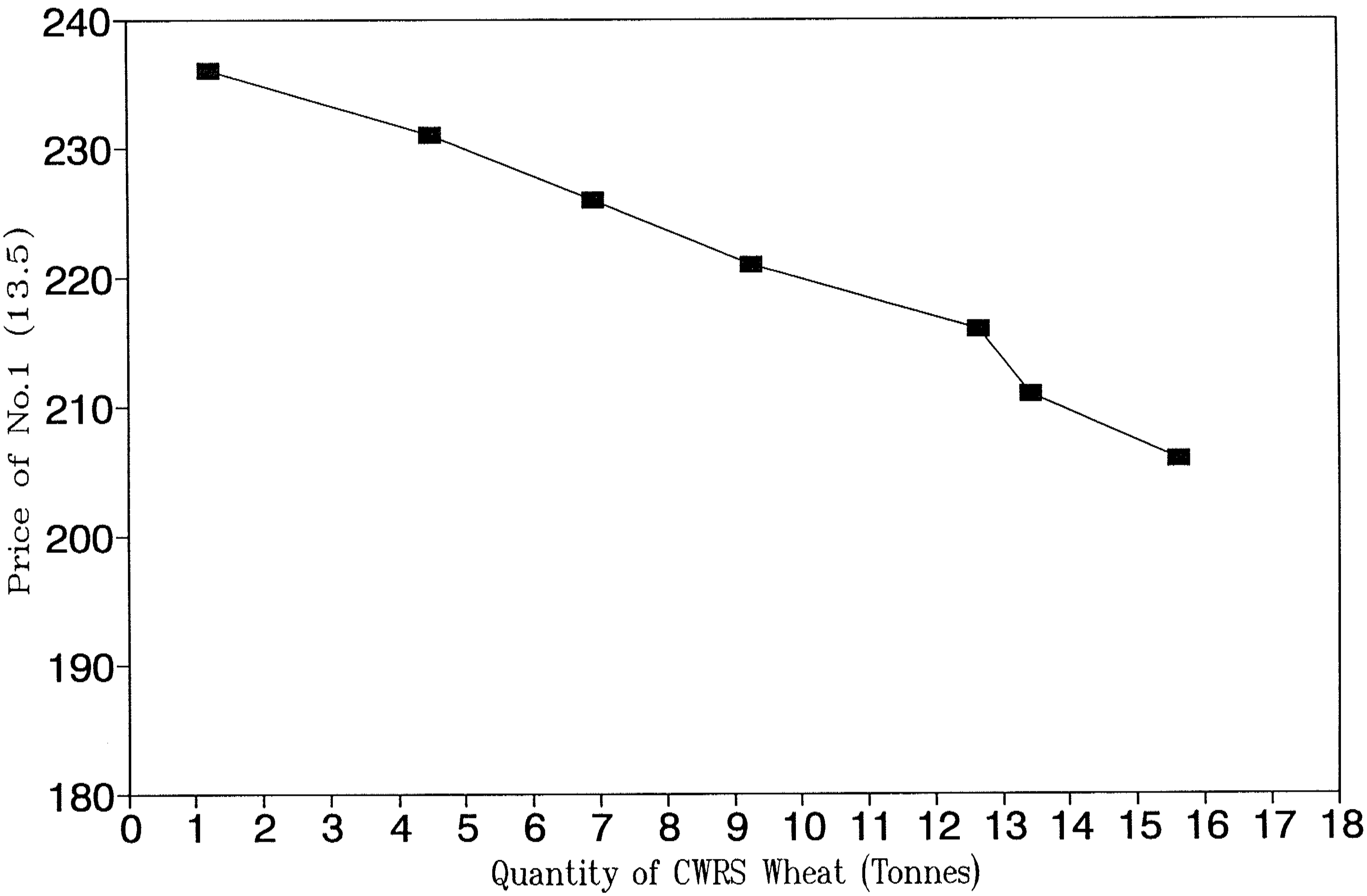

Table 7.19. Estimated Price Elasticities For CWRS Wheat in Large Bakery Flours

Price No.1 (13.5)	Quantity (Tonnes)	Elasticity
235.96	123.50	-
230.96	424.80	52.24
225.96	559.90	12.53
220.96	744.00	12.33
215.96	1024.20	13.84
210.96	1162.80	5.43
205.96	1262.00	3.41

Source: Calculated by author.

Table 7.20. Estimated Price Elasticities for CWRS Wheat in Small Bakery Flours

Price No.1 (13.5)	Quantity (Tonnes)	Elasticity
235.96	123.20	Original
230.96	448.20	53.19
225.96	691.90	19.49
220.96	925.50	12.89
215.96	1263.60	13.50
210.96	1342.80	2.60
205.96	1562.00	6.28

Source: Calculated by author.

7.8. Summary

CWRS wheat has long been regarded as one of the best, if not the best, pan bread milling wheat in the world. However, CWRS wheat must compete with other wheats in the world market, and often being the best may not be enough to be competitive. In this

Chapter, the ability of CWRS wheat to compete in the pan bread milling wheat market with wheat from Australia and the U.S. was discussed. Under the assumptions and limitations reported, use of the six grades and protein segregations of CWRS wheat did not present an optimistic prospect for the future of CWRS in the world market.

The results show that the cost of the end flour was substantially reduced when the miller was provided with additional wheat choices. Also the results show that when the miller could choose from all the wheats in the study, very little No.1. or No. 2. CWRS wheat was used in the flour blends. The lowest cost blends used large percentages of DNS from the U.S. and both the medium quality ASW's and high protein (APHD) from Australia in the grist. The middle of the CWRS quality spectrum, the No. 1 and No. 2 (13.5) and (12.5) wheats were limited in use when blended with wheats from other countries.

Depending on transportation costs, it appears that a distinct possibility exists that CWRS wheat could be supplanted in Canadian mills by DNS from the U.S. as the major milling wheat. Conversely, although not developed at length in this chapter, the results also indicate that a market should exist in the U.S. for CWRS wheat to blend with the U.S. wheat to produce a high quality lower cost flour than is available with DNS alone.

The results of the analysis presented in this chapter indicate that the grades of CWRS wheat grades are over-priced relative to the quality advantage which they provide over competitive wheats. However, the results also show that CWRS wheats are very price elastic over the range of price reductions used in the parametric analysis. Consequently, one may conclude that CWRS wheat could be more competitive in the pan bread markets than is indicated in the original analysis. The high calculated elasticities indicate that as the price of CWRS grade/segregations is lowered, the quality inherent in the grades allows CWRS not only to substitute for both DNS and APHD14, but also to compete with the Australian middle quality wheats in the pan bread blends.

CHAPTER 8. French Bread Flours Analysis Using Wheats from Three Countries

8.1. Introduction

Chapter 7 analysed CWRS competiveness with other wheats in the pan bread flour markets. The study assumed the representative miller was a profit maximizer hence the miller selected wheats which would enable him/her to produce the least cost flour Pan breads of the type used in North America represent only a small portion of world food wheat consumption. This chapter examines the potential for CWRS wheat in another wheat bread market, specifically the French style bread market.

French breads have different quality requirements than North American pan breads. In particular, the flours used for baking French style breads require lower protein contents and allow higher ash contents than the flours used for pan breads. These differences in quality characteristics tend to make French breads less expensive than North American pan breads. While part of the popularity of French breads may be due to taste, price may also contribute to the popularity of these breads in lower income counties. Wheat prices tend to increase as the protein content increases, hence consumers with lower incomes may have developed taste preferences for products that use lower protein content wheat than consumers in higher income countries.

The analysis in this chapter used three ranges of protein contents, 10.5 to 11.0 percent, 11.0 to 11.5 and 11.5 to 12 percent. Also two allowable ash content levels, .5 percent and .6 percent were used in the analysis. The .5 percent level represents the low ash range for French bread flours, and the .6 percent ash is in the upper range. Due to data limitations, protein content and allowable ash are the only quality factors which are varied in the analysis.

The analysis is based on two of the four choice sets analyzed in Chapter 7, the **Commonwealth (COM)** choice set which contains only CWRS and Australian wheats, and the **ALL** choice set which contained the six CWRS grades/segregations, U.S. No.2 DNS and the Australian wheats. The analysis was limited to these two choice sets as there were very few feasible solutions for either the CAN or NOR choice sets, Table 8.1. Only 5 feasible French bread solutions were obtained from these choice sets and only when No. 3 CWRS had less than 12 percent protein. The addition of No.2 DNS to the miller's choice set did not increase the number of feasible solutions as No.2 DNS is a high protein wheat.

Examining the results presented in Table 8.1 reveals that one of the five cases had the potential to produce a lower cost flour if the allowable protein level were increased beyond 12 percent. Liquefaction number was a limiting factor in another one of the seven feasible solutions. For the other three feasible solutions No. 3 CWRS was the lowest cost wheat after the spreadsheet adjustments. The results of this section of the analysis indicate that, CWRS wheat by itself is unable to produce a competitive low cost flour for the French style breads used in this study. The remainder of the chapter analyzes the potential of CWRS wheat as a blending wheat.

Table 8.1. French Bread Feasible Solutions: NOR Choice Set, .5 Ash, 11.0-12.0 Protein Range

QTR	PRICE CAN.$/ TONNE	WHEATS IN THE BLEND	PERCENT OF BLEND	BINDING PROTEIN	CONSTRAINTS LIQUEFACT. NUMBER
84/85-1W	288.37	No.3	100	1.07918	--
85/86-1E	262.99	No.3	100	- -	0.173292
85/86-2E	304.86	No.3	100	NONE	--
86/87-1W	211.48	No.3	100	NONE	--
86/87-2E	190.18	No.3	100	NONE	--

Source: Linear programming results.

8.2. French Bread Analysis Using the COM Choice Set

The results of the COM choice set (CWRS and the Australian wheats) are presented in Tables 8.2 through to 8.16. Tables 8.2 through 8.9 pertain to .5 percent ash and Tables 8.10 through 8.16 for .6 percent ash.

8.2.1. French Bread .5 Percent Allowable Ash

Table 8.2, Table 8.3 and Table 8.4 show the present the use of the various wheats for the three protein content levels; Table 8.2 presents the results for 10.5 to 11.0 percent protein, and Table 8.3 and Table 8.4 for the 11.0 to 11.5 and 11.5 to 12.0 percent protein ranges, respectively. Throughout the 10.5 to 11.0 percent protein range of the COM choice set only two grade/segregations of CWRS wheat were selected, No.1 (14.5) and No. 3 CWRS. These two segregations represent the extreme ends of the CWRS quality spectrum. As can be seen in Table 8.2 neither CWRS wheats were selected in the flour blends during the first 10 and 12 crop year quarters for the eastern port and western port blends, respectively, at the 10.5 - 11.0 percent protein level. However, when No. 1 (14.5) was selected it substitued for APHD14 and CWRS No. 3 for ASWSA. No.1 (14.5) was selected seven times for the western ports flours and five times for the Eastern. Conversely, No. 3 CWRS is only selected once in the western ports blends but was selected five times for the eastern blends. As No. 3 CWRS alone provided five feasible solutions in the NOR choice set (Table 8.1), these results suggest that the Australian wheats provide the necessary qualities at a lower relative price hence their selection, and the protein level in No. 3 CWRS may also be too high relative to the flour requirements thus inhibiting its use.

Table 8.3 shows the wheat choices for the grists with 11.0 to 11.5 percent protein. A similar pattern was exhibited with respect to the first 12 quarters of the study where no CWRS wheat was selected. However, a comparison of Table 8.3 and Table 8.2 indicates that the content of Australian and CWRS wheats changed as protein increased. In the blends where they were selected, the percent use of No. 1 (14.5) and CWRS No. 3 increased. CWRS No. 3 generally constituted a larger percent of a blend than did No. 1 (14.5). In general, No. 1 (14.5) CWRS substituted for APHD14 for the western port blends whereas both No. 1 (14.5) and No.3 CWRS replaced APHD14 for the eastern port blends.

Table 8.2. Percent Use Of Various Wheats COM Choice Set 10.5-11.0 Percent Protein, .50 Percent Ash

QUARTER	WESTERN PORTS ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	EASTERN PORTS ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA
					percent					
81/82-1			11.11	88.89				11.11	88.89	
81/82-2			11.11	88.89				11.11	88.89	
81/82-3			11.11	88.89			10.00		90.00	
81/82-4			11.11	88.89			10.00		90.00	
82/83-1				100.00					100.00	
82/83-2				100.00					100.00	
82/83-3				100.00					100.00	
82/83-4				100.00					100.00	
83/84-1			44.44	55.56				44.44	55.56	
83/84-2			44.44	55.56				44.44	55.56	
83/84-3			44.44	55.56		30.44	30.44			53.78
83/84-4			44.44	55.56				40.00		60.00
84/85-1	4.16		19.45	76.39			34.95	3.03	62.03	
84/85-2	5.35		17.40	77.25			34.95	3.03	62.03	
84/85-3		0.48	25.51	74.00		5.18		9.62	69.01	
84/85-4	15.91			84.09		4.94	0.21	17.62	77.23	
85/86-1	23.91			76.09		22.90			76.80	0.30
85/86-2	19.15				80.85	20.46				79.55
85/86-3	20.37			8.27	71.36	19.91			7.93	72.16
85/86-4	18.79			19.63	61.58	19.47			7.61	72.91
86/87-1			27.08	72.92				27.08	72.92	
86/87-2			27.08	72.92			50.00		50.00	

Source: Author's calculations based on linear programming results.

Table 8.3. Percent Use of Various Wheats:COM Choice Set, 11-11.5 Percent Protein, .5 Percent Ash

	WESTERN PORTS					EASTERN PORTS				
QRTER	ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	ONE CWRS 14.5	THREE CWRS	APHD14	ASWS	AASWWA
81/82-1			29.63	70.37				29.63	70.37	
81/82-2			29.63	70.37				29.63	70.37	
81/82-3			29.63	70.37			26.67		73.33	
81/82-4			29.63	70.37			26.67		73.33	
82/83-1			11.11	88.89				11.11	88.89	
82/83-2			11.11	88.89				11.11	88.89	
82/83-3			11.11	88.89				11.11	88.89	
82/83-4			11.11	88.89				11.11	88.89	
83/84-1			58.33	41.67				58.33	41.67	
83/84-2			58.33	41.67				58.33	41.67	
83/84-3	38.30				61.70	40.00			40.00	20.00
83/84-4			58.25	40.78	0.10		52.50		47.50	
84/85-1	12.50		25.00	62.50			34.95	3.03	62.03	
84/85-2	22.08		22.08	68.64			34.95	3.03	62.03	
84/85-3		1.45	43.21	55.34		21.37		9.62	69.01	
84/85-4	27.27			72.73		21.37		9.62	69.01	
85/86-1	34.78			65.22		33.33			66.67	
85/86-2	29.79				70.21	31.82				68.18
85/86-3	31.85			16.69	51.46	31.14			16.17	52.70
85/86-4	29.38			34.46	36.16	30.45			15.67	53.88
86/87-1			37.50	62.50				37.50	62.50	
86/87-2			37.50	62.50			69.23		30.77	

Source: Author's calculations based on linear programming results.

Table 8.4. Percent Use Of Various Wheats; COM Choice Set, 11.5-12.0 Percent Protein, .5 Percent Ash

QUARTER	WESTERN PORTS ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	EASTERN PORTS ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA
					percent					
81/82 1			48.24	51.47	0.30		0.16	47.98	51.86	
81/82-2		0.17	48.01	51.82			0.11	48.04	51.86	
81/82-3		0.16	48.04	51.81			43.33		56.67	
81/82-4		0.26	47.94	51.80			43.33		56.67	
82/83-1		2.98	35.36	61.66				29.63	70.37	
82/83-2			29.63	70.37				29.63	70.37	
82/83 3			29.63	70.37				29.63	70.37	
82/83-4			29.63	70.37				29.63	70.37	
83/84 1			72.22	27.78				72.22	27.78	
83/84 2			72.22	27.78				72.22	27.78	
83/84 3	48.94				51.06		49.56		26.22	24.22
83/84 4			72.17	27.18	0.65		65.00		35.00	
84/85 1	30.55		30.55	48.61			53.13		46.88	

QUARTER	WESTERN PORTS ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	EASTERN PORTS ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA
84/85-2	38.82		1.15	60.04			53.13		46.88	
84/85-3		2.42	60.91	36.68		37.56		1.76	60.69	
84/85-4	37.56		1.76	60.69		37.56		1.76	60.69	
85/86-1	45.65			54.35		43.75			56.25	
85/86-2	40.43				59.57	43.18				56.82
85/86-3	43.34			25.12	31.55	42.37			24.40	33.23
85/86-4	39.97			49.29	10.73	41.44			23.72	34.85
86/87-1			47.92	52.08				47.92	52.08	
86/87-2			47.92	52.08			88.46		11.54	

Source: Author's calculations based on linear programming results.

The only time ASW from Western Australia (ASWWA) was used occurred when No. 1 (14.5) was also used. ASWWA is the lowest protein content wheat used in the study, and No.1 (14.5) the highest protein content, hence these two wheats tended to complement each other. No.1 CWRS (14.5) also appears to provide lower cost protein than is attainable with APHD14.

A closer inspection of the use of No. 3 CWRS indicates that the grade appears to lack the carrying power of CWRS No.1 (14.5). An indication of this "lack of carrying power" is that ASWSA is generally combined with No. 3 CWRS in the grists. ASWSA tends to be the "higher" quality of the two ASW's, thus it may better complement No.3 CWRS.

Also there were differences between ports with respect to No. 3 CWRS wheat use. At no time in the western port blends did CWRS No. 3 substitute for APHD14 but CWRS No. 3 substituted for APHD14 in all blends it was selected for in eastern port blends. As well there were two instances where both No.1 CWRS 14.5 and APHD14 were used in the western blend (first and second quarter 1984/85) but only No. 3 CWRS was used in the eastern blend. While No.3 CWRS likely does not have the quality characteristics of APHD14, it does generally have competitive prices. Consequently, it may frequently substitute for APHD14, depending on the relative price-quality relationship that exists at that point in time.

The results of the COM choice set at .50 percent allowable ash and 11.5 - 12 percent protein are shown in Table 8.4. There are several noticeable differences in percent mix when the protein level was increased within each blend which used

APHD14. First, the amount of APHD14 increased by about 20 percent. The frequency and amount of the two CWRS wheats used also changed when the protein content of the flour was increased. The trend not to include No.1 (14.5) in any of the blends during the first 10 quarters continued at this protein level. This trend suggests that the pricing policy of the CWB may have changed during the period of the study. The major change with respect to the CWRS wheats was that No.3 was included in more blends. In addition, the contribution of No.3 generally increased in the blends that included that grade. The western and eastern use trends continued at the 11.5 to 12.0 percent protein content level, with No.1 CWRS (14.5) being the predominant CWRS wheat used in the western port flours and both No.1 (14.5) and No.3 being used in the eastern blends. No.3 CWRS was used more frequently and in larger amounts that the No.1 CWRS (14.5) in the eastern blends.

Table 8.5 presents the calculated flour prices for the three protein levels of French breads used in the analysis. As expected, the calculated price increases as the protein content increases. Also apparent is that the cost of flour is generally lower for the eastern ports than for the western ports[219].

Table 8.6 shows the average flour costs and the standard deviations of those costs for the blends presented in Table 8.5. The results indicate that western cargoes tended to be more costly and exhibit more variability in cost than eastern cargo blends. It is also apparent that the differences in both the level of cost and cost variability between

[219] The only exception is during the second and fourth quarter 1985/86 when western port blends for all ash levels were cheaper than eastern port blends.

Atlantic and Pacific blends increased as the protein content increased. These two trends are interrelated and can be explained by the way the CWB prices CWRS wheat.

The CWB tends to price CWRS wheat higher on the west coast than it does at the St. Lawrence ports, thus *ceteris paribus,* a flour blend using exactly the same quantities of CWRS grades/segregations will be more expensive from the western ports than from eastern ones. As the contribution of CWRS wheat to the blend increases, the differences in price is exaggerated. This difference in pricing will impact on the selection of the wheat used in the blend.

The differences between the averages shown on the bottom section of Table 8.6, indicate that reducing the protein content of the flour decreases the cost $5 to $6/tonne. This is because less APHD14 and CWRS No.1 (14.5) and a greater amount of ASW is being used. The results also indicate that the savings appear to be greater moving from 11.5 to 12.0 percent protein down to 11.0 to 11.5 protein, than from 11.0 to 11.5 down to 10.5 to 11.0 percent. This is because the "medium quality" protein level wheat is less able to meet the protein requirement at the higher protein content flour and requires the addition of "high quality" protein wheat. It is interesting to note that the average differences between ports and protein levels are almost the same, at $0.80/tonne. This may imply that a constant relationship exists for protein content over the period of the study.

Table 8.5. French Bread Flour Costs at .5 Ash For Three Protein Levels

	WESTERN PORTS			EASTERN PORTS		
	PROTEIN LEVEL			PROTEIN LEVEL		
QUARTER	10.5-11%	11-11.5%	11.5-12%	10.5-11%	11-11.5%	11.5-12%
	PRICE IN CAN.$/TONNE			PRICE IN CAN.$/TONNE		
81/82-1	234.29	239.13	244.01	234.29	239.13	243.99
81/82-2	231.81	235.54	239.3	231.81	235.54	239.29
81/82-3	226.15	232.53	238.94	225.17	229.91	234.66
81/82-4	225.47	231.94	238.46	224.52	229.4	234.27
82/83-1	224.21	227.3	235.15	224.21	227.3	232.43
82/83-2	235.35	237.49	241.06	235.35	237.49	241.06
82/83-3	238.8	240.26	242.7	238.8	240.26	242.7
82/83-4	227.34	230.08	234.63	227.34	230.08	234.63
83/84-1	237.53	242.49	247.44	237.53	242.49	247.44
83/84-2	230.16	235.38	240.6	230.16	235.38	240.6
83/84-3	238.98	245.65	252.38	238.77	245.41	252.06

QUARTER	WESTERN PORTS PROTEIN LEVEL 10.5-11%	11-11.5%	11.5-12%	EASTERN PORTS PROTEIN LEVEL 10.5-11%	11-11.5%	11.5-12%
	PRICE IN CAN.$/TONNE			PRICE IN CAN.$/TONNE		
83/84-4	246.88	254.52	262.16	242.38	248.61	254.84
84/85-1	246.05	252.75	259.44	244.48	246.43	249.78
84/85-2	244.85	251.27	257.68	243.29	244.8	247.98
84/85-3	247.01	253.8	260.6	246.48	251.71	256.94
84/85-4	230.94	239.63	248.39	230.65	236.16	241.69
85/86-1	220.09	228.48	236.87	218.23	225.75	233.28
85/86-2	230.97	241.8	252.63	233.05	245.03	257.01
85/86-3	241.2	250.81	260.62	239.5	248.26	257.01
85/86-4	195.06	203.31	211.17	199.5	210.05	220.61
86/87-1	173.79	178.48	183.16	173.79	178.48	183.16
86/87-2	180.37	184.94	189.5	179.34	183.51	187.68

Source: Author's calculations based on linear programming results.

Table 8.6. Averages And Standard Deviations For The Three French Bread Protein Levels

PROTEIN RANGE	PACIFIC CARGOES	ATLANTIC CARGOES	DIFFERENCE BETWEEN PORTS
	dollars per tonne		
10.5-11.0%			
AVERAGE	227.60	227.21	.39
STD DEV	19.47	18.94	.51
11.0-11.5%			
AVERAGE	233.53	232.33	1.20
STD DEV	19.83	18.74	1.09
11.5-12.0%			
AVERAGE	239.86	237.87	1.99
STD DEV	20.42	18.96	1.48
DIFFERENCES BETWEEN THE AVERAGES			
10.5-11 TO 11-11.5%	5.92	5.12	.80
11.0-11.5 TO 11.5-12%	6.33	5.54	.79

Source: Author's calculation based on linear programming results.

The shadow prices for protein when it was the binding constraint are shown in Table 8.7. Protein content was a binding constraint in almost all cases[220], except for 10.5 to 11.0 percent protein flour blends during the 1982-83 crop year when ASWSA was used exclusively. During that year, the cost of the flour could not be lowered further as ASWSA had a protein content of 10.5 percent that year. All other wheats had higher protein contents hence, they were more expensive than ASWSA. In general, it appears that flour costs could decrease $1 to $2 per tonne for each .1 percent the protein requirement was lowered.

The instances where water absorption was a binding constraint are shown in Table 8.8. In 1982-83, where ASWSA was used exclusively were the only instances where water absorption was not binding. In general, the water absorption and protein content restrictions prevented exclusive use of the two lower quality Australian wheats ASWWA and ASWSA. These wheats are less expensive than the CWRS wheats or Australian Prime Hard, but lack the quality characteristics necessary to produce acceptable French breads.

There were very few instances where liquefaction number was a binding constraint, Table 8.9. The instances where liquefaction number was binding occurred when CWRS grades/segregations were included in the blend. If one CWRS grade/segregation was chosen over another, which appeared lower in cost, the reason was

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[220] A negative number indicates that the cost of flour blends could have been reduced if the allowable protein in the flour blend were lower.

Table 8.7. Protein as a Binding Constraint, COM Choice Set, .50 Percent Ash

QUARTER	WESTERN PORTS 10.5-11% PROTEIN	WESTERN PORTS 11-11.5% PROTEIN	WESTERN PORTS 11.5-12% PROTEIN	EASTERN PORTS 10.5-11% PROTEIN	EASTERN PORTS 11-11.5% PROTEIN	EASTERN PORTS 11.5-12% PROTEIN
			dollars per tonne reduction in cost			
81/82-1	-0.96680	-0.96680	-1.14594	-9.66800	-0.96680	-1.06038
81/82-2	-0.74563	-0.74563	-0.84673	-0.74563	-0.74563	-0.82849
81/82-3	-1.27606	-1.27606	-1.40474	-0.94905	-0.94905	-0.94905
81/82-4	-1.29328	-1.29328	-1.48397	-0.97534	-0.97534	-0.97534
82/83-1	0	-1.02735	-1.24851	0	-1.02733	-1.02733
82/83-2	0	-0.71424	-0.71424	0	-0.71424	-0.71424
82/83-3	0	-0.48724	-0.48724	0	-0.48724	-0.48724
82/83-4	0	-0.91146	-0.91146	0	-0.91146	-0.91146
83/84-1	-0.99060	-0.99060	-0.99060	-0.99060	-0.99060	-0.99060
83/84-2	-1.04403	-1.04403	-1.04403	-1.04403	-1.04403	-1.04403
83/84-3	-1.34199	-1.34438	-1.34438	-1.32894	-1.32891	-1.32891
83/84-4	-1.52736	-1.52736	-1.52736	-1.24543	-1.24543	-1.24543

QUARTER	WESTERN PORTS 10.5-11% PROTEIN	WESTERN PORTS 11-11.5% PROTEIN	WESTERN PORTS 11.5-12% PROTEIN	EASTERN PORTS 10.5-11% PROTEIN	EASTERN PORTS 11-11.5% PROTEIN	EASTERN PORTS 11.5-12% PROTEIN
			dollars per tonne reduction in cost			
84/85-1	-1.33916	-1.33917	-1.33917	-0.39125	-0.39125	-0.75454
84/85-2	-1.28267	-1.28267	-1.28267	-0.30342	-0.30343	-0.73686
84/85-3	-1.35859	-1.35859	-1.35860	-1.04598	-1.04598	-1.04598
84/85-4	-1.73928	-1.73927	-1.68418	-1.08160	-1.10630	-1.10630
85/86-1	-1.67809	-1.67809	-1.67809	-1.24144	-1.50712	-1.50712
85/86-2	-2.16587	-2.16587	-2.16587	-2.39681	-2.39681	-2.39681
85/86-3	-1.94228	-1.94228	-1.94229	-1.75085	-1.75085	-1.75085
85/86-4	-1.61086	-1.61086	-1.61086	-2.11124	-2.11124	-2.11124
86/87-1	-0.93789	-0.93789	-0.93789	-0.937892	-0.93789	-0.93789
86/87-2	-0.91324	-0.91324	-0.91324	-0.83403	-0.83403	-0.83403

Source: Linear programming results.

Table 8.8. Water Absorption as a Binding Constraint, COM Choice Set, .50 Percent Ash

QUARTER	WESTERN PORTS 10.5-11% PROTEIN	WESTERN PORTS 11-11.5% PROTEIN	WESTERN PORTS 11.5-12% PROTEIN	EASTERN PORTS 10.5-11% PROTEIN	EASTERN PORTS 11-11.5% PROTEIN	EASTERN PORTS 11.5-12% PROTEIN
			dollars per tonne reduction in cost			
81/82-1	-0.9668	-0.9668	-1.1459	-9.6680	-0.9668	-1.0604
81/82-2	-0.7456	-0.7456	-0.8467	-0.7456	-0.7456	-0.8285
81/82-3	-1.2761	-1.2761	-1.4047	-0.9491	-0.9491	-0.9491
81/82-4	-1.2933	-1.2933	-1.4840	-0.9753	-0.9753	-0.9753
82/83-1	0.0000	-1.0274	-1.2485	0.0000	-1.0273	-1.0273
82/83-2	0.0000	-0.7142	-0.7142	0.0000	-0.7142	-0.7142
82/83-3	0.0000	-0.4872	-0.4872	0.0000	-0.4872	-0.4872
82/83-4	0.0000	-0.9115	-0.9115	0.0000	-0.9115	-0.9115
83/84-1	-0.9906	-0.9906	-0.9906	-0.9906	-0.9906	-0.9906
83/84-2	-1.0440	-1.0440	-1.0440	-1.0440	-1.0440	-1.0440
83/84-3	-1.3420	-1.3444	-1.3444	-1.3289	-1.3289	-1.3289
83/84-4	-1.5274	-1.5274	-1.5274	-1.2454	-1.2454	-1.2454
84/85-1	-1.3392	-1.3392	-1.3392	-0.3913	-0.3913	-0.7545

QUARTER	WESTERN PORTS 10.5-11% PROTEIN	WESTERN PORTS 11-11.5% PROTEIN	WESTERN PORTS 11.5-12% PROTEIN	EASTERN PORTS 10.5-11% PROTEIN	EASTERN PORTS 11-11.5% PROTEIN	EASTERN PORTS 11.5-12% PROTEIN
			dollars per tonne reduction in cost			
84/85-2	-1.2827	-1.2827	-1.2827	-0.3034	-0.3034	-0.7369
84/85-3	-1.3586	-1.3586	-1.3586	-1.0460	-1.0460	-1.0460
84/85-4	-1.7393	-1.7393	-1.6842	-1.0816	-1.1063	-1.1063
85/86-1	-1.6781	-1.6781	-1.6781	-1.2414	-1.5071	-1.5071
85/86-2	-2.1659	-2.1659	-2.1659	-2.3968	-2.3968	-2.3968
85/86-3	-1.9423	-1.9423	-1.9423	-1.7509	-1.7509	-1.7509
85/86-4	-1.6109	-1.6109	-1.6109	-2.1112	-2.1112	-2.1112
86/87-1	-0.9379	-0.9379	-0.9379	-0.9379	-0.9379	-0.9379
86/87-2	-0.9132	-0.9132	-0.9132	-0.8340	-0.8340	-0.8340

Source: Linear programming results.

often due to the liquefaction number. The liquefaction number of the lower cost wheat may not have met this requirement even though the other requirements may have been acceptable. One case occurred in the higher protein blends during 1981-82 where one of the CWRS grade/segregations was not selected as the liquefaction number was too good, i.e. the alpha amylase activity was extremely low.

8.2.2. French Bread .60 Percent Ash Content

The results for the COM choice set using a .60 percent allowable ash content are shown in Table 8.10 through to Table 8.16. The percent use of the various wheats for flour blends with 10.5 -11.0 percent allowable protein content are shown in Table 8.10. With the exception of No.1 CWRS (12.5) which was used once, the only CWRS wheats used were No.1 1 (14.5) and No. 3 CWRS. Comparing Table 8.10 with Table 8.2 reveals that there are few composition differences between the two ash levels for the crop year quarters. There are only five cases of composition differences in the western port blends and only one difference in the eastern port blends. In two of the changes which took place, very small amounts of ASWWA were included in the western port blends. Thus at the low protein level, the increase in the allowable ash content did not result in substantial changes in the constituents of the various flours. The various wheat flours used in the 11.0 to 11.5 percent protein content blends are shown in Table 8.11. The addition of No.2 CWRS (13.5) was the most noticeable difference between the .50 and .60 percent ash content allowable ash results. While No. 2 CWRS (13.5) use was limited to the first quarter of 1985-86, No. 2 (13.5) contributed almost 40 percent to boht the western and eastern blends. This was the only difference between the .50 and .60

Table 8.9. Liquefaction Number As A Binding Constraint:COM Choice Set, .5 Percent Ash

QUARTER	WESTERN PORTS 10.5-11% PROTEIN	11-11.5% PROTEIN	11.5-12% PROTEIN	EASTERN PORTS 10.5-11% PROTEIN	11-11.5% PROTEIN	11.5-12% PROTEIN
			dollars per tonne reduction			
81/82-1	0.0000	0.0000	-3.9318	0.0000	0.0000	-2.0537
81/82-2	0.0000	0.0000	-2.2189	0.0000	0.0000	-1.8187
81/82-3	0.0000	0.0000	-2.8243	0.0000	0.0000	0.0000
81/82-4	0.0000	0.0000	-4.1854	0.0000	0.0000	0.0000
82/83-1	0.0000	0.0000	-2.4780	0.0000	0.0000	0.0000
82/83-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
82/83-3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
82/83-4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
83/84-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
83/84-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
83/84-3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
83/84-4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

QUARTER	WESTERN PORTS			EASTERN PORTS		
	10.5-11% PROTEIN	11-11.5% PROTEIN	11.5-12% PROTEIN	10.5-11% PROTEIN	11-11.5% PROTEIN	11.5-12% PROTEIN
84/85-1	-0.7277	-0.7277	-0.7277	0.0000	0.0000	0.0000
84/85-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
84/85-3	-0.4157	-0.4157	0.0000	0.0000	0.0000	0.0000
84/85-4	0.0000	0.0000	0.0000	-8.4044	0.0000	0.0000
85/86-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
85/86-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
85/86-3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
85/86-4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
86/87-1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
86/87-2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Linear programming results.

Table 8.10. Proportional Use Of Various Wheats: COM Choice Set, 10.5-11.0 Percent Protein, .6 Percent Ash

	WESTERN PORTS						EASTERN PORTS				
QUARTER	ONE CWRS 14.5	ONE CWRS 12.5	THREE CWRS	APHD14	ASWSA	ASWWA	ONE CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA
							percent				
81/82-1				11.11	88.89				11.11	88.89	
81/82-2				11.11	88.89				11.11	88.89	
81/82-3				11.11	88.89			10.00		90.00	
81/82-4				11.11	88.89			10.00		90.00	
82/83-1					100.00					100.00	
82/83-2					100.00					100.00	
82/83-3					100.00					100.00	
82/83-4					100.00					100.00	
83/84-1				44.44	55.56				44.44	55.56	
83/84-2				44.44	55.56				44.44	55.56	
83/84-3				44.34	54.37	1.30		39.50		40.72	19.78
83/84-4				44.34	54.37	1.30		40.00		60.00	
84/85-1	4.16			19.45	76.39			8.47	15.89	75.84	
84/85-2	4.09			19.41	76.50			8.47	15.89	75.64	
84/85-3			0.48	25.51	74.00		5.18		17.48	77.34	
84/85-4	5.18			17.48	77.34		4.94	0.21	17.62	77.23	
85/86-1		26.83			73.17		22.90			76.80	0.30
85/86-2	19.15					80.85	20.46				79.55
85/86-3	20.37				8.27	71.36	19.91			7.93	72.16
85/86-4	18.79				19.65	61.58	19.47			7.61	72.91
86/87-1				27.08	72.92				27.08	72.92	
86/87-2				27.08	72.92			50.00		50.00	

Source: Linear programming results.

percent allowable ash analyses for the western port blends. Only one change in blend composition resulted from the increase in allowable ash content for eastern port blends. The constituents of the lowest cost flour in the third quarter of 1983/84 changed, as No.1 (14.5) was replaced by No. 3 CWRS. The increase in allowable ash content resulted in a total of only three composition changes at this protein level.

The 11.5 to 12.0 percent protein content analysis results are shown in Table 8.12. As in the 11.0 to 11.5 protein range, CWRS No. 2 grade was used in the first quarter of 1985/86 for both port blends, but No. 2 (12.5) was used in the western port blends rather than No. 2 (13.5). Changing the allowable ash content also resulted in some other western port blend changes. Two fewer blends used No.1 CWRS (14.5) and in two other blends, the amount of No.1 CWRS (14.5) was substantially reduced.

There were few changes in the composition of eastern port blends. The number of eastern blends containing CWRS wheat decreased by one. No.3 CWRS increased at the expense of the Australian wheats (1983/84-3). Generally, the contribution of the Australian wheats stayed the same as ash content increased except for in 1981/82-3. ASWSA wheat increased at the expense of No. 3 CWRS wheat. No pattern was observed to emerge.

The calculated flour costs for the blends at three protein levels and at .6 percent allowable ash are shown in Table 8.13. Comparing the results in Table 8.13 to those in Table 8.5 indicates that the cost of producing the least cost flour blend decreased by between $7.00 and $10.00/tonne when the allowable ash content was increased from .50 to .60 percent. This was expected as higher allowable ash contents enable the miller to increase the extraction rate.

Table 8.11. Proportional Use Of Various Wheats:COM Choice Set 11.0-11.5 Percent Protein, .5 Percent Ash

QUARTER	WESTERN PORTS ONE CWRS 14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA	EASTERN PORTS ONE CWRS 14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA
						percent						
81/82-1				29.63	70.37					29.63	70.37	
81/82-2				29.63	70.37					29.63	70.37	
81/82-3				29.63	70.37				26.67		73.33	
81/82-4				29.63	70.37				26.67		73.33	
82/83-1				18.39	81.61					11.11	88.89	
82/83-2				11.11	88.89					11.11	88.89	
82/83-3				11.11	88.89					11.11	88.89	
82/83-4				11.11	88.89					11.11	88.89	
83/84-1				58.33	41.67					58.33	41.67	
83/84-2				58.33	41.67					58.33	41.67	
83/84-3				54.55		45.45			51.90		22.84	25.26
83/84-4				58.25	40.78	0.97			52.50		47.50	

	WESTERN PORTS						EASTERN PORTS					
QUARTER	ONE CWRS 14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA	ONE CWRS 14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA
						percent						
84/85-1	12.50			25.00	32.50				34.95	3.03	62.03	
84/85-2	12.29			24.87	62.84				34.95	3.03	62.03	
84/85-3			1.45	43.21	55.34		21.37			9.62	69.01	
84/85-4	27.27				72.73		21.37			9.62	69.01	
85/86-1		39.02			60.98			38.10			61.91	
85/86-2	29.79					70.21	31.82					68.18
85/86-3	31.85				16.69	51.46	31.14				16.17	52.70
85/86-4	29.38				34.46	36.16	30.45				15.67	53.88
86/87-1				37.50	62.50					37.50	62.50	
86/87-2				37.50	62.50				69.23		30.77	

Source: Linear programming results.

Table 8.12. Proportional Use Of Various Wheats: COM Choice Set 11.5-12.0 Percent Protein, .60 Percent Ash

	WESTERN PORTS						EASTERN PORTS					
QUARTER	ONE CWRS 14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA	*ONE *CWRS *14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA
							percent					
81/82-1			0.30	48.24	51.47		*		0.16	47.98	51.86	
81/82-2			0.17	48.01	51.82		*		0.11	48.04	51.86	
81/82-3			0.16	48.04	51.81		*34.21				65.79	
81/82-4			0.26	47.94	51.80		*		43.33		56.67	
82/83-1			2.98	35.36	61.66		*			29.63	70.37	
82/83-2				29.63	70.37		*			29.63	70.37	
82/83-3				29.63	70.37		*			29.63	70.37	
82/83-4				29.63	70.37		*			29.63	70.37	
83/84-1				72.22	27.78		*			72.22	27.78	
83/84-2				72.22	27.78		*			72.22	27.78	
83/84-3				69.70		30.30	*		61.14	3.56	6.06	29.26
83/84-4				72.17	27.18	0.65	*		65.00		35.00	

QUARTER	WESTERN PORTS						EASTERN PORTS					
	ONE CWRS 14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA	*ONE *CWRS *14.5	TWO CWRS 13.5	THREE CWRS	APHD14	ASWSA	ASWWA
						percent						
84/85-1	20.84			30.55	48.61		*		53.13		46.88	
84/85-2	20.50			30.32	49.18		*		53.13		46.88	
84/85-3			2.42	60.92	36.68		*37.56			1.76	60.69	
84/85-4	38.64				61.36		*37.56			1.76	60.69	
85/86-1		51.22			48.78		*	50.00			50.00	
85/86-2	40.43					59.36	*43.18					56.82
85/86-3	43.34				25.12	31.55	*42.37				24.40	33.23
85/86-4	39.97				49.29	10.73	*41.44				23.72	34.85
G86/87-1				47.92	52.08		*			47.92	52.08	
86/87-2				47.92	52.08		*		88.46		11.54	

Source: Linear programming results.

The averages and standard deviations for the calculated flour blend costs at .6 percent ash content are shown in Table 8.14. The results shown in Table 8.14 are similar to the results shown in Table 8.6 for the .5 percent ash analysis. Comparing the two tables shows that the average cost differences and variability in costs between the ports also increased as the level of protein increased. The difference in the average costs between the protein levels also tended to be higher between the top two ranges. The between ports average differences for the .50 percent ash results were both about $0.80 per tonne. For the .6 percent ash results, the between ports average differences were $0.84 per tonne between the low and medium levels and $0.51 per tonne between the medium and the high protein levels. Although not conclusive, the $0.29/tonne (35 percent) difference between the averages of the two higher protein levels may indicate that ash content has a greater impact on blend cost differences at the higher protein content levels.

The instances of when protein content was a binding constraint are shown in Table 8.15. The results are similar to those discussed for the .50 percent ash analysis. Few instances existed where the required flour protein content did not prevent lower cost feasible solutions. Protein was not binding in only eight blends which contained ASWSA; when ASWSA was not used in the blend, protein was a binding constraint. The average shadow price of protein decreased as the ash content increased. Increasing the allowable ash content did not affect the number of instances where

Table 8.13. French Bread Flour Costs at .60 Ash For Three Protein Levels

QUARTER	WESTERN PORTS PROTEIN LEVEL 10.5-11%	WESTERN PORTS PROTEIN LEVEL 11-11.5%	WESTERN PORTS PROTEIN LEVEL 11.5-12%	EASTERN PORTS PROTEIN LEVEL 10.5-11%	EASTERN PORTS PROTEIN LEVEL 11-11.5%	EASTERN PORTS PROTEIN LEVEL 11.5-12%
			dollars per tonne			
81/82-1	224.89	229.42	234.01	224.89	229.42	233.99
81/82-2	222.56	226.06	229.58	222.56	226.06	229.58
81/82-3	217.24	223.23	229.25	216.30	220.74	228.48
81/82-4	216.60	222.67	228.79	215.68	220.23	224.77
82/83-1	215.26	220.02	225.46	215.26	218.13	222.93
82/83-2	225.70	227.69	231.02	225.70	227.69	231.02
82/83-3	228.93	230.29	232.55	228.93	230.29	232.55
82/83-4	218.19	220.74	224.99	218.19	220.74	224.99
83/84-1	227.75	232.36	236.97	227.75	232.36	236.97
83/84-2	220.83	225.70	230.56	220.83	225.70	230.56

	WESTERN PORTS			EASTERN PORTS		
	PROTEIN LEVEL			PROTEIN LEVEL		
QUARTER	10.5-11%	11-11.5%	11.5-12%	10.5-11%	11-11.5%	11.5-12%
			dollars per tonne			
83/84-3	229.41	235.65	242.04	228.92	235.12	241.37
83/84-4	236.51	243.63	250.76	232.25	238.05	243.84
84/85-1	235.70	242.24	248.77	234.09	235.91	239.03
84/85-2	234.60	241.05	247.50	232.99	234.48	237.49
84/85-3	236.45	242.77	249.10	236.13	241.56	246.98
84/85-4	222.15	230.47	238.99	221.28	226.95	232.64
85/86-1	211.99	220.10	228.21	210.37	217.21	224.41
85/86-2	221.84	232.41	242.98	223.86	235.55	247.24
85/86-3	231.53	241.15	250.77	229.90	238.60	247.30
85/86-4	188.24	196.20	204.16	192.40	202.70	213.01
86/87-1	167.79	172.14	176.50	167.79	172.14	176.50
86/87-2	173.95	178.19	182.43	173.17	177.11	181.05

Source: Based on spreadsheet calculations.

Table 8.14. Averages And Standard Deviations For The Three French Bread Protein Levels,.60 Percent Ash

PROTEIN RANGE		PACIFIC CARGOES	ATLANTIC CARGOES	DIFFERENCE BETWEEN PORTS
		dollars per tonne		
10.5-11%				
AVERAGE		218.55	218.15	0.40
STD DEV		18.28	17.75	0.53
11-11.5%				
AVERAGE		224.28	223.03	1.25
STD DEV		18.67	17.62	1.04
11.5-12%				
AVERAGE		230.25	228.49	1.76
STD DEV		19.30	17.91	1.39
DIFFERENCES BETWEEN PROTEIN LEVELS				
10.5-11 TO	11-11.5%	-5.73	-4.89	-0.84
11-11.5 TO	11.5-12%	-5.96	-5.45	-0.51

Source: Author's Calculations.

Table 8.15. Protein as a Binding Constraint: COM Choice Set, .60 Percent Ash

QUARTER	WESTERN PORTS 10.5-11% PROTEIN	WESTERN PORTS 11-11.5% PROTEIN	WESTERN PORTS 11.5-12% PROTEIN	EASTERN PORTS 10.5-11% PROTEIN	EASTERN PORTS 11-11.5% PROTEIN	EASTERN PORTS 11.5-12% PROTEIN
	dollars per tonne reduction in cost					
81/82-1	-0.9079	-0.9079	-1.0720	-0.9079	-0.9079	-0.9942
81/82-2	-0.7002	-0.7002	-0.7947	-0.7002	-0.7002	-0.7776
81/82-3	-1.1983	-1.1983	-1.3178	-0.8873	-0.8873	-1.1413
81/82-4	-1.2144	-1.2144	-1.3900	-0.9085	-0.9085	-0.9085
82/83-1	n.b.	-0.7908	-1.1658	n.b	-0.9585	-0.9585
82/83-2	n.b.	-0.6648	-0.6648	n.b	-0.6648	-0.6648
82/83-3	n.b.	-0.4520	-0.4520	n.b.	-0.4520	-0.4520
82/83-4	n.b.	-0.8499	-0.8499	n.b.	-0.8499	-0.8499
83/84-1	-0.9222	-0.9222	-0.9222	-0.9222	-0.9222	-0.9222
83/84-2	-0.9727	-0.9727	-0.9727	-0.9727	-0.9727	-0.9727
83/84-3	-1.2715	-1.2796	-1.2796	-1.2408	-1.2408	-0.1277
83/84-4	-1.4253	-1.4253	-1.4253	-1.1585	-1.1585	-1.1585

QUARTER	WESTERN PORTS 10.5-11% PROTEIN	WESTERN PORTS 11-11.5% PROTEIN	WESTERN PORTS 11.5-12% PROTEIN	EASTERN PORTS 10.5-11% PROTEIN	EASTERN PORTS 11-11.5% PROTEIN	EASTERN PORTS 11.5-12% PROTEIN
84/85-1	-1.3075	-1.3075	-1.3075	-0.3657	-0.3657	-0.7030
84/85-2	-1.2899	-1.2899	-1.2899	-0.2977	-0.2977	-0.6949
84/85-3	-1.2651	-1.2651	-1.2651	-1.0855	-1.0855	-1.0855
84/85-4	-1.6857	-1.7028	-1.7028	-1.1210	-1.1367	-1.1367
85/86-1	-1.6207	-1.6207	-1.6207	-1.2487	-1.4399	-1.4399
85/86-2	-2.1133	-2.1133	-2.1133	-2.3375	-2.3375	-2.3375
85/86-3	-1.9241	-1.9241	-1.9241	-1.7405	-1.7405	-1.7405
85/86-4	-1.5922	-1.5922	-1.5922	-2.0610	-2.0610	-2.0610
86/87-1	-0.8713	n.b.	-0.8713	-0.8713	-0.8478	-0.8713
86/87-2	-0.8479	-0.8713	-0.8478	-0.7978	-0.8713	-0.7878

n.b.- not binding.

Source: Linear programming results.

liquefaction number and water absorption were binding constraints. However, the shadow price of these other quality characteristics also declined as ash content increased. The shadow prices declined as the allowable ash content increased because the extraction rate increased, deemphasizing the cost effect of changing the protein level. When a constraint was binding, the relative difference in the costs should be lower for the .60 percent ash content blend as all the other characteristics would be lower in cost.

8.3. French Bread Analysis Using the All Choice Set

The results for the ALL choice set (the COM Choice set plus No. 2. DNS) are presented in Tables 8.16 through to 8.21. The same two ash content levels and three protein levels were also used in this section.

8.3.1. French Bread .5 Percent Allowable Ash Content

The inclusion of No.2 DNS from the U.S. in the choice set restricted the analysis to only 10 crop year quarters due to data limitations. The percent wheat use results for all three of the protein content levels, 10.5 to 11.0, 11.0 to 11.5 and 11.5 to 12.0 percent are shown in Table 8.16. The most frequently used wheat in the blends was ASWSA which is similar to the results of the COM choice set analysis, Figures 8.1 and 8.2. Similarly, the amount of ASWSA used in for each port and in each quarter declined as the required protein content range increases. ASWSA is a relatively low protein wheat, so this decline in use was expected and is also similar to the results for the COM choice set analysis.

The major difference between the COM choice set and the ALL choice set results was selection of No. 2 DNS which reduced the amount of CWRS wheat used. The amount of No.1 CWRS (14.5) used was negligible when selected. In the instances where No.1 (14.5) was selected, it accounted for a maximum .69 of a percent of the blend or 6.9 kilograms/tonne of wheat used. No. 3 CWRS wheat was not selected for any of the western port blends. Relative to the COM results it was also used less frequently in eastern port blends. However, No.3 CWRS provided significant amounts when used.

The amount of APHD14 used in the blends also declined. The APHD14 contribution ranged from 3.0 to 15.8 percent of the mix at eastern ports and 6.0 to 47.0 percent at western ports.

Both the CWRS wheats and APHD14 were replaced by No. 2 DNS. There were only two crop year quarters where No.2 DNS was not used in any of the three protein content level blends, 1984/85-2 and 1986/87-1. As the protein requirements of the blend increased, the contribution by No. 2 DNS increased and the APHD14 contribution was eliminated.

Including No.2 DNS in the millers wheat flour choices resulted in lower flour costs compared to the COM choice set flour blends. The calculated flour costs for the .5 percent ash content and the three protein levels are shown in Table 8.17. The averages and standard deviations calculated for the two coasts and protein ranges are shown in Table 8.18. As with the COM choice set, the differences between the average

Table 8.16. Proportional Use Of Various Wheats;ALL Choice Set, Three Protein Levels, .50 Percent Ash Content

		WESTERN PORTS					EASTERN PORTS					
QUARTER	PROTEIN LEVEL	ONE CWRS 14.5	APHD14	ASWSA	ASWWA	No.2 DNS	CWRS 1 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	NO.2 DNS
						percent						
84/85 1	10.5-11%		14.09	76.51		9.40			14.094	76.51		9.36
	11-11.5%			64.71		35.29				64.71		35.29
	11.5-12%			50.00		50.00				50.00		50.00
84/85 2	10.5-11%		14.09	76.51		9.40		8.472	15.885	75.64		
	11-11.5%			64.71		35.29		34.947	3.026	62.03		
	11.5-12%			50.00		50.00		53.125		46.87		
84/85 3	10.5-11%			80.00		20.00			14.894	76.59		8.51
	11-11.5%			65.71		34.29				65.71		
	11.5-12%			51.43		48.57				51.43		48.57
84/85-4	10.5-11%		14.89	76.60		8.51				66.67		33.33
	11-11.5%			65.71		34.29				65.71		34.29
	11.5-12%			51.43		48.57				51.43		48.57
85/86 1	10.5-11%			70.27		29.73				70.27		29.73
	11-11.5%			56.76		43.24				56.76		43.24
	11.5-12%	0.69		43.41		55.91	0.606			43.42		55.97

QUARTER	PROTEIN LEVEL	ONE CWRS 14.5	APHD14	ASWSA	ASWWA	No.2 DNS	CWRS 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	NO.2 DNS
						percent						
85/86 2	10.5-11%				74.29	25.71					74.29	25.71
	11-11.5%				60.00	40.00					60.00	40.00
	11.5-12%	0.34			45.83	53.83	0.31				45.79	53.90
85/86 3	10.5-11%			68.57		31.43				68.57		31.43
	11-11.5%			54.29		45.71				54.29		45.71
	11.5-12%			40.00		60.00				40.00		60.00
85/86 4	10.5-11%			68.57		31.43				68.57		31.43
	11-11.5%			54.29		45.71				54.29		45.71
	11.5-12%			40.00		60.00				40.00		60.00
86/87 1	10.5-11%		27.08	72.92					6.04	69.32		24.64
	11-11.5%		37.50	62.50						56.10		43.90
	11.5-12%		47.92	52.08						43.90		56.91
86/87 2	10.5-11%		6.04	69.32		24.64		11.68		64.02		24.30
	11-11.5%			56.10		43.90				56.10		43.90
	11.5-12%			43.90		56.10				43.90		56.91

Source: Linear programming results.

Figure 8.1 Wheat Use 11-11.5% Protein
All Choice Set – West Coast; .5% Ash

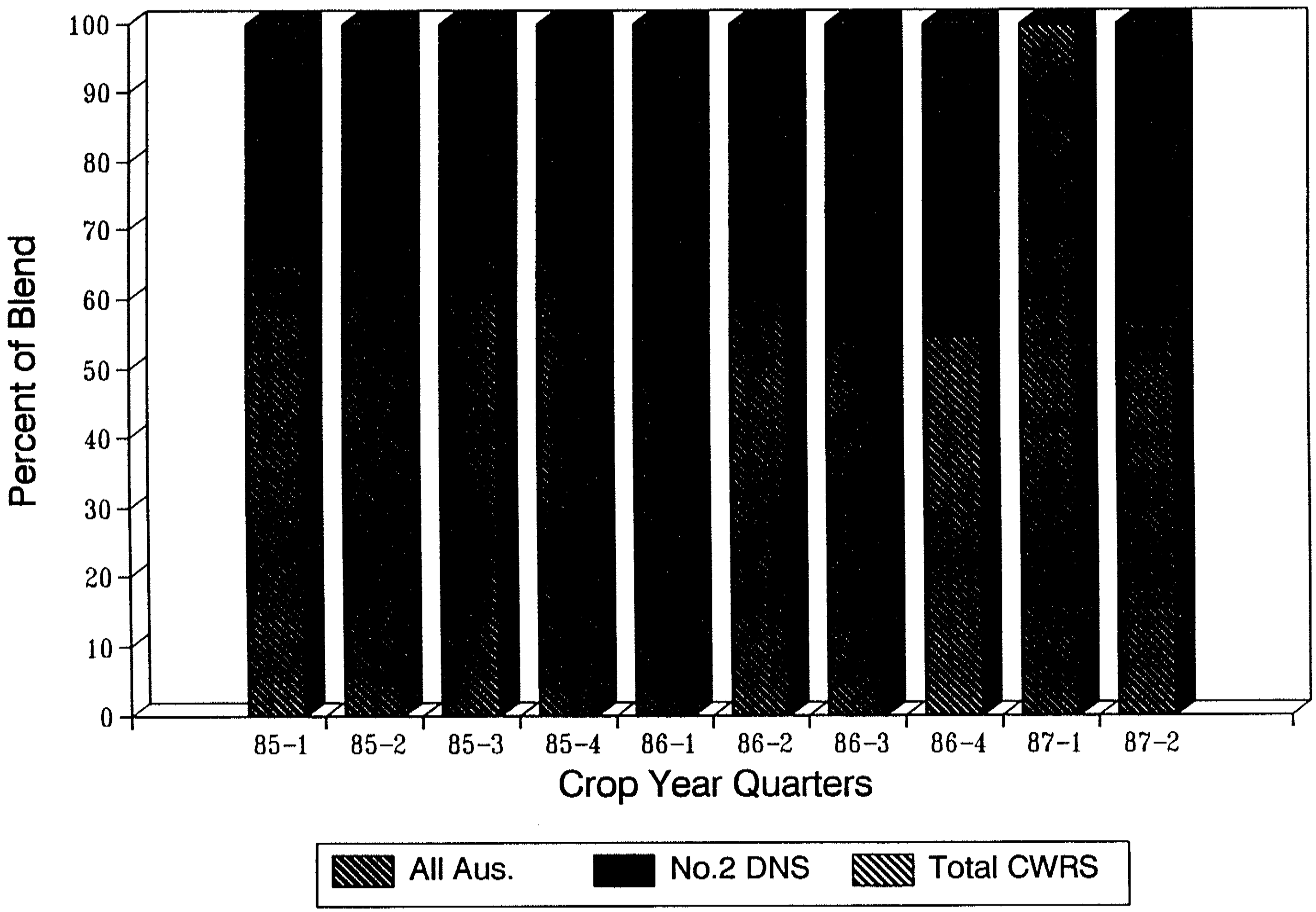
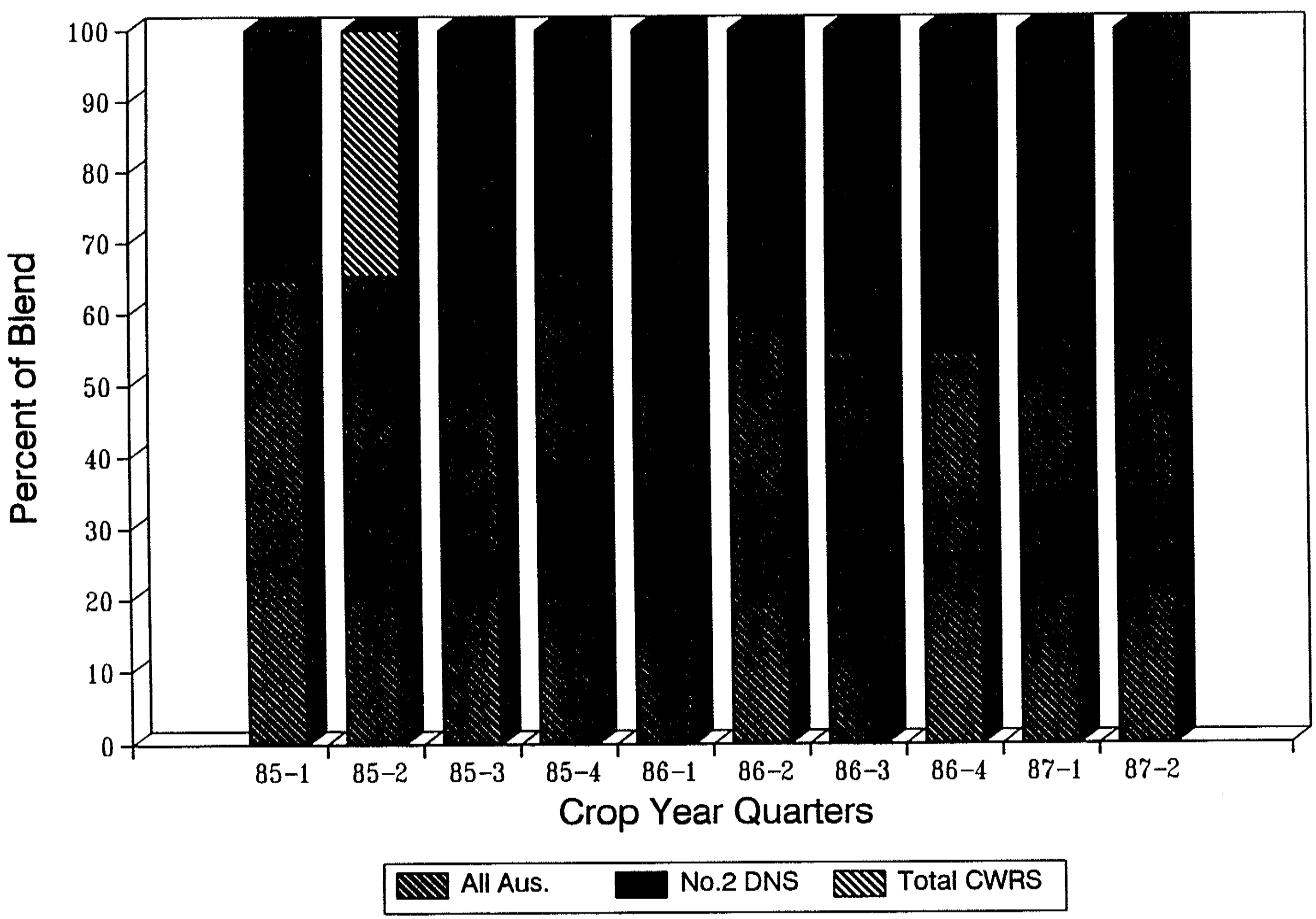


Figure 8.2 Wheat Use 11-11.5% Protein
All Choice Set - East Coast; .5% Ash



costs at the two ports increased as the protein content increased. This direct relationship implies that protein is more costly at the west coast than at eastern ports. Comparing the average costs for the two choice sets at .50 percent ash (Table 8.18 and Table 8.6)indicates that use of No.2 DNS intensified the between port cost differences. The between port differences between the protein levels shown at the bottom of Table 8.18 are much larger than those shown for the COM choice set at the bottom of Table 8.6, but the variability between the ports is less as protein increases. This may suggest there is less variability in U.S. prices between ports, as when the protein level increases the percent contribution of DNS also increases.

8.3.2.French Bread .60 Percent Allowable Ash Content

The wheat combinations used in the French bread blends at .60 percent ash are shown in Table 8.19. Increasing the allowable ash content from .50 to .60 percent resulted in no composition changes. However, increasing the allowable ash content did substantially reduce the costs of the flour, Table 8.20.

Inspection of Table 8.17 and Table 8.20 shows that the cost of flour within each protein level decreased over the study period. This reflects the decline in wheat prices over that period. In 1985, the U.S. introduced the Export Enhancement Program (EEP) in response to E.C. export subsidies, which allegedly caused a decline in U.S. wheat exports. These export subsidies caused world wheat prices to decline, and in response Canada and other exporters lowered their prices in order to make sales.

The averages and standard deviations of the blend costs between protein ranges and ports as well as the differences between the averages and standard deviations are

Table 8.17. French Bread Flour Costs At .50 Ash For Three Protein Levels: ALL Choice Set

QUARTER	WESTERN PORTS PROTEIN LEVEL 10.5-11%	11-11.5%	11.5-12%	EASTERN PORTS PROTEIN LEVEL 10.5-11%	11-11.5%	11.5-12%
			dollars per tonne			
84/85-1	245.43	250.53	256.19	244.09	245.50	249.06
84/85-2	243.80	247.36	252.32	243.29	244.80	247.98
84/85-3	244.49	249.37	254.25	245.32	247.71	251.04
84/85-4	230.50	235.75	242.83	228.35	228.63	232.73
85/86-1	217.84	225.20	232.63	213.45	218.82	224.31
85/86-2	230.91	241.70	252.49	228.8	238.42	248.11
85/86-3	235.79	246.36	256.93	231.08	239.51	247.94
85/86-4	190.87	199.98	207.32	189.12	196.55	203.98
86/87-1	173.79	178.48	183.16	173.13	177.31	181.68
86/87-2	179.95	184.19	188.55	178.52	182.02	185.78

Source: Author's calculations based on linear programming results.

Table 8.18. Averages And Standard Deviations For The Three French Bread Protein Levels

PROTEIN RANGE		PACIFIC CARGOES	ATLANTIC CARGOES	DIFFERENCES BETWEEN PORTS
		dollars per tonne		
10.5-11.0%				
AVERAGE		219.34	217.52	1.82
STD DEV		26.23	26.24	-0.01
11.0-11.5				
AVERAGE		225.89	221.93	3.97
STD DEV		26.54	25.70	0.84
11.5-12.0%				
AVERAGE		232.67	227.26	5.41
STD DEV		27.44	25.91	1.54
DIFFERENCES BETWEEN THE AVERAGES				
10.5-11 TO	11-11.5%	6.56	4.41	2.15
11-11.5 TO	11.5-12%	6.78	5.33	1.45

Source: Author's calculations.

Table 8.19. Proportion Use Of Various Wheats: ALL Choice Set: Three Protein Levels at .60 Percent Ash

QUARTER	PROTEIN LEVEL	WESTERN PORTS: ONE CWRS	APHD14	ASWSA	ASWWA	No.DNS	EASTERN PORTS: ONE 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	NO.2 DNS
						percent						
84/85-1	10.5-11%		14.09	76.51		9.40			14.09	76.51		9.40
	11-11.5%			64.71		35.29				64.71		35.29
	11.5-12%			50.00		50.00				50.00		50.00
84/85-2	10.5-11%		14.09	76.51		9.40		8.47	15.89	75.64		
	11-11.5%			64.71		35.29		34.95	3.05	62.03		
	11.5-12%			50.00		50.00		53.13		46.88		
84/85-3	10.5-11%			80.00		20.00			14.89	76.60		8.51
	11-11.5%			65.71		34.29				65.71		34.29
	11.5-12%			51.43		48.57				51.43		48.57
84/85-4	10.5-11%		14.89	76.60		8.51				66.67		33.33
	11-11.5%			65.71		34.29				65.71		34.29
	11.5-12%			51.43		48.57				51.43		48.57

QUARTER	PROTEIN LEVEL	WESTERN PORTS ONE CWRS	APHD14	ASWSA	ASWWA	No.DNS	EASTERN PORTS ONE 14.5	THREE CWRS	APHD14	ASWSA	ASWWA	NO.2 DNS
						percent						
85/86-1	10.5-11%			70.27		29.73				70.27		29.73
	11-11.5%									56.76		43.24
	11.5-12%	.69		43.41		55.91	0.61			43.42		55.97
85/86-2	10.5-11%				74.29	25.71					74.29	25.71
	11-11.5%				60.00	40.00					60.00	40.00
	11.5-12%	.34			45.84	53.83	0.31				45.79	53.90
85/86-3	10.5-11%			68.57		31.43				68.57		31.43
	11-11.5%			54.29		45.71				54.29		45.71
	11.5-12%			40.00		60.00				40.00		60.00
85/86-4	10.5-11%			68.57		31.43				68.57		31.43
	11-11.5%			54.29		45.71				54.29		45.71
	11.5-12%			40.00		60.00				40.00		60.00
86/87-1	10.5-11%		27.08	72.92					6.04	69.32		24.64
	11-11.5%		37.50	62.50						56.10		43.90
	11.5-12%		47.92	52.08						43.90		56.10
86/87-2	10.5-11%		6.04	69.32		24.64		11.68		64.02		24.30
	11-11.5%			56.10		43.90				56.10		43.90
	11.5-12%			43.90		56.10				43.90		56.10

Source: Linear programming results.

Table 8.20. French Bread Flour Costs At .60 Ash For Three Protein Levels :ALL Choice Set

QUARTER	WESTERN PORTS PROTEIN LEVEL 10.5-11%	11-11.5%	11.5-12%	EASTERN PORTS PROTEIN LEVEL 10.5-11%	11-11.5%	11.5-12%
			dollars per tonne			
84/85-1	234.93	239.56	244.76	233.68	234.87	238.11
84/85-2	233.40	236.60	241.15	232.99	234.48	237.49
84/85-3	234.10	238.64	243.19	234.87	236.53	240.19
84/85-4	220.98	225.89	232.49	218.96	219.21	223.04
85/86-1	209.16	215.97	228.87	205.06	210.00	215.09
85/86-2	220.99	231.08	241.18	219.02	228.02	237.09
85/86-3	225.99	235.80	245.60	221.58	229.39	237.20
85/86-4	183.89	191.53	199.17	182.25	189.14	196.04
86/87-1	167.79	172.14	176.50	167.19	171.09	175.15
86/87-2	173.58	177.53	181.58	172.28	175.50	178.99

Source: Author's calculations based on linear programming results.

Table 8.21. Averages And Standard Deviations: ALL Choice Set For The Three French Bread Protein Levels, .6 Percent Ash

PROTEIN RANGE	PACIFIC CARGOES	ATLANTIC CARGOES	DIFFERENCES BETWEEN PORTS
		dollars per tonne	
10.5-11.0%			
AVERAGE	210.48	208.79	1.69
STD DEV	24.57	24.57	
11.0-11.5%			
AVERAGE	216.47	212.82	3.65
STD DEV	24.92	24.01	
11.5-12.0%			
AVERAGE	223.45	217.84	5.61
STD DEV	25.73	24.26	
DIFFERENCES BETWEEN THE AVERAGES			
10.5-11 TO 11-11.5%	5.99	6.98	.99
11-11.5 TO 11.5-12%	4.04	5.02	.99

Source: Author's calculation.

shown in Table 8.21. The same pattern that was observed in the COM choice set and the All choice set at .50 percent ash. The differences between the average blend costs calculated from the figures in Tables 8.18 and 8.21 are shown in Table 8.22. The

Table 8.22. Average Cost Differences Between .5 and .6 Percent Ash, ALL Choice Set.

Protein Content	Western Ports	Eastern Ports
percent	dollars per tonne	
10.5 - 11.0	8.86	8.73
11.0 - 11.5	9.42	9.11
11.5 - 12.0	9.22	9.42

Source: Author's calculations.

Comparing the .60 percent ash content results for both the ALL and COM choice sets reveal that a substantial cost reduction occurred when No.2 DNS was added to the millers wheat choices. Table 8.23 shows the differences between the cost averages at

Table 8.23. Differences in the Calculated Cost Averages at .60 Percent Ash Content Between the COM and ALL Choice Sets.

Protein Range	Western Ports	Eastern Ports
percent	dollars per tonne	
10.5 -11.0	8.07	9.36
11.0 - 11.5	7.81	10.20
11.5 - 12.0	6.80	10.65

Source: Author's calculations.

.60 percent ash between the All and COM choice sets (Tables 8.14 minus Tables 8.21).increase in ash content resulted in a cost decrease of about $9.00 per tonne. It is interesting to note that as the protein level increases, the cost differences between the two choice sets move in opposite directions for the two port blends. The western blend cost differences tended to decrease as protein content increased, whereas the eastern blend cost differences tended to increase. These two trends for the between port differences appear to indicate there is a greater premium for protein on the east U.S. coast at least within the time period covered in this study.

8.4. Parametric Analysis

To determine the impact of price on the selection of Canadian wheats, parametric testing of the asking prices was undertaken. Six separate analyses are presented, the first adjusting No. 1 (13.5) prices downward $5.00/tonne, then in five dollar increments to $30.00/tonne. New prices for the other CWRS grade/segregations were calculated relative to their original price relationship with No. 1 (13.5). The analyses in this section pertain to the ALL choice set for French bread flours at a 11.0 to 11.5 percent protein level and .50 percent ash content. The middle protein range was chosen as the protein range is slightly below the pan bread protein ranges in Chapter 7, but high enough that higher protein wheats could be considered in blend selections. The results of the parametric programming results are shown in Tables 8.24, 8.25, 8.26, 8.27, 8.28 and 8.29.

Table 8.24 shows the results of lowering No. 1 (13.5) prices $5.00/tonne and the other CWRS wheats grade/segregations an amount reflecting the original price relationship between CWRS wheats. The results show that by reducing the price of CWRS wheat relative to the Australian and No. 2 DNS wheats there was a substantial increase in the frequency of use and average contribution of CWRS grade/segregations, as none were selected in the original prices series at the 11.0-11.5 percent protein level. Frequency in use increased to six selections and the average contribution increased to 42.4 percent. Of the CWRS segregations chosen, only No. 1 (14.5) and No. 3 CWRS grade/segregations were selected. A comparison of Table 8.16 and Table 8.24 shows that No. 1 (14.5) appeared in two selections and contributed on average 23.5 percent of the wheat in the blends it was selected. No. 3 CWRS use increased from zero to four appearances with an average contribution of 51.9 percent. Dropping the CWRS asking prices approximately $5.00/tonne resulted in No. 1 (14.5) and No. 3 reducing and replacing the contributions of both No. 2 DNS and ASWSA.

The results of reducing the CWRS asking prices another five dollars to $10.00/tonne are shown in Table 8.25. CWRS wheats were selected in three more blends, raising the total number of selections to nine out of a possible 20 appearances but average contribution declined from 42.4 percent to 38.1. The reason for the decline in average contribution is that No. 1 (14.5) only was selected in the three additional selections and on average contributes less to French bread flour blends than No. 3. The selection of No. 1 (14.5) reduced and replaced No. 2 DNS in several blends but contributed to an increase in the use of Australian ASWSA.

Table 8.24. Results of Parametric Analysis: French Bread Flour Blends, CWRS Prices Reduced Approximately $5.00/Tonne

QUARTER	PRICE	ONE 14.5	ONE 13.5	ONE 12.5	TWO 13.5	TWO 12.5	THREE	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	250.53							35.29		64.71	
85-2W	247.36							35.29		64.71	
85-3W	249.37							34.29		65.71	
85-4W	235.75							34.29		65.71	
85-1E	244.26						34.95		3.02	62.03	
85-2E	242.67						41.18			58.82	
85-3E	247.11							34.29		65.71	
85-4E	228.63							34.29		65.71	
86-1W	225.20							43.24		56.76	
86-2W	239.88	29.79									70.21
86-3W	245.91	17.22						22.59		60.19	
86-4W	199.10							45.71		54.29	
86-1E	218.82							43.24		56.76	
86-2E	238.42							40.00			60.00
86-3E	239.51							45.71		54.29	
86-4E	196.55							45.71		54.29	
87-1W	178.48								37.50	62.50	
87-2W	184.19							43.90		56.10	
87-1E	176.09						62.07			37.93	
87-2E	179.54						69.23			30.77	

Source: Linear programming results.

Table 8.25. Results of Parametric Analysis: French Bread Flour, CWRS Prices Reduced Approximately $10.00/Tonne.

Quarter	Price	ONE 14.5	ONE 13.5	ONE 12.5	TWO 13.5	TWO 12.5	THREE	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	249.72	28.57								71.43	
85-2W	247.36							35.29		64.71	
85-3W	249.37							34.29		65.71	
85-4W	235.75							34.29		65.71	
85-1E	241.76						41.18			58.82	
85-2E	240.18						41.18			58.82	
85-3E	247.11							34.29		65.71	
85-4E	228.63							34.29		65.71	
86-1W	223.95	34.78								65.22	
86-2W	238.03	29.79								70.21	
86-3W	244.83	17.22						22.60		60.18	
86-4W	198.20	18.39						18.39		63.22	
86-1E	218.82							43.24		56.76	
86-2E	238.42							40.00			60.00
86-3E	239.51							45.71		54.28	
86-4E	196.55							45.71		54.29	
87-1W	178.48							37.50		62.50	
87-2W	184.19							43.90		56.10	
87-1E	175.51						62.07			37.93	
87-2E	175.55						69.23			30.77	

Source: Linear programming results.

Similar results were obtained when the CWRS prices were dropped another $5.00/tonne. A $15.00/tonne decrease in price increased the frequency of use to 13 selections but the average contribution continued to decline dropping to 28.5 percent. Again the average contribution across all CWRS grade/segregations declined because No. 1 (14.5) was selected in the additional appearances and its contribution in these appearances was much lower ranging between 2 and 16 percent of the wheat mix. It appears that No.1 (14.5) price/characteristics relationship exhibited during these three periods was such that No. 1 (14.5) was less able to replace No.2 DNS.

Table 8.27 shows the results of lowering No. 1(13.5) prices $20.00/tonne. The frequency of use increased to 18 and average contribution 36.3 percent. Both No. 1 (14.5) and No. 3 increased in frequency of use and average contribution:

	Frequency of Use		**Average Contribution**	
	$15.00	$20.00	$15.00	$20.00
No. 1 (14.5)	9	11	17.4	23.1
No. 3	4	5	53.4	64.2

In addition, No. 2 (13.5) and (12.5) were both chosen once contributing 40.0 percent to the resulting flour blend.

In general, dropping the CWRS asking prices approximately $20.00/tonne resulted in No. 1 (14.5) substituting for U.S. No. 2 DNS. The total number of selections for No. 2 DNS declined from 12 to 4 and the average contribution dropped from 32.9 to 30.7 percent. The impact of the CWRS price reduction on the Australian wheats was

Table 8.26. Results of Parametric Analysis: French Bread Flours, CWRS Prices Reduced $15.00/Tonne.

QUARTER	PRICE	ONE 14.5	ONE 13.5	ONE 12.5	TWO 13.5	TWO 12.5	THREE	NO.2DNS DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	247.91	28.57								71.43	
85-2W	247.97	7.07						26.36		66.58	
85-3W	249.37							34.29		65.71	
85-4W	235.65	2.13						31.61		66.26	
85-1E	239.19						41.18			58.83	
85-2E	237.68						41.18			58.83	
85-3E	247.02	2.13						31.61		66.26	
85-4E	228.63							34.29		65.71	
86-1W	221.75	34.78								65.22	
86-2W	236.12	29.79									70.21
86-3W	243.73	17.22						22.60		60.19	
86-4W	197.02	18.39						18.39		63.22	
86-1E	218.88							43.24		56.76	
86-2E	238.42							40.00			60.00
86-3E	239.07	16.65						22.88		60.47	
86-4E	196.55							45.71		54.29	
87-1W	178.48								37.50	62.50	
87-2W	184.19							43.90		56.10	
87-1E	168.93						62.07			37.93	
87-2E	171.60						69.23			30.77	

Source: Linear programming results.

Table 8.27. Results of Parametric Analysis: French Bread Flours, CWRS Prices Reduced by Approximately $20.00/Tonne.

QUARTER	PRICE	ONE 14.5	ONE 13.5	ONE 12.5	TWO 13.5	TWO 12.5	THREE	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	246.10	28.57								71.43	
85-2W	245.65	22.08							9.27	68.64	
85-3W	247.43					40.00				60.00	
85-4W	234.47	21.37							9.62	69.01	
85-1E	236.54						53.13			46.87	
85-2E	234.88						53.13			46.87	
85-3E	246.26	21.37							9.62	69.01	
85-4E	228.56	2.13						31.61		66.26	
86-1W	219.37				39.02					60.98	
86-2W	234.18	29.79									70.21
86-3W	242.61	17.22						22.60		60.19	
86-4W	195.40	29.38								34.46	36.16
86-1E	217.30	33.33								66.67	
86-2E	236.95	31.82									68.18
86-3E	237.91	16.65						22.89		60.47	
86-4E	196.55							45.71		54.29	
87-1W	178.47								37.50	62.50	
87-2W	181.64						64.29			37.71	
87-1E	165.35						62.07			37.93	
87-2E	167.69						88.46			11.54	

Source: Linear Programming results.

less obvious than the impact on No. 2 DNS. There was a slight increase in the number of times APHD14 was selected but in the blends No. 1 (14.5) was selected, there was also a slight increase in the amount of the Australian Standard White (ASW) wheats used. The increase in the use of ASW wheats could have been to offset the higher protein content in the No. 1 (14.5) which replaced No. 2 DNS.

The results of reducing the CWRS asking prices by $25.00/tonne are shown in Table 8.28. The effect of reducing the asking prices an additional $5/tonne had minimal impact of the frequency of CWRS wheats selected. More CWRS wheat was used in the blends at this price level than the previous price level, rising from 36.3 percent to 39.1 percent, but the shifts were relatively small compared to those achieved with the $20.00/tonne price reduction. Overall, there was a slight drop in the amount of Australian wheats used in the blends.

The results of lowering the asking prices of CWRS wheats approximately $30.00/tonne are shown in Table 8.29 and are similar to those arising when CWRS wheats were lowered $25.00/tonne. The major impact of this further price reduction appears to be a redistribution of the selection of CWRS grade/segregations. When selected, No. 1 and 2 (13.5) and (12.5) wheats replaced No. 1 (14.5) selections, their total contribution being slightly higher than that of the No. 1 (14.5) they replaced. Further price reductions would not increase the use of CWRS wheat as the protein constraint was binding. A summary of the change in frequency use and average contribution in the blends for which CWRS wheats were selected is summarized in Table 8.30.

Table 8.28. Results of Parametric Analysis: French Bread Flours, CWRS Prices Reduced by Approximately $25.00/Tonne.

QUARTER	PRICE	ONE 14.5	ONE 13.5	ONE 12.5	TWO 13.5	TWO 12.5	THREE	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	244.29	28.57								71.43	
85-2W	243.78				34.94				3.03	62.03	
85-3W	245.75	29.27								70.73	
85-4W	233.10	21.37							9.62	69.01	
85-1E	233.22						53.13			46.87	
85-2E	231.90						53.13			46.87	
85-3E	244.89	21.37							9.62	69.01	
85-4E	228.43	2.13						31.31		66.26	
86-1W	216.95				39.02					60.98	
86-2W	232.22	29.79									70.21
86-3W	240.69	31.85								16.69	51.46
86-4W	193.65	29.38								34.46	36.16
86-1E	214.26				38.10					61.90	
86-2E	234.93	31.82									68.18
86-3E	236.92	16.65						22.89		60.47	
86-4E	196.55							45.71		54.29	
87-1W	174.72						64.29			35.71	
87-2W	177.00						64.29			35.71	
87-1E	161.78						62.07			37.93	
87-2E	162.27						90.91			9.09	

Source: Linear Programming Results.

Table 8.29. Results of Parametric Analysis: French Bread Flours, CWRS Prices Reduced by Approximately $30.00/Tonne.

QUARTER	PRICE	ONE 14.5	ONE 13.5	ONE 12.5	TWO 13.5	TWO 12.5	THREE	NO.2 DNS	APHD 14	ASWSA	ASWWA
						percent					
85-1W	242.49	28.57								71.43	
85-2W	241.38				41.18					58.82	
85-3W	243.29					40.00				60.00	
85-4W	231.72	21.37							93.62	69.01	
85-1E	230.44						57.14			28.57	14.29
85-2E	229.03						53.13			46.87	
85-3E	245.56		23.08						15.38	61.54	
85-4E	227.29	37.56							1.76	60.68	
86-1W	214.25				39.02					60.98	
86-2W	230.31	29.79									70.20
86-3W	238.59	31.85								16.69	51.46
86-4W	191.75	29.38								34.46	36.16
86-1E	212.63				38.10					61.90	
86-2E	232.91	31.82									68.18
86-3E	235.81	16.65						22.89		60.47	
86-4E	196.27	16.11						23.16		60.73	
87-1W	170.93						64.29			35.71	
87-2W	174.20						64.29			35.71	
87-1E	158.19						79.31			20.68	
87-2E	158.86						90.91			9.09	

Source: Linear programming results.

Table 8.30. Average Percent Contribution and Frequency of Use of CWRS Wheats in French Bread Flour Blends as Price Declines.

Price Adjustment	French Bread Flours	
	Frequency Selected #	Average Contrib %
Original Series	0	0.0
$ 5.00/tonne	6	42.4
$10.00/tonne	9	38.1
$15.00/tonne	13	28.5
$20.00/tonne	18	36.3
$25.00/tonne	19	39.1
$30.00/tonne	20	41.7

Source: Author's calculations.

The parametric analysis in this section indicates that reducing the price of CWRS wheats by about $20.00/tonne, CWRS wheats can for the most part replace No. 2 DNS in the French bread flour blends. The average price difference between No. 2 DNS and No. 1 CWRS (14.5) was between $27.00 and $33.00/tonne depending on the FOB point of pricing. Consequently, it appears that the qualities inherent in CWRS wheats combined with a simultaneous $20.00/tonne drop in price would permit CWRS wheats to out compete No. 2 DNS while still fetching higher prices than No. 2 DNS.

It also appears that after the first $5.00 drop in price, price is not the limiting factor in determining the contribution of CWRS in a blend. Rather the quality characteristics of CWRS wheat appear to limit its average contribution in French bread flour blends to approximately 40 percent of the required wheat mix.

8.4.1. Elasticities

The effect of price reductions on the quantity of CWRS wheat used in the medium protein range French bread flours are illustrated in Figure 8.3. The quantity of CWRS was determined by multiplying the frequency of use by the average contribution of CWRS wheats found in Table 8.30. CWRS price elasticities for each $5.00 reduction in price are also shown in Table 8.31. To calculate the elasticities, the average No.1 (13.5) price of $235.96/tonne over the 20 situations was used as a base price. The base points for the elasticity calculations were the price and quantity occuring in the first $5.00 reduction as no CWRS was used at the original price level[221].

The results indicate that CWRS utilization in French bread flours is price elastic. However, the elasticities calculated for the French bread are much lower than those reported for the two pan breads in Chapter 7. It is also interesting to note that elasticities appear to increase as the price reductions increase rather than decline as was the case forthe pan breads. The first $5.00 decrease resulted in a large increase in CWRS wheat

[221] The same base was used to calculate all the elasticities as was the case in Chapter 7. In general in economtric studies the mean of the dependent and independent variables are used when elasticites are calculated to facilitate reproduction of the results for comparisons. In this case as there is no mean, a base point was chosen for the calculation of the elasticities.

Figure 8.3 Medium Protein French Bread

Parametric Price–Quantity Relationship

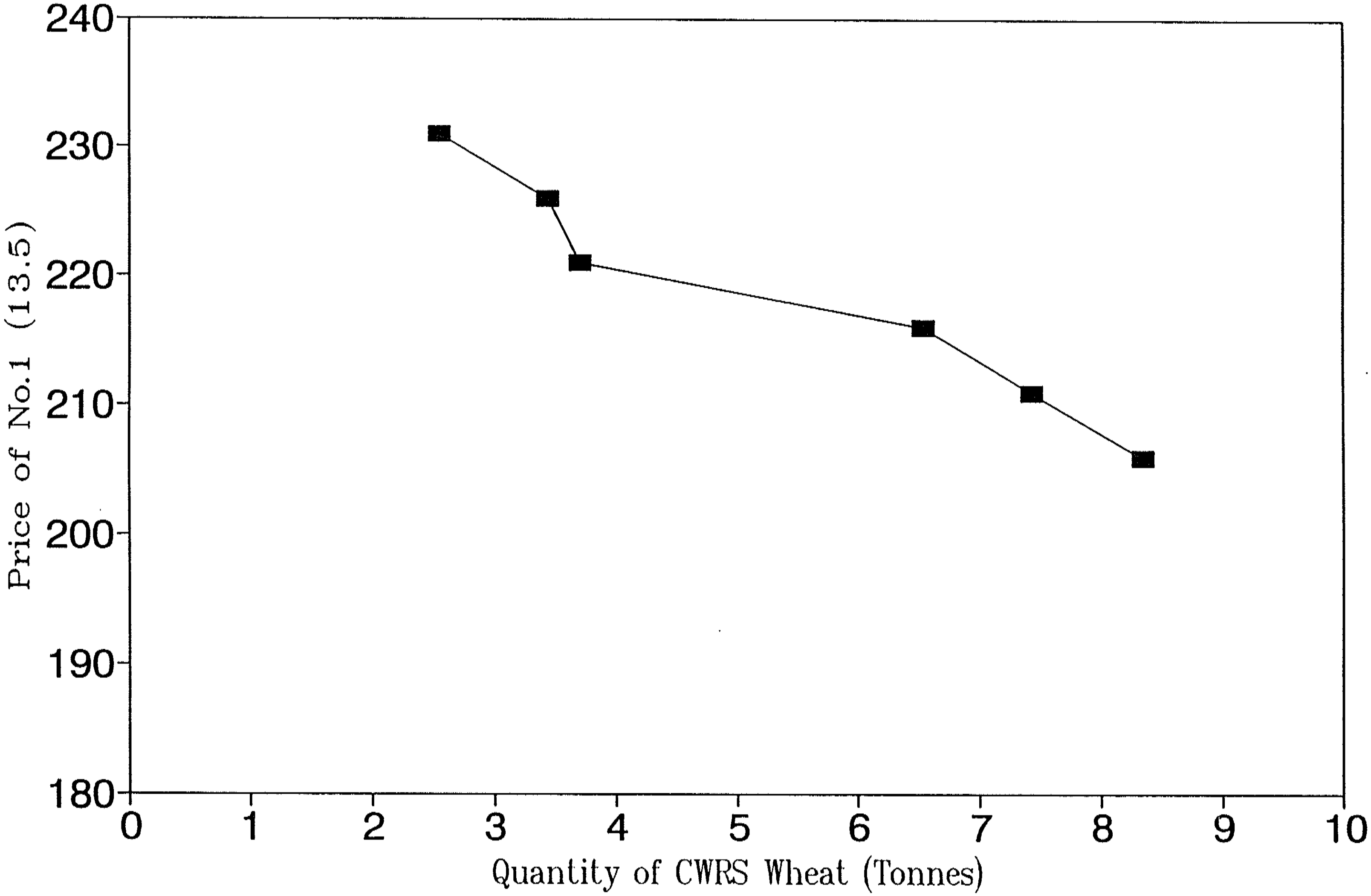


Table 8.31. Calculated Elasticities For No.1 CWRS (13.5) in French Bread Flours

Price No.1 (13.5)	**Quantity** (Tonnes)	**Elasticiy**
235.96	0.00	Original
230.96	254.40	93.11
225.96	342.90	13.51
220.96	370.50	3.46
215.96	653.40	24.16
210.96	742.90	5.42
205.96	834.00	4.81

Source: Author's Calculations.

use and utilization. This price reduction lowered the costs/quality relationships within CWRS wheat grade/segregations enabling CWRS wheats to compete with DNS and APHD14 in the French bread flours. However, subsequent price reductions did not increase the average utilization rate but did increase the number of times CWRS wheats were selected. The protein content and other characteristics inherent in CWRS wheats limited its absolute contribution to each blend, precluding any increases in average contribution. However, as prices declined further, CWRS continued to substitute for DNS and APHD14 predominantly on a cost/tonne basis. Given higher protein wheats are limited in the amount they can contribute to French bread flours, the elasticity of use was not as great as was found for the pan breads in Chapter 7.

8.5. Summary

The results examined in this chapter indicate that CWRS wheat may be non-competitive in the world markets where French bread is the primary end product. The limited and sporadic appearance of CWRS wheat in the blends indicates that given a choice, profit maximizing millers would choose other wheats.

The results of the COM choice set shows that protein content was the most frequent binding constraint for these breads. The analyses indicate that if the protein content of CWRS wheat were lower and all the other quality characteristics maintained, more CWRS wheat would have been used in the blends. However, price also appears to be the major factor which prevented CWRS wheat from be selected more frequently in the French bread blends.

Three protein ranges and two ash content levels were used in the analysis to reflect the differences in French breads consumed in different countries or world areas. As expected, the cost of the flour increased as protein content increased in all cases, reflecting the fact that protein content is a price determining quality characteristic. Also an increase in the protein content resulted in changes in the blend composition, as higher protein wheats were substituted for lower protein wheat. However, even in the highest protein range very little CWRS wheat was selected under the original asking price regime. The parametric analyses showed that CWRS wheats can be competitive with other high protein wheats when prices are lowered[222]. Over the range of price reductions used in the parametric analysis, CWRS wheats are price elastic. Thus the competitiveness of the CWRS grade/segregations with other other high protein wheats

[222] When CWRS wheats were reduced between $20.00 and $30.00/tonne, the average contribution to the mixes was similar to No. 2 DNS which also contributed between 35 to 40 percent of the wheat mix in a blend in the original price series regime.

in the French bread flour markets may be greater than was indicated by the results of the original analysis.

Regardless of price, the extent to which CWRS wheats can be used in the French Bread market is limited by its quality characteristics[223]. As the end-use products in those markets in which grain consumption and imports are expanding generally require low protein flour, CWRS appears to be limited in suitability.

[223] Even Australia's APHD14 was infrequenlty used and contributed a limited proportion to the mixes in which it was selected. However, Australia has the advantage that it can also produce and sell medium quality wheats, providing a broader spectrum of wheat characteristics to the trade.

CHAPTER 9. CONCLUSIONS AND POLICY IMPLICATIONS

9.1. Introduction

Canada developed a reputation as an exporter of high protein and consistent quality wheat throughout most of the twentieth century. Due to agronomic factors, the focus of grain research and development in western Canada has been directed towards hard red spring wheats. The severe winters in most of the prairies precluded production of winter wheats. Moist autumns also mitigated against white wheats and red wheats tend to be more resistant to sprouting. The discovery of Red Fife wheat coupled with technological advance in milling at the end of the nineteenth century also contributed to the focus on hard red spring wheats. Western Canada thus appeared to have a competitive advantage in the production of hard red spring wheat for the North American and western European milling markets.

During the early years of the grain industry in western Canada, the framework for a heavily regulated marketing system was established. One area of regulation which has been integral to the development of Canada's reputation as a wheat exporter was the development of the grading system. The grading system coupled with the strict control of released varieties has ensured that Canada Western Red Spring (CWRS) wheat has maintained a consistency not evident in wheats from other countries.

Grading systems are supposed to enhance product marketing by facilitating communication between buyers and sellers with respect to product quality. Grading systems should also reflect the quality characteristics of the product which are important to the buyer. Given that Canada is producing a wheat similar to that which was produced over 60 years ago, the question arises "Is the grading system still relevant"?. The grading system for CWRS wheat was last changed in 1971. Since then there have been several changes in the world wheat market. Included in these changes are the decline of some traditional CWRS wheat markets and innovations in baking technology. The advent of innovations in baking technology are of great importance for CWRS wheat producers as high protein, high gluten wheats are in less demand.

This begs the question " Is the current emphasis on hard red spring wheat an appropriate strategy?" Erosion of premiums that high protein wheats garnered over other wheats raises further doubts concerning the emphasis on CWRS. Another question arises, "Is it the product, or the way the product is graded?" This study examined the relevance of the grading system by determining how well suited CWRS wheats were in producing flour meeting the characteristics required in different bread markets.

9.2. Summary and Conclusions

A Linear programming (L.P.) package was used to determine the wheat flours which would be used to produce a least cost flour blend which contained specific quality characteristics. The linear programming package chosen for the research was the Brill Flour Formulation, Flour Blending package produced jointly by the Canadian International Grains Institute and the Brill Corporation of Norcross, Georgia.

The package contained a spreadsheet which is used to determine of the real cost of the flour obtained from each wheat grade or protein segregation. It also determined the impact of changing the allowable ash content on the cost of wheat flour. The quality factors used in the analysis were Wet Gluten, Protein, Starch Damage, Amylase

Activity (Falling Number and Amylograph Peak Viscosity), Alveograph, Water Absorption, and Thousand Kernel weight. Moisture content was held constant throughout the analysis. The allowable ash content in the desired flour blends was varied for different analyses. The end-products determining flour characteristics included two North American style pan breads and three French style breads. The difference between the two North American style pan breads was the protein content of the flour. The French breads required different quality characteristics than the pan breads, and also differed from each other in protein content. The three French breads represent consumption products in Algeria, Syria and Brazil.

9.2.1. Pan Bread Markets Utilizing Only CWRS

Chapter 6 examined the domestic market for CWRS wheat. The basic assumption was that the miller had to produce a least cost flour from the six grades and protein segregations of CWRS wheat[224]. The least cost flour blends for large and small bakery flours differentiated by protein level were determined and the relative composition analyzed. The allowable ash content level was varied to provide a greater and perhaps futuristic, scope to the analysis.

Analysis of the data showed that the ash content of CWRS wheat varies between grade and crop years, and by protein segregation within grade. As well, the ash content of the flour extracted from a particular grade can vary between export port even in the same crop year quarter. The ash content of the CWRS grades and protein segregations

[224] This section of the used data from two ports for 26 crop year quarters, at three different ash content levels for a total of 156 observations.

studied ranged between .42 and .54 percent, 89 percent falling below .50, the current upper level limit to ash content in pan breads. The higher protein segregations of CWRS wheat tended to have the lowest ash content which reduced the cost of wheat flour. Generally, a change of .01 percent in the ash content resulted in about a 1 percent change in the cost of wheat flour.

The analysis of the pan bread market in Canada showed that small bakery pan bread flour sometimes cost less to produce than large bakery flour which has a lower protein content. The reason for this seemingly obtuse result is related to the spreadsheet calculation of the true cost of the wheat flour. No.1 CWRS wheat has a lower foreign material and moisture content than No.2 or No.3 CWRS, hence the customer receives more millable wheat for his/her money. As well the ash content of these higher grades/segregations is often much lower than the allowable ash content of the flour blend which it is to be used in. The extraction rate of these wheats is correspondingly adjusted upwards thus reducing the real cost of the wheat flour. As a result of these factors, the wheat flour produced from the higher grade/protein segregations could be less costly than the wheat flour available from the lower grade/protein segregations. The small bakery flour blends which use wheat flour derived from these higher grades/protein segregations may, therefore, be less costly than the lower protein content large bakery flour blends.

Another finding of note was that protein content was the most frequent binding constraint in minimizing flour cost. In about 30 percent of small and large bakery blends, the wheats which could have contributed to lower cost flour had too low a protein content. This is not a problem of the grading system but rather a restriction set by the characteristics in the end-product.

The analysis concerning the use of various grade/segregations of CWRS wheat produced some surprising results. The fact that 1 No.1 CWRS (14.5) was selected more frequently in small bakery flours than large bakery flours was expected. However, what was not expected was the relatively low amounts of No.1 (13.5) required in both the small and large bakery flour blends, particularly the small bakery blends. Only 33 percent of the small bakery flour blends contained any amount of No. 1 (13.5) CWRS. Large bakery blends used No.1 (13.5) in only 17 percent of the blends. This is very poor performance on the part of the "flagship" CWRS grade protein segregation as not only was the No.1 (13.5) use rate low, but the amount used in the blends was also quite low.

The most frequent No. 1 grade selected for both the small and large bakery flours was No.1 (12.5). This protein segregation was frequently specified in conjunction with No.1 CWRS (14.5) and in lieu of No. 1 (13.5) in the small bakery blends. Thus it seems blending No.1 (12.5) and No. 1 (14.5) provides similar protein and other characteristics at a lower cost than using No.1 (13.5) exclusively. This suggests that No.1 CWRS (13.5) may be over priced when compared to the other two protein segregations for the protein and other characteristics the grade represents.

No. 1 CWRS wheat also did not perform well when the choices of wheat available for the miller to select from were limited to the three segregations of the grade.

The feasibility ratios[225] were 46.15 percent and 34.6 percent, for the large and small bakery flours, respectively. This result indicates that the grading standards may be too stringent for No.1 CWRS, with respect to the quality characteristics required in the main target product flour and too much emphasis is placed on wheat protein content. In many cases, the level of the characteristics were "better" than required for the small bakery flour as specified in international standards. It may be that millers could use No.1 CWRS to produce pan bread flour, but that the flour would contain a characteristics mix which was "better" than necessary.

The No.2 (CWRS) grade results were similar to the No. 1 with respect to the two protein segregations in the grade. No. 2 (12.5) was used in far more blends than the 13.5 percent protein segregation. In fact, No. 2 (13.5) was the least used segregation in the study. Conversely, No. 2 (12.5) was used in more small bakery blends than any other segregation except No.3 CWRS. No.2 (12.5) also contributed large amounts to the blends in which it was selected. On the basis of protein segregation, 12.5 percent protein was by far the most useful segregation to the miller. The addition of the No.2 CWRS to the choices of wheats selected substantially increased the number of feasible solutions there rising to 72 percent and 64 percent for the large and small bakery blends, respectively. Generally No. 2 comprised the majority of wheat flour in the additional feasible solutions, with No.1 serving as a complementary wheat. Also No. 2 CWRS often substituted for some or all of the No.1 which had been selected in previously feasible solutions using No.1 CWRS alone. Therefore, No.2 functioned both as a

[225] Feasibility ratio is the number of feasible solutions as a percent of possible solutions.

competitor and a complement to No.1 in these blends. Had No.2 (12.5) been available in more annual quarters, the feasibility ratio may have increased even more. The fact that the feasibility ratio is not 100 percent indicates that perhaps even the standards for No.2 CWRS are higher than necessary for pan breads.

No.3 CWRS was used more frequently in flour blends than any other grade or segregation. The addition of No. 3 CWRS wheats to the inputs matrix raised the feasibility ratios to 100 percent all the large and small bakery blends. In addition, the protein content in No. 3 was also low enough to produce feasible solutions for the hypothetical low protein flour in several cases. No. 3 CWRS was used exclusively in 11.5 and 32.0 percent of the small and large bakery pan bread pan breads, respectively. The frequent use of No. 3 indicates that although the grading system down grades the wheat to No. 3, protein content and other factors are at appropriate levels to produce small and large bakery flours.

The analysis also showed that No. 3 was often selected in lieu of the other grades/segregations of CWRS wheat due to its relatively low price, particularly at the eastern ports. However, the grade lacks consistency which may preclude its purchase by some millers. No.3 CWRS was not chosen as frequently in the western ports blends as its cost advantage over the higher grades was not as great. Perhaps this suggests that in markets served by the eastern ports the demand for No.3 CWRS is less, therefore, the grade is priced lower. Conversely, No. 3 may be in higher demand in markets served by western Canadian ports hence the price spread between No. 3 and higher grade/segregations is lower. Alternatively, it may also indicate that quality is not as important in some markets served by western ports.

In the linear programming analysis, the levels of quality characteristics required were set over a range rather than a specific point. These ranges, as was discussed in Chapter 5, were selected from data obtained from expert sources. For the small and large bakery analyses, when the choice of wheats was restricted to just No.1 CWRS, or No.1 and No.2, there were many instances where the grade/segregations were unable to produce a feasible solution due to quality constraints other than protein. While factors such as too little alpha-amylase may be ameliorated through the addition of an extra ingredient such as malt[226], these flours may be more expensive than those produced using all three grades and protein segregations. The results show that the infeasible solutions which resulted when the package was restricted to just No. 1, or No. 1 and No. 2 CWRS wheats, were often higher cost than the corresponding feasible solutions when all three grades were available. In addition, the cost of the ameliorating ingredient would need to be factored into the cost solution to determine which is the least cost method of producing the acceptable flour.

9.2.2. Pan Bread Markets Utilizing Wheats from the United States, Australia and Canada

In Chapter 7 the analysis focused on the ability of the CWRS wheat grades to compete in the North American pan bread markets with Australia and U.S wheats. The results showed that for both pan bread flours, CWRS wheats alone produced the most expensive flour blends when compared to the other combinations analyzed.

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[226] The relative costs would depend on the cost of malt and No.3 CWRS.

Combinations of CWRS and Australian wheats (COM) produced lower cost flours than CWRS and U.S. wheat combined (NOR). It is interesting to note that often the cost difference between large bakery flour blends made from CWRS wheats alone (CAN) and those using CWRS and DNS[227] (NOR) was not very different. The small difference in cost between the CAN and NOR choice set may refute the thesis of Gibson et al when transportation costs to Canada are considered. In other words, the quality of CWRS wheat may preclude large scale imports of DNS wheat from the U.S. by domestic millers.

When the miller could choose from wheat from all three countries, the CWRS grades and protein segregations were selected less often than competitor wheats. When the Australian wheats were available, the only CWRS grades/protein segregations selected were No.1 CWRS (14.5) and No. 3 CWRS. Although No.1 (14.5) and No.3 CWRS were selected, their frequency of selection and contribution to the blend was quite low.

No.1 CWRS (13.5), which tends to be one of the most popular CWRS grade/segregations and is a major focus of the CWRS breeding program, was selected infrequently in the COM and ALL[228] choice sets yet No.1 CWRS (14.5) was the most commonly selected of the No. 1 and 2 CWRS segregations throughout this section of the analysis. No. 3 CWRS was selected more often than other CWRS grade/segregations.

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[227] DNS is Number 2 Dark Northern Spring wheat. DNS wheat is commonly grown in North Dakota and Minnesota and the other Great Plains States of the U.S.

[228] The ALL Choice Set contain all six grades/segregations of CWRS wheat, No. 2 DNS and the three Australian wheats.

This indicates that in certain crop year quarters, No. 3 CWRS contained adequate quality characteristics and enough low cost protein for it to be competitive. The lower cost of No. CWRS (14.5) on the west cost probably reduced the selection of No. 3 CWRS for these blends than otherwise occurred in east coast blends.

The wheats which contributed the most to the flour blends when all were available were No. 2 DNS from the U.S., and the Australian Standard White wheat from South Australia (ASWSA). DNS tended to be a greater contributor in the small bakery pan blends than in the large bakery flour blends. The converse was true for the ASWSA which contributed more to the large bakery than the small bakery four blends. As well, the other higher protein wheat APHD14 contributed more to flour blends than No.1 (14.5). The low utilization of the CWRS grades indicate that U.S. and Australian wheats, particularly the Australian standard white wheat, can provide a lower cost grist suitable for pan bread production than CWRS. The high percentage utilization of ASWSA in the blends indicates the importance of having a reasonably priced medium quality wheat available for use in grists.

9.2.3. French Bread Markets Utilizing Wheats from the United States, Australia and Canada

In this section of the analysis three protein ranges were used to represent three different French bread markets. The analysis was further expanded by using two ash content levels, .50 and .60 percent ash. As well other constraints were adjusted to reflect the quality factors required in French bread flours. The linear program was restricted to producing the least cost flour from a choice of 1) Australian and Canadian wheats and 2) Canadian, Australian and United States wheats. The reason the CAN and NOR combinations (CWRS grades and CWRS and DNS No. 2) were not analyzed more fully was there were very few feasible solutions for the CAN or NOR choice set. In fact only No. 3 CWRS was chosen in the feasible solutions and only when the protein level was between 11.5 and 12 percent. No. 2 DNS being a high protein wheat did not increase the number of feasible solutions. Consequently, it appears that the only way CWRS wheat will penetrate the French bread flour markets is as a blending wheat.

The ability of CWRS wheat to penetrate the French bread markets as a blending wheat may also be limited. Of the COM and ALL combinations analyzed, only two CWRS grades/ protein segregations made significant contributions to any of the French bread flour blends, No.1 CWRS (14.5) and No. 3 CWRS, and only when they could be blended with Australian wheats. When the U.S. No. 2 DNS, also a high protein wheat, was added to the choice sets the amount of CWRS wheat was reduced, as was the amount of Australian Prime Hard wheat. Changing the ash content of the flour blend resulted in a substantial reduction in flour cost, but caused only minor changes in the use of CWRS wheat.

One of the problems CWRS wheats face is illustrated on Figures 9.1 and 9.2. These figures plot the costs of the five protein levels found in the end-use products used in the study. The costs are at a standard ash content level of .5 percent. The two most expensive products are the small and large pan bread flours for which CWRS wheats were developed. The three French breads, with lower protein levels, are less expensive than the two Canadian style pan bread flours. The lower cost flour for the French breads may make these products more attractive to consumers in lower income countries. As CWRS wheats were shown to be fairly non-competitive in the French bread flours analysis, CWRS wheats may be shut out of a major wheat consumption market. The figures also illustrate that the relative cost between the five protein levels remains fairly constant throughout the 10 crop year quarters when wheats from all three countries were available. This relationship provides some indication of the relative value of protein content in flour throughout the period.

It appears that Canada may have difficulty in competing with the U.S. and Australia for markets where French breads are the dominant end-use product. No. 3CWRS and No.1 CWRS (14.5) were the only CWRS wheats selected in this analysis and were only chosen when they substituted for the two Australian medium protein wheats. DNS and APHD14 were selected more frequently that CWRS wheats because they generally offer a lower per unit protein price. If the other quality characteristics of DNS been closer to those exhibited by CWRS, more of this wheat would have been used.

9.2.4 Parametric Analysis

The prices used in the study were based on published asking prices F.O.B. specific ports and not landed prices. Therefore, differences in ocean shipping rates could affect the landed price hence the wheats selected in the various blends. To determine the impact of price on the selection of CWRS wheats, parametric testing was undertaken. Six separate price regimes were used in the analysis for three end-products, large and small bakery pan breads, and the mid-protein range French breads. The price of No.1 CWRS (13.5) was adjusted downwards by $5.00/tonne, $10.00/tonne, $15.00/tonne,

Figure: 9.1 Protein Cost Comparison
All Choice Set: West Coast Ports .5 ASH

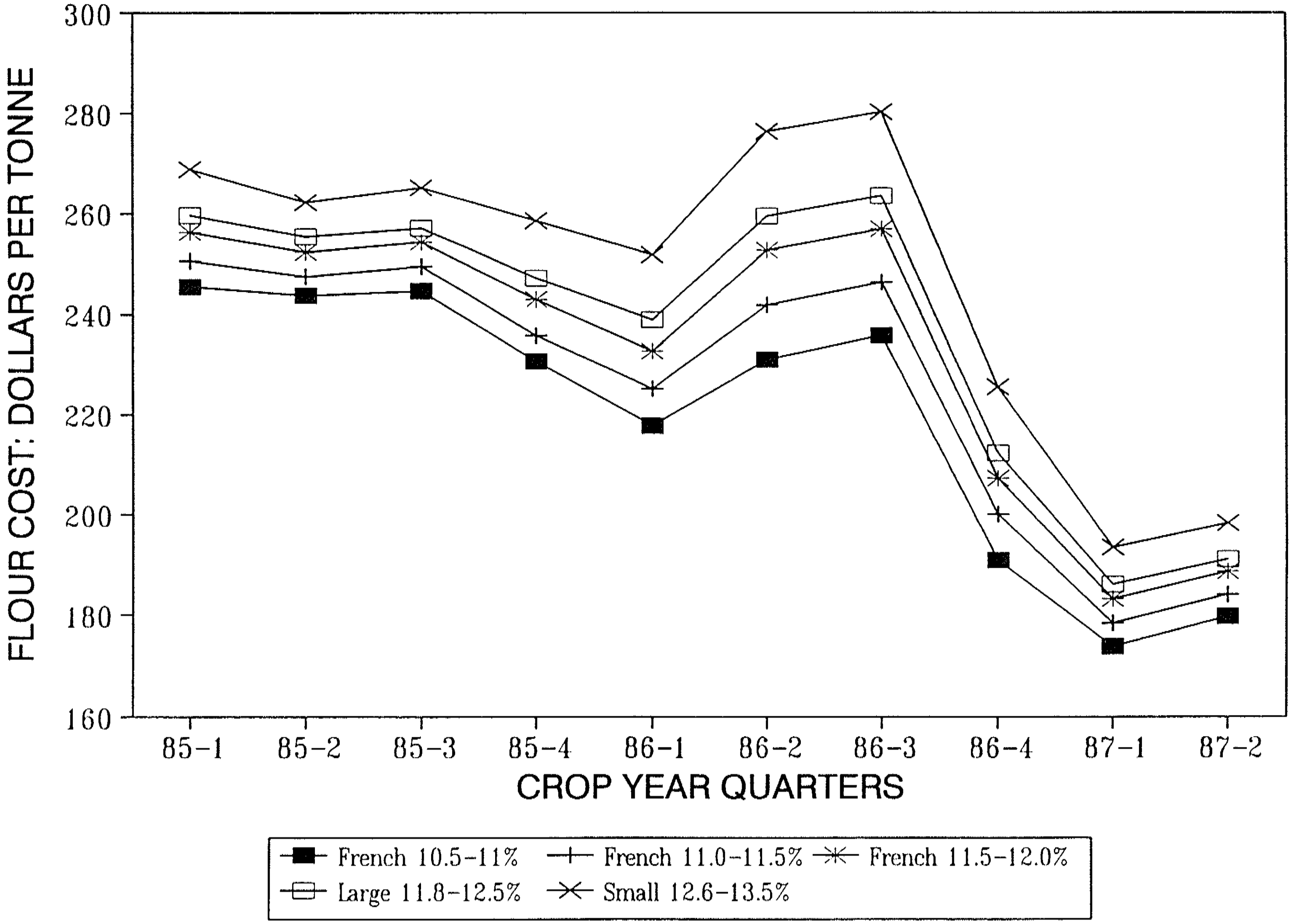
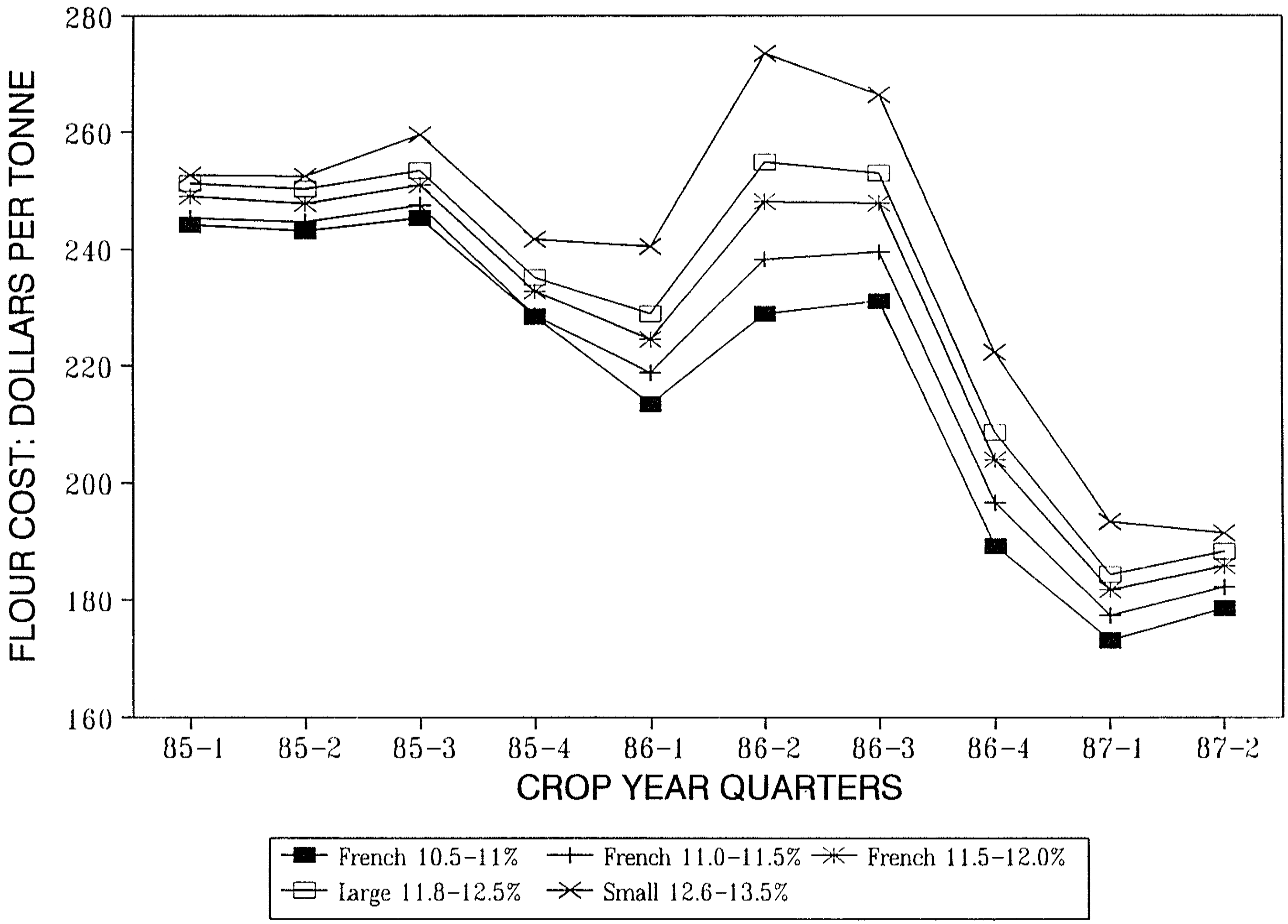


Figure: 9.2 Protein Cost Comparison
All Choice Set: East Coast Ports .5 ASH



$20.00/tonne, $25.00/tonne and $30.00/tonne. New prices for the other CWRS grades/segregations were calculated relative to their original relationship with No. CWRS (13.5) The analyses assumed an ash content of .50 percent and pertained to the ALL choice set.

The results show that the competitiveness of CWRS wheat may be greatly enhanced if the actual landed prices are lower than the listed asking prices for CWRS wheat. The elasticity of use calculated from the parametric analysis indicates that the price of CWRS wheat has a large impact on the amount used in the two pan bread flour blends. Therefore, where ocean shipping rates from Canadian export ports to specific import destinations are lower than that of their competitors, CWRS wheat may be more competitive than indicated in the original analysis. For example, decreasing the price of CWRS wheats by $10.00/tonne not only increased the use of CWRS wheats in pan breads from approximately 4 to 11 appearances, the average contribution in the blends increased from 30.8 to 62.9 percent for small bakery flours and 24.7 to 50.9 percent for large bakery blends. These results may give a truer picture of CWRS use where ocean shipping rates to specific import destinations are $10.00 less than their competitors. For example freight rates to the United Kingdom from the St. Lawrence averaged $9.00/tonne less than from Australia. However, the increase in CWRS frequency of use and average contribution to blends for price reductions over $20.00/tonne result were marginal. Even when prices were reduced $30.00/tonne, CWRS grades/segregations were not used exclusively to produce the pan bread flour blends. At this price reduction, the least cost small bakery flour blends still selected approximately 22 percent Australian

Standard White wheats and large bakery pan blends selected over 35 percent U.S. and Australian wheats.

The parametric analysis showed that the use of CWRS wheats in the two pan breads appears to be very elastic through the range of prices used in the analysis. This elasticity of wheat use indicates that through competitive pricing, CWRS wheat could gain or at least retain share in specific markets. The fact that CWRS wheat use was so price elastic may indicate why the CWB does not wish to publish selling prices. In all likelihood the asking prices are higher than actual selling prices. The estimated elasticities also indicate that the quality of CWRS wheat is such that as the price decreases, CWRS wheat substitutes for DNS and APHD14 as well as replacing some of the ASW used in the pan bread mixes.

The parametric analysis of French bread flours indicated that the contribution of CWRS wheats in the blends was less dependent on price. Beyond the first $5.00/tonne drop in price, price was not the limiting factor in determining the contribution of CWRS in a blend. In fact price reductions up to $30.00/tonne did not increase the average contribution. Rather the quality characteristics of CWRS wheat appear to limit its average contribution in French bread flour blends to approximately 40 percent of the required wheat mix. This is not entirely unexpected given that the CWRS grading system was developed targeting the pan bread market as its end use market.

Price reductions only allowed CWRS wheats to be selected more often. Given the characteristics of CWRS wheats and the requirements of French bread flours, prices would have to be reduced $20.00 to $30.00/tonne before CWRS wheats could be consistently viewed as a staple in the wheat mix required to produce French bread flours. At these price reductions, the qualities inherent in CWRS wheats would permit CWRS wheats to out compete U.S. No. 2 DNS. In summary, it would seem that the grading characteristics and prices assigned to reflect the value of each grade/segregation do not coincide with the values French bread flour millers might place on CWRS wheat quality characteristics.

Although the contribution of CWRS wheat to French bread flour blends may be restricted by the high protein content, its selection or use relative to other high protein wheats appears to be quite elastic. The potential exists for possible market penetration through competitive pricing.

CWRS wheat elasticity of use in both of the pan breads and the French bread was high. In the absence of Canada developing suitable medium quality wheats, this elasticity of use may allow CWRS wheat to retain markets and perhaps compete in markets in the short and intermediate run which otherwise would be closed to CWRS wheat. However, lower prices which would enable CWRS wheat to compete in growing middle protein wheat markets would inevitably reduce producer returns and possibly more importantly reduces the prices charges by competitors.

9.3. Policy Implications

The results of this study have some serious implications for grain marketing policy in Canada. Historically, Canada has emphasized protein and consistent quality in order to develop and maintain markets for the wheats produced in western Canada. One of the objectives of the research was to determine whether the quality factors and their predetermined levels distinguishing grades and protein segregations in the Canadian Western Red Spring grading system reflect those desired by end-users in the production of flour suitable for baking Canadian style pan breads. The results of the analyses show that the Canadian system tends to over emphasize protein as a quality factor for milling wheats. This is borne out by the fact that the 13.5 percent protein segregations of both No.1 and No.2 CWRS were selected infrequently in the production of the end-use products, even when the miller was restricted to CWRS wheats. The frequency with which the 12.5 percent protein segregations of No.1 and No.2 CWRS were selected provides more evidence that too much emphasis has been placed on protein by the Canadian system.

A second objective of the study, to determine the competitiveness of CWRS vis-a-vis wheats from other countries in the production of flours suitable for pan and French style breads, can also be related to protein content. Part of the Canadian emphasis on protein content stems from the fact that protein has, in the past, garnered a premium from the market, in part because protein was related to quality in the minds of some buyers and sellers. However, a brief examination of the end-use products consumed in many of the growth markets throughout the world show that high protein is not necessary for many of them. For example, the Arabic style breads require 8 to 10 percent protein and ash contents between .7 and 1.0 percent. In the Pacific Rim markets, Chinese noodles require between 10 and 11.5 percent protein with .44 to .46 percent ash, and Japanese noodles require wheat flours with a 8 to 9 percent protein range and .38 percent ash content. The protein and ash contents of CWRS wheat clearly do not fit any of these market niches[229]. In addition, technological advances in the past and perhaps in the future have reduced the need for high protein wheats.

The Canadian use of protein segregations is also a result of the demands of Canadian producers who feel that since producers in the U.S. receive a premium for high protein wheat, the same should occur in Canada. However, the situation with respect to the grading systems in the two countries is quite different. The U.S. grading system lacks the consistency which is one of the hallmarks of the Canadian. In order to compensate for the lack of consistency protein content is used as an indicator of wheat quality. As a result premiums are paid for parcels of wheat with high protein contents as these are assumed to be the better quality wheats. In Canada, the wheat grading system does not rely on protein content as the basis for measuring wheat quality, other often more suitable factors are used, hence high protein is not a required signal.

The fourth objective of the study was to determine the implications of the current set of CWRS grades and standards on the income of western Canadian wheat growers and on the grain handling and transportation system. Although not explicitly analyzed, it can be hypothesized that replacing the emphasis on high protein with more emphasis on higher yielding lower protein wheats may in the longer run provide increased benefits to producers. The costs and benefits of Canada's tendency towards the production of higher protein wheats in western Canada should be examined. Although the majority of the CWRS wheat produced each year is sold, the question is at what price? A study would need to be undertaken in conjunction with the Canadian Wheat Board as the exact

[229] Protein and ash content ranges for various products are illustrated in Table 5.3

selling prices and earnings from the various pool accounts would be required and these are confidential CWB information. Such a study would determine whether or not producers incomes are truly being maximized under the present system which emphasizes the production of high protein CWRS wheat.

Protein premiums also impose costs on the primary elevator system. In order to satisfy their customers, many elevator companies had to purchase protein testers to remain competitive in the handling market. The use of protein segregations at the primary elevator has also increased costs and reduced efficiency due to the necessity for binning high protein wheat separately. Changes to the CWRS grading system with respect to protein content are unlikely to have a great effect on the transportation system. However, in certain cases because 14.5 percent CWRS wheat is segregated from the rest of the CWRS wheat, it must also be shipped in separate rail cars. In some cases doing this may cause an increase in transportation costs. If the protein premium was removed, this would reduce the number of grades/segregations handled at the primary elevator by one, but would also remove the requirements for elevator managers to carry out protein tests on many of the loads delivered to the elevator. Because the protein content in CWRS wheat tends to be consistent within a geographical area, removing the protein premium may not have an impact on the number of grade/segregations handled by a primary elevator. However, research needs to be undertaken to ensure that segregating 14.5 percent protein wheat is economically sound. If otherwise production the goal of producing high protein CWRS wheat should be de-emphasised.

Because high protein content is not a necessary grading factor, a program for breeding wheats which conform to the present standards but have an average protein content of 12-13 percent would be in order for Canada. Such wheats would be suitable to satisfy the most of the present markets for CWRS wheat. However, as markets do exist for wheat of 13.5 percent protein or greater, the CWB could develop a high protein contracting program, such as those which grain companies have with producers of special crops, to satisfy these markets. Explicit, rather than implicit, contracts between the CWB and participating producers would limit the production of higher protein wheat to those producers who can consistently produce such wheat. This process may result in a more efficient and effective wheat marketing strategy in the long run. In addition, reducing the possible oversupply of higher protein wheat may allow the CWB to extract slightly greater premiums for higher protein wheat from the marketplace.

The frequent selection of No. 3 CWRS for various flours indicates that this particular grade often has price/quality advantages over other CWRS grades/protein segregations. This frequent selection shows that the characteristics which caused the parcel to be downgraded are set at somewhat inappropriate levels and that even though the wheat was downgraded this did not prevent the parcel from being used to produce a least cost blend. However, No.3 CWRS is not always selected due to inconsistencies with respect to its quality characteristics. These two conclusions were confirmed by Canadian millers. Several millers revealed that they prefer to utilize as much No. 3 CWRS as possible in their grists as costs are reduced. However, they also indicated that the characteristics of No. 3 CWRS are inconsistent thus prohibiting higher utilization rates. The implication of the conversations was that if specific quality factor lot of this grade were known ex ante more of the grade would be used in pan bread flour blends. This use of No. 3 CWRS indicates that the grading factors for CWRS should be reevaluated to determine if some of the grading factors are inconsistent with the needs of the market and if others are more relevant.

Identification of low ash content wheat prior to sale should justify extracting a premium from the market. The results show that the lower the ash content at a 75 percent extraction rate, the higher the potential extraction of flour. Thus when one mill receives wheat with low ash content at the same price as a mill receiving a higher ash content wheat, the first mill receives an extra benefits. Millers should be willing to pay for this benefit. On this point, millers' opinions were mixed concerning willingness to pay a premium for low ash content CWRS wheat. Some millers were unwilling to pay a premium while others indicated they may be willing to pay such a premium. The impact of ash and the ability to extract premiums for low ash should be further investigated to ensure that producers will receive the highest return for their product.

The use of costing packages such as the Brill package used in this study will increase in the future. The ability to provide customers with the information such as that used in the study would provide a marketing advantage. At, present, the Grain Research Laboratory does most of these tests after the wheat has been shipped. If the information was available prior to sale, millers would be aware of what they were going to receive and the value of the wheat to them. The same would be true in the export market.

Having quality information *ex ante* would also allow the seller (CWB) to extract premiums for particular parcels of wheat from the market place.

The results show that, in general, CWRS wheat can be competitive in the world market for pan bread flours. The performance of No.2 Dark Northern Spring (DNS) wheat in the study vis-a-vis CWRS shows that it is unlikely the Canadian flour milling market will be flooded by U.S. wheats given current price relationships and transportation costs. However, the results do indicate that if the asking prices for CWRS wheat are indicative of selling prices, then the U.S. DNS wheat has a lower per unit protein cost. This low per unit protein cost allowed DNS to supplant CWRS wheat in many of the least cost blends. However, CWRS can be price competitive as was shown in the parametric analysis. When CWRS wheat prices were lowered by $20.00/tonne to a price close to the prices asked for DNS, the DNS in the blends is replaced by CWRS grade/segregations. These results imply that Canada needs to pursue the development of a wheat which has a lower cost of protein on a per unit basis in order to compete with U.S. wheats.

The performance of the Australian white wheats in both the pan style bread and French bread flour blends show that Canada must re-evaluate its emphasis on red wheats. In particular the emphasis on high protein red spring wheat needs to be reexamined as CWRS wheats are not competitive with the white wheats from Australia. White wheat itself has the advantage of about a 10 percent higher extraction rate. In addition, the white wheat from Australia also has the advantage of being shipped drier than Canadian wheats. Consequently, these wheats have two advantages over the red spring wheats from western Canada.

Australia's ability to produce white wheats and to ship drier wheat is related to both regulation and climate. White wheats lack sprouting resistance that has been developed in the red wheats produced in western Canada. However, this is not a problem as the Australian wheat harvest is carried out during the driest season of the year, therefore sprouting resistance is not a necessary quality constraint for their wheats. The dryness of the harvest season also means that the wheat is harvested much drier than wheat in western Canada. As a result of the warm climate, Australian stored grain is more subject to insect infestations than grain stored in the cold dry winters of Canada. To reduce insect infestations, Australian grading regulations require that grain be delivered dry to storage silos. These regulations ensure that Australian farmers utilize their climatic advantage.

The need for Canada to develop suitable white wheats may be accelerated if other competitor countries develop white wheat varieties which are competitive with the Australian wheats. Australia, does not produce enough wheat to seriously impact on the world market. However, if the E.E.C. and the U.S. were to move towards producing a consistent quality white wheat, this could have serious implications for Canada.

The third objective of the study was to determine the impact of price on the selection of wheats for various flour blends. The results of the parametric analysis show that price does have an impact on the selection of wheats and that often the price of CWRS wheat precluded its selection until the price was reduced. Price was extremely important in the selection of wheats for the pan breads and the French breads. However, the results show that the ability of CWRS to penetrate the French bread market through competitive price reduction is limited. The results are analogous to the potential for selling luxury cars in the world market, for some people it doesn't matter how much the price is lowered, they still cannot use a luxury car. This is the case with CWRS wheat and the French bread market, there is only so much CWRS which can be used in French bread flours. The results show that is extremely important that Canada pursue the development of a medium quality wheat which can be produced in western Canada. The medium quality Australian Standard white wheats contributed about 22 percent to small bakery pan bread flours and 58 percent in French bread flour even when the price of the CWRS wheats were reduced $30.00/tonne.

A shift in emphasis towards developing wheats which are more in tune with the present market situation would result in an increase in the production of lower priced wheats. Farmers in western Canada could achieve similar, if not greater, per acre returns through the higher yields of these lower valued wheats. In addition, if the emphasis is changed, other agronomic and economic benefits will accrue to producers.

Changes would also need to be made to the grain handling and transportation system to accommodate any shift in Canadian wheat marketing. If lower protein and white wheats were introduced, it may place a strain on the existing grain handling and transportation infrastructure as the production of lower value wheats will create the need for lower cost handling and transportation systems. A system designed to handle and transport the higher value hard red spring wheats may well be too expensive for medium quality wheats. Efficiencies obtained by constructing large inland terminals with large capacities, coupled with bulk loading of vessels may be required to reduce overall marketing costs.

Until Canada can develop suitable white wheats, changes could be made to the grading system to encourage drier wheat in the Canadian system. In 1984, the Canada Grains Council publication " Wheat Grades For Canada" suggested that the discounts for wheats containing excess moisture be increased and enforced. This recommendation has not been fully implemented and the results of the analysis show that CWRS wheat is placed at a slight cost of flour disadvantage to the drier Australian wheats. At present, the grain handling and transportation system condones the shipment of damp or moist grain, and grain containing dockage in excess of export tolerances which results in inefficient transportation. This wheat is cleaned and dried at the terminal elevators prior to export.

The factors used to grade other wheat classes now produced in Canada should also be examined to determine if they result in missed market opportunities. For example, the CWB is now looking at markets for the Canadian Utility variety Glenlea. The potential of this wheat to "carry" other wheats in flour blends was identified by W. Bushuk several years ago. During the interim, a market opportunity for western Canadian producers was not fully exploited. Interdisciplinary research needs to be carried out to determine the potential markets for all classes of wheat produced in western Canada.

The grading system for CWRS wheat is efficient at separating the parcels of wheat by respective quality factors and communicating these quality factors to the end user. However, the grading system does not accurately reflect the levels of quality required by end users. Canada needs to overcome the inertia which exists within the regulatory structure and re-evaluate the CWRS grading system. The pan bread flour market within Canada could be better served by changes to the grading system and the emphasis on protein content. Factors such as providing *ex ante* ash content information and Falling Numbers for No.3 CWRS will assist in marketing CWRS wheat. CWRS wheat is competitive with the hard wheats from the U.S. and Australia, but needs to pursue the market through improving the ability of the product to meet the needs of end-users. Changes to the CWRS wheat grading system and aggressive development of other Classes of wheat are required if Canada is to remain competitive.

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APPENDICES

APPENDIX A.1 1980/81 PRICING ADJUSTMENTS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (14.5) CWRS							
8121	0.43	281.17	335.11	326.41	53.94	45.24	8.70
8131	0.43	276.83	330.22	321.66	53.39	44.83	8.56
8141	0.45	270.50	323.69	317.68	53.19	47.18	6.01
9121	0.43	289.26	347.88	338.71	58.62	49.45	9.17
9131	0.43	269.93	321.36	313.11	51.43	43.18	8.25
9141	0.44	256.59	304.02	297.44	47.43	40.85	6.58
AVERAGE					53.00	45.12	7.88
STD.DEV					3.32	2.74	1.16
No. 1 (13.5) CWRS							
8112	0.44	269.00	320.01	312.96	51.01	43.96	7.05
8122	0.43	282.00	336.99	328.23	54.99	46.23	8.76
8132	0.42	273.66	326.88	317.27	53.22	43.61	9.61
8142	0.45	267.33	318.82	312.92	51.49	45.59	5.90
9112	0.44	255.67	305.09	298.43	49.42	42.76	6.66
9122	0.43	286.00	343.46	334.41	57.46	48.41	9.05
9132	0.44	266.67	316.94	309.98	50.27	43.31	6.96
9142	0.44	253.33	299.93	293.47	46.60	40.14	6.46
AVERAGE					51.81	44.25	7.56
STD.DEV					3.16	2.33	1.29

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR	ADJUSTED FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (12.5) CWRS							
8123	0.45	277.00	329.11	322.99	52.11	45.99	6.12
8113	0.45	265.33	319.40	313.46	54.07	48.13	5.94
8133	0.44	270.00	322.82	315.64	52.82	45.64	7.18
8143	0.45	266.00	317.81	311.94	51.81	45.94	5.87
8113	0.46	252.33	299.97	295.61	47.64	43.28	4.36
9123	0.46	282.33	341.73	336.48	59.40	54.15	5.25
9133	0.45	263.66	309.95	304.35	46.29	40.69	5.60
AVERAGE					52.02	46.26	5.76
STD.DEV					3.99	3.90	0.80
No 2 (13.5) CWRS							
9114	0.46	251.50	302.38	296.79	50.88	45.29	5.59
9124	0.43	281.83	344.27	332.78	62.44	50.95	11.49
9134	0.45	262.50	313.27	306.08	50.77	43.58	7.19
9144	0.46	249.16	296.90	292.81	47.74	43.65	4.09
AVERAGE					52.96	45.87	7.09
STD.DEV					5.62	3.01	2.77

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 2 (12.5) CWRS							
8115	0.46	261.33	316.29	310.37	54.96	49.04	5.92
8125	0.44	272.83	330.12	320.83	57.29	48.00	9.29
8135	0.45	265.83	322.21	314.62	56.38	48.79	7.59
8145	0.46	261.83	313.18	307.39	51.35	45.56	5.79
9115	0.45	248.16	300.44	293.52	52.28	45.36	6.92
AVERAGE					54.45	47.35	7.10
STD.DEV					2.30	1.58	1.28
No. 3 CWRS							
8117	0.49	254.47	312.50	310.93	58.03	56.46	1.57
8127	0.47	266.30	327.76	322.81	61.46	56.51	4.95
8137	0.47	259.13	320.13	315.30	61.00	56.17	4.83
8147	0.47	235.97	287.16	283.02	51.19	47.05	4.14
9117	0.48	241.30	297.98	295.02	56.68	53.72	2.96
9127	0.45	271.47	337.95	329.41	66.48	57.94	8.54
9137	0.46	252.47	310.14	304.07	57.67	51.60	6.07
9147	0.48	239.13	297.92	289.83	58.79	50.70	8.09
AVERAGE					58.91	53.77	5.14
STD.DEV					4.11	3.49	2.23

Explanation of uncorrected and adjusted flour costs in Sections 6.5.
Source: Spreadsheet Calculations.

APPENDIX A.2 1981/82 PRICING ADJUSTMENTS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (14.5) CWRS							
8211	0.46	252.74	298.27	291.85	45.53	39.11	6.42
8221	0.45	240.74	281.64	272.84	40.90	32.10	8.80
8231	0.44	245.07	286.06	280.01	40.99	34.94	6.05
8241	0.47	244.41	285.38	280.34	40.97	35.93	5.04
9211	0.44	247.50	291.09	280.98	43.59	33.48	10.11
9221	0.44	246.33	287.19	281.04	40.86	34.71	6.15
9231	0.46	232.16	269.43	265.71	37.27	33.55	3.72
9241	0.46	230.16	268.06	260.79	37.90	30.63	7.27
AVERAGE					41.00	34.31	6.70
STD.DEV					2.52	2.40	1.90
No. 1 (13.5) CWRS							
8212	0.45	249.33	293.06	285.81	43.73	36.48	7.25
8222	0.46	237.33	277.64	269.93	40.31	32.60	7.71
8232	0.46	241.66	281.66	277.67	40.00	36.01	3.99
8242	0.47	241.00	280.27	275.37	39.27	34.37	4.90
9212	0.45	244.00	287.70	278.70	43.70	34.70	9.00
9222	0.45	243.33	285.97	280.89	42.64	37.56	5.08
9232	0.46	228.66	266.24	260.80	37.58	32.14	5.44
9242		226.66	264.03	256.92	37.37	30.26	7.11
AVERAGE					40.58	34.27	6.31
STD.DEV					2.38	2.30	1.60

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
<u>No. 1 (12.5) CWRS</u>							
8213	0.47	245.66	289.66	282.50	44.00	36.84	7.16
8223	0.46	234.00	273.05	265.52	39.05	31.52	7.53
8233	0.46	238.33	276.08	272.19	37.75	33.86	3.89
8243	0.49	237.66	276.06	271.25	38.40	33.59	4.81
9213	0.47	241.00	283.94	277.01	42.94	36.01	6.93
9223	0.46	240.00	284.86	280.76	44.86	40.76	4.10
9233	0.47	224.67	260.59	256.16	35.92	31.49	4.43
9243	0.48	223.00	260.59	255.30	37.59	32.30	5.29
AVERAGE					40.06	34.55	5.52
STD.DEV					3.15	2.98	1.38
<u>No 2 (13.5) CWRS</u>							
8214	0.48	246.74	294.15	286.19	47.41	39.45	7.96
8224	0.47	234.74	277.69	269.19	42.95	34.45	8.50
8234	0.49	238.07	279.35	278.09	41.28	40.02	1.26
8244	0.49	238.41	279.07	272.96	40.66	34.55	6.11
9214	0.49	241.41	287.99	281.55	46.58	40.14	6.44
9224	0.47	240.74	284.79	280.95	44.05	40.21	3.84
9234	0.47	226.07	265.91	257.96	39.84	31.89	7.95
8244	0.48	224.07	263.66	256.89	39.59	32.82	6.77
AVERAGE					42.80	36.69	6.10
STD.DEV					2.81	3.37	2.28

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR	ADJUSTED FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 2 (12.5) CWRS							
8215	0.47	243.07	288.51	279.60	45.44	36.53	8.91
8225	0.48	231.46	272.59	270.16	41.13	38.70	2.43
8235	0.48	235.74	274.57	272.14	38.83	36.40	2.43
8245	0.48	235.07	274.23	267.13	39.16	32.06	7.10
9215	0.48	238.41	287.02	284.38	48.61	45.97	2.64
9245	0.48	220.41	258.32	251.79	37.91	31.38	6.53
AVERAGE					41.85	36.84	5.01
STD.DEV					3.89	4.83	2.61
No. 3 CWRS							
8217	0.50	235.63	284.04	278.69	48.41	43.06	5.35
8227	0.47	223.81	265.67	262.03	41.86	38.22	3.64
8237	0.50	228.14	268.95	268.95	40.81	40.81	0.00
8247	0.51	227.47	268.75	265.05	41.28	37.58	3.70
9217	0.49	230.64	277.09	275.78	46.45	45.14	1.31
9227	0.46	229.81	276.01	270.87	46.20	41.06	5.14
9237	0.47	214.81	254.22	246.42	39.41	31.61	7.80
9247	0.49	212.97	251.99	246.43	39.02	33.46	5.56
AVERAGE					42.93	38.87	4.06
STD.DEV					3.34	4.32	2.33

*Explanation in Sections 6.5.

Source: Spreadsheet calculations.

APPENDIX A.3 1982/83 PRICING ADJUSTMENTS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
8311	0.48	238.33	277.92	275.96	39.59	37.63	1.96
8331	0.46	239.00	280.15	276.22	41.15	37.22	3.93
9311	0.44	226.33	265.49	260.00	39.16	33.67	5.49
9321	0.46	232.33	273.28	269.45	40.95	37.12	3.83
9331	0.43	235.00	276.15	269.46	41.15	34.46	6.69
9341	0.49	234.66	276.95	275.97	42.29	41.31	0.98
AVERAGE					40.72	36.90	3.81
STD.DEV					1.05	2.47	1.94

No. 1 (13.5) CWRS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
8312	0.48	234.66	273.19	271.27	38.53	36.61	1.92
8322	0.44	230.33	270.29	264.69	39.96	34.36	5.60
8332	0.47	235.33	275.57	272.66	40.24	37.33	2.91
8342	0.47	238.00	277.32	274.42	39.32	36.42	2.90
9312	0.45	222.00	261.23	256.74	39.23	34.74	4.49
9322	0.45	228.00	267.81	263.19	39.81	35.19	4.62
9332	0.47	230.67	270.81	267.98	40.14	37.31	2.83
9342	0.49	230.33	270.14	269.19	39.81	38.86	0.95
AVERAGE					39.63	36.35	3.28
STD.DEV					0.53	1.42	1.43

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (12.5) CWRS							
8313	0.48	231.66	268.47	266.60	36.81	34.94	1.87
8323	0.47	227.00	267.35	264.54	40.35	37.54	2.81
8333	0.49	230.33	270.82	269.86	40.49	39.53	0.96
8343	0.50	240.00	281.50	281.50	41.50	41.50	0.00
9313	0.46	217.67	254.47	251.02	36.80	33.35	3.45
9323	0.46	225.00	264.71	261.06	39.71	36.06	3.65
9333	0.48	224.67	263.25	261.44	38.58	36.77	1.81
9343	0.50	226.33	265.37	265.37	39.04	39.04	0.00
AVERAGE					39.16	37.34	1.82
STD.DEV					1.60	2.47	1.34
No 2 (13.5) CWRS							
8314	0.49	229.71	270.68	269.46	40.97	39.75	1.22
8324	0.46	225.38	267.26	262.57	41.88	37.19	4.69
8334	0.49	230.38	274.19	272.96	43.81	42.58	1.23
8344	0.50	233.05	274.72	274.72	41.67	41.67	0.00
9314	0.48	217.05	256.37	254.14	39.32	37.09	2.23
9324	0.46	223.05	264.98	260.36	41.93	37.31	4.62
9334	0.48	225.72	269.32	266.93	43.60	41.21	2.39
9344	0.51	225.38	265.96	267.14	40.58	41.76	-1.18
AVERAGE					41.72	39.82	1.90
STD.DEV					1.40	2.16	1.92

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 2 (12.5) CWRS							
8315	0.49	226.71	267.14	265.95	40.43	39.24	1.19
8325	0.47	222.05	263.35	259.88	41.30	37.83	3.47
8335	0.50	225.38	266.61	266.61	41.23	41.23	0.00
8345	0.51	229.05	270.10	271.31	41.05	42.26	-1.21
9325	0.47	220.05	260.77	257.38	40.72	37.33	3.39
9335	0.47	219.72	256.97	253.67	37.25	33.95	3.30
9345	0.52	221.38	260.91	263.22	39.53	41.84	-2.31
AVERAGE					40.22	39.10	1.12
STD.DEV					1.33	2.76	2.20
No. 3 CWRS							
8317	0.50	221.20	262.09	262.09	40.89	40.89	0.00
8327	0.49	216.17	260.88	259.66	44.71	43.49	1.22
8337	0.54	220.87	267.07	272.26	46.20	51.39	-5.19
8347	0.54	224.04	270.79	276.06	46.75	52.02	-5.27
9317	0.49	207.88	267.17	265.93	59.29	58.05	1.24
9327	0.48	214.50	257.03	254.67	42.53	40.17	2.36
9337	0.52	215.71	259.11	261.57	43.40	45.86	-2.46
9347	0.53	216.37	261.39	265.16	45.02	48.79	-3.77
AVERAGE					46.10	47.58	-1.48
STD.DEV					5.30	5.75	2.87

*Explanation Section 6.5.

Source: Spreadsheet calculations.

APPENDIX A.4 1983/84 PRICING ADJUSTMENTS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING CORRECTED	DIFFERENCE LESS
		percent		dollars per tonne			
No. 1 (14.5) CWRS							
8421	0.47	237.07	276.73	273.77	39.66	36.70	2.96
8431	0.49	247.07	285.67	284.64	38.60	37.57	1.03
8441	0.51	257.74	302.36	303.49	44.62	45.75	-1.13
9411	0.50	238.50	279.53	279.53	41.03	41.03	0.00
9421	0.47	240.50	283.47	280.40	42.97	39.90	3.07
9431	0.47	245.50	288.42	285.30	42.92	39.80	3.12
9441	0.51	244.83	289.45	290.53	44.62	45.70	-1.08
AVERAGE					42.06	40.92	1.14
STD.DEV					2.19	3.33	1.79
No. 1 (13.5) CWRS							
8412	0.49	241.66	281.61	280.61	39.95	38.95	1.00
8422	0.46	235.66	274.90	271.03	39.24	35.37	3.87
8432	0.48	243.66	286.86	284.78	43.20	41.12	2.08
8442	0.51	254.33	296.32	297.41	41.99	43.08	-1.09
9412	0.49	235.00	275.23	274.26	40.23	39.26	0.97
9422	0.47	237.00	278.67	275.70	41.67	38.70	2.97
9432	0.46	242.00	286.46	282.33	44.46	40.33	4.13
9442	0.52	241.33	286.01	288.14	44.68	46.81	-2.13
AVERAGE					41.93	40.45	1.48
STD.DEV					1.93	3.17	2.10

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (12.5) CWRS							
8413	0.48	238.66	278.58	276.63	39.92	37.97	1.95
8423	0.48	232.33	272.60	270.67	40.27	38.34	1.93
8433	0.51	240.00	281.61	282.63	41.61	42.63	-1.02
8443	0.53	250.66	295.16	298.43	44.50	47.77	-3.27
9413	0.49	231.67	272.01	271.05	40.34	39.38	0.96
9423	0.48	233.67	275.43	273.47	41.76	39.80	1.96
9443	0.53	238.00	282.24	285.37	44.24	47.37	-3.13
AVERAGE					41.81	41.89	-0.09
STD.DEV					1.74	3.85	2.20
No 2 (13.5) CWRS							
8414	0.49	237.91	281.30	280.04	43.39	42.13	1.26
8424	0.46	231.91	277.60	272.61	45.69	40.70	4.99
8434	0.48	239.91	290.20	287.51	50.29	47.60	2.69
8444	0.48	250.58	301.61	298.81	51.03	48.23	2.80
9414	0.50	231.34	275.79	275.79	44.45	44.45	0.00
9424	0.48	233.65	278.28	275.76	44.63	42.11	2.52
9434	0.46	238.25	287.04	281.78	48.79	43.53	5.26
9444	0.49	237.58	286.68	285.34	49.10	47.76	1.34
AVERAGE					47.17	44.56	2.61
STD.DEV					2.77	2.76	1.70

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 2 (12.5) CWRS							
8415	0.50	234.91	278.67	278.67	43.76	43.76	0.00
8425	0.48	228.58	273.39	270.94	44.81	42.36	2.45
8435	0.50	236.25	282.08	282.08	45.83	45.83	0.00
8445	0.51	246.91	297.94	299.35	51.03	52.44	-1.41
9415	0.50	227.92	271.34	271.34	43.42	43.42	0.00
9445	0.51	234.25	281.80	283.10	47.55	48.85	-1.30
AVERAGE					46.07	46.11	-0.04
STD.DEV					2.61	3.52	1.27
No. 3 CWRS							
8417	0.52	224.74	270.60	273.19	45.86	48.45	-2.59
8427	0.49	218.58	266.97	265.70	48.39	47.12	1.27
8437	0.49	257.74	318.07	316.47	60.33	58.73	1.60
8447	0.52	237.08	290.07	292.95	52.99	55.87	-2.88
9417	0.52	217.92	261.01	263.46	43.09	45.54	-2.45
9427	0.48	219.92	267.49	264.97	47.57	45.05	2.52
9437	0.48	224.58	271.93	269.38	47.35	44.80	2.55
9447	0.51	224.25	270.98	272.27	46.73	48.02	-1.29
AVERAGE					49.04	49.20	-0.16
STD.DEV					4.99	4.89	2.22

*Explanation Sections 6.5.
Source: Spreadsheet calculations.

APPENDIX A.5 1984/85 PRICING ADJUSTMENTS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING CORRECTED	DIFFERENCE LESS
		percent		dollars per tonne			
No. 1 (14.5) CWRS							
8511	0.48	254.58	296.46	294.30	41.88	39.72	2.16
8521	0.45	251.58	297.06	291.63	45.48	40.05	5.43
8531	0.45	256.91	302.34	296.84	45.43	39.93	5.50
8541	0.49	252.24	296.38	295.29	44.14	43.05	1.09
9511	0.50	235.33	273.71	273.71	38.38	38.38	0.00
9521	0.47	238.33	277.09	274.15	38.76	35.82	2.94
9531	0.49	247.66	288.36	287.32	40.70	39.66	1.04
9541	0.49	239.33	278.44	277.44	39.11	38.11	1.00
AVERAGE					41.74	39.34	2.40
STD.DEV.					2.77	1.93	1.95
No. 1 (13.5) CWRS							
8512	0.49	251.00	292.82	291.75	41.82	40.75	1.07
8522	0.47	248.00	288.20	285.12	40.20	37.12	3.08
8532	0.46	253.33	299.97	295.57	46.64	42.24	4.40
8542	0.49	248.66	293.47	292.39	44.81	43.73	1.08
9512	0.52	232.00	270.07	271.99	38.07	39.99	-1.92
9522	0.50	235.00	270.18	270.18	35.18	35.18	0.00
9532	0.51	244.33	285.28	286.32	40.95	41.99	-1.04
9542	0.50	236.00	275.24	275.24	39.24	39.24	0.00
AVERAGE					40.86	40.03	0.83
STD.DEV.					3.41	2.64	1.95

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (12.5) CWRS							
8513	0.50	247.00	290.06	290.06	43.06	43.06	0.00
8543	0.52	245.00	289.21	291.35	44.21	46.35	-2.14
9513	0.53	228.67	266.43	269.27	37.76	40.60	-2.84
9543	0.50	232.33	269.82	269.82	37.49	37.49	0.00
AVERAGE					40.63	41.88	-1.25
STD.DEV.					3.03	3.25	1.27
No 2 (13.5) CWRS							
8514	0.49	248.54	298.58	297.18	50.04	48.64	1.40
8524	0.45	245.54	294.05	287.38	48.51	41.84	6.67
8534	0.47	250.87	300.12	295.96	49.25	45.09	4.16
8544	0.49	246.20	293.24	291.88	47.04	45.68	1.36
9514	0.53	229.54	272.15	275.92	42.61	46.38	-3.77
9524	0.48	241.84	286.13	283.53	44.29	41.69	2.60
AVERAGE					46.96	44.89	2.07
STD.DEV.					2.68	2.47	3.19

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
<u>No. 2 (12.5) CWRS</u>							
8515	0.51	244.54	293.89	295.27	49.35	50.73	-1.38
8525	0.46	242.20	293.11	287.74	50.91	45.54	5.37
8535	0.46	247.54	294.12	288.78	46.58	41.24	5.34
8545	0.53	242.54	292.84	296.99	50.30	54.45	-4.15
9515	0.52	226.21	270.04	272.50	43.83	46.29	-2.46
9525	0.47	229.54	272.27	268.71	42.73	39.17	3.56
AVERAGE					47.28	46.24	1.05
STD.DEV.					3.15	5.21	3.84
<u>No. 3 CWRS</u>							
8517	0.52	234.13	285.56	288.37	51.43	54.24	-2.81
8527	0.48	231.46	281.18	278.52	49.72	47.06	2.66
8537	0.48	236.80	289.05	286.26	52.25	49.46	2.79
8547	0.51	231.96	282.66	284.04	50.70	52.08	-1.38
9517	0.52	215.47	258.67	261.10	43.20	45.63	-2.43
9527	0.49	218.63	260.22	259.03	41.59	40.40	1.19
9537	0.51	227.80	275.61	276.94	47.81	49.14	-1.33
9547	0.49	219.30	264.91	263.68	45.61	44.38	1.23
AVERAGE					47.79	47.80	-0.01
STD.DEV.					3.70	4.12	2.10

*Explanation in Section 6.5.
Source: Spreadsheet calculations.

APPENDIX A.6 1985/86 PRICING ADJUSTMENTS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING CORRECTED	DIFFERENCE LESS
		percent		dollars per tonne			
No. 1 (14.5) CWRS							
8611	0.47	241.32	281.84	278.82	40.52	37.50	3.02
8621	0.46	265.91	318.04	313.27	52.13	47.36	4.77
8631	0.46	266.58	320.46	315.68	53.88	49.10	4.78
8641	0.48	227.58	268.68	266.82	41.10	39.24	1.86
9611	0.47	237.92	276.92	273.98	39.00	36.06	2.94
9621	0.48	271.54	319.32	316.93	47.78	45.39	2.39
9631	0.48	266.25	311.39	309.10	45.14	42.85	2.29
9641	0.48	243.91	283.94	281.92	40.03	38.01	2.02
AVERAGE					44.95	41.94	3.01
STD.DEV					5.40	4.62	1.09
No. 1 (13.5) CWRS							
8612	0.46	237.66	278.73	274.79	41.07	37.13	3.94
8622	0.47	262.33	312.55	309.10	50.22	46.77	3.45
8632	0.46	263.00	314.83	310.23	51.83	47.23	4.60
8642	0.45	224.00	264.66	260.19	40.66	36.19	4.47
9612	0.46	234.65	274.64	270.77	39.99	36.12	3.87
9622	0.46	268.33	318.83	314.11	50.50	45.78	4.72
9632	0.48	263.00	313.25	310.92	50.25	47.92	2.33
9642	0.47	240.66	287.97	284.89	47.31	44.23	3.08
AVERAGE					46.48	42.67	3.81
STD.DEV					4.73	4.91	0.77

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (12.5) CWRS							
8613	0.47	234.00	272.86	269.99	38.86	35.99	2.87
8623	0.45	259.66	305.89	300.48	46.23	40.82	5.41
8633	0.46	259.00	308.86	304.40	49.86	45.40	4.46
8643	0.45	220.00	258.49	254.19	38.49	34.19	4.30
9613	0.47	231.67	271.84	268.97	40.17	37.30	2.87
9623	0.46	265.00	319.69	314.96	54.69	49.96	4.73
9633	0.48	259.66	313.62	311.29	53.96	51.63	2.33
AVERAGE					46.04	42.18	3.85
STD.DEV					6.49	6.41	1.07
No 2 (13.5) CWRS							
8614	0.46	231.87	276.82	271.91	44.95	40.04	4.91
8624	0.46	256.54	310.81	305.07	54.27	48.53	5.74
8634	0.45	257.21	312.08	304.90	54.87	47.69	7.18
8644	0.46	218.21	259.35	254.93	41.14	36.72	4.42
9614	0.47	227.88	269.33	265.73	41.45	37.85	3.60
9624	0.48	262.54	313.79	310.90	51.25	48.36	2.89
9634	0.49	257.21	310.11	308.67	52.90	51.46	1.44
9644	0.50	234.87	280.55	280.55	45.68	45.68	0.00
AVERAGE					48.31	44.54	3.77
STD.DEV					5.30	5.19	2.17

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 2 (12.5) CWRS							
8615	0.48	228.21	272.31	269.89	44.10	41.68	2.42
8625	0.46	253.87	305.30	299.75	51.43	45.88	5.55
8635	0.45	253.21	306.62	299.63	53.41	46.42	6.99
8645	0.45	214.21	253.31	248.01	39.10	33.80	5.30
9615	0.47	225.38	273.50	269.81	48.12	44.43	3.69
9625	0.50	259.21	312.23	312.23	53.02	53.02	0.00
9635	0.47	253.87	306.88	302.64	53.01	48.77	4.24
9645	0.49	231.54	277.80	276.55	46.26	45.01	1.25
AVERAGE					48.56	44.88	3.68
STD.DEV					4.83	5.22	2.19
No. 3 CWRS							
8617	0.50	222.04	269.75	269.75	47.71	47.71	0.00
8627	0.48	247.20	301.24	298.32	54.04	51.12	2.92
8637	0.48	247.21	303.42	300.45	56.21	53.24	2.97
8647	0.49	208.21	249.43	248.31	41.22	40.10	1.12
9617	0.48	219.38	265.45	262.99	46.07	43.61	2.46
9627	0.49	252.88	306.35	304.86	53.47	51.98	1.49
9637	0.46	247.34	302.19	296.40	54.85	49.06	5.79
9647	0.47	224.21	270.35	266.62	46.14	42.41	3.73
AVERAGE					49.96	47.40	2.56
STD.DEV					5.04	4.53	1.65

Explanation in Sections 6.5.
Source: Spreadsheet calculations.

APPENDIX A.7 1986/87 PRICING ADJUSTMENTS

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (14.5) CWRS							
9711	0.47	198.83	228.07	225.87	29.24	27.04	2.20
9721	0.47	190.17	219.28	217.18	29.11	27.01	2.10
AVERAGE					29.18	27.03	2.15
STD.DEV					0.07	0.02	0.05
No. 1 (13.5) CWRS							
8712	0.46	201.67	234.17	231.17	32.50	29.50	3.00
8722	0.46	202.00	233.27	230.25	31.27	28.25	3.02
9712	0.47	186.66	217.47	215.43	30.81	28.77	2.04
9722	0.47	187.00	217.13	215.07	30.13	28.07	2.06
AVERAGE					31.18	28.65	2.53
STD.DEV					0.86	0.56	0.48

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 1 (12.5) CWRS							
8713	0.46	197.67	228.49	225.59	30.82	27.92	2.90
8723	0.48	198.67	228.51	227.04	29.84	28.37	1.47
9713	0.48	183.66	213.05	211.73	29.39	28.07	1.32
9723	0.47	183.33	211.94	209.97	28.61	26.64	1.97
AVERAGE					29.67	27.75	1.92
STD.DEV					0.80	0.66	0.62
No 2 (13.5) CWRS							
8714	0.46	195.88	230.14	226.43	34.26	30.55	3.71
8724	0.47	196.21	231.08	228.23	34.87	32.02	2.85
9714	0.48	180.87	209.54	207.92	28.67	27.05	1.62
9724	0.48	181.21	211.66	210.01	30.45	28.80	1.65
AVERAGE					32.06	29.61	2.46
STD.DEV					2.59	1.86	0.88

WHEAT NO.	ASH	SELLING PRICE	FLOUR COST UNCORR*	ADJUSTED* FLOUR COST	SELLING LESS UNCORR	SELLING LESS CORRECTED	DIFFERENCE
	percent			dollars per tonne			
No. 2 (12.5) CWRS							
8715	0.46	191.67	223.91	220.37	32.24	28.70	3.54
8725	0.52	192.88	226.72	228.61	33.84	35.73	-1.89
9715	0.48	177.87	206.99	205.41	29.12	27.54	1.58
9725	0.49	177.54	207.21	206.40	29.67	28.86	0.81
AVERAGE					31.22	30.21	1.01
STD.DEV					1.92	3.23	1.95
No. 3 CWRS							
8717	0.50	179.82	211.48	211.48	31.66	31.66	0.00
8727	0.48	180.55	214.70	212.90	34.15	32.35	1.80
9717	0.48	165.37	192.18	190.71	26.81	25.34	1.47
9727	0.46	165.38	193.14	190.18	27.76	24.80	2.96
AVERAGE					30.10	28.54	1.56
STD.DEV					2.96	3.48	1.06

*Explanation in Sections 6.5.
Source: Spreadsheet calculations.

Appendix B.1 **No.1 CWRS (14.5) Price Differences**

WESTERN PORTS

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8121	0.43	281.17	335.11	326.41	53.94	45.24	8.70
8131	0.43	276.83	330.22	321.66	53.39	44.83	8.56
8141	0.45	270.50	323.69	317.68	53.19	47.18	6.01
8211	0.46	252.74	298.27	291.85	45.53	39.11	6.42
8221	0.45	240.74	281.64	272.84	40.90	32.10	8.80
8231	0.44	245.07	286.06	280.01	40.99	34.94	6.05
8241	0.47	244.41	285.38	280.34	40.97	35.93	5.04
8311	0.48	238.33	277.92	275.96	39.59	37.63	1.96
8331	0.46	239.00	280.15	276.22	41.15	37.22	3.93
8421	0.47	237.07	276.73	273.77	39.66	36.70	2.96
8431	0.49	247.07	285.67	284.64	38.60	37.57	1.03
8441	0.51	257.74	302.36	303.49	44.62	45.75	-1.13
8511	0.48	254.58	296.46	294.30	41.88	39.72	2.16
8521	0.45	251.58	297.06	291.63	45.48	40.05	5.43
8531	0.45	256.91	302.34	296.84	45.43	39.93	5.50
8541	0.49	252.24	296.38	295.29	44.14	43.05	1.09
8611	0.47	241.32	281.84	278.82	40.52	37.50	3.02
8621	0.46	265.91	318.04	313.27	52.13	47.36	4.77
8631	0.46	266.58	320.46	315.68	53.88	49.10	4.78
8641	0.48	227.58	268.68	266.82	41.10	39.24	1.86
AVERAGE	0.46	252.37	297.22	292.88	44.85	40.51	4.35
STD.DEV	0.02	13.83	18.75	17.66	5.27	4.58	2.66

Appendix B-1 No.1 CWRS (14.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	EASTERN PORTS CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B - C)
		percent				dollars per tonne	
9121	0.43	289.26	347.88	338.71	58.62	49.45	9.17
9131	0.43	269.93	321.36	313.11	51.43	43.18	8.25
9141	0.44	256.59	304.02	297.44	47.43	40.85	6 .58
9211	0.44	247.50	291.09	280.98	43.59	33.48	10.11
9221	0.44	246.33	287.19	281.04	40.86	34.71	6.15
9231	0.46	232.16	269.43	265.71	37.27	33.55	3.72
9241	0.46	230.16	268.06	260.79	37.90	30.63	7.27
9311	0.44	226.33	265.49	260.00	39.16	33.67	5.49
9321	0.46	232.33	273.28	269.45	40.95	37.12	3.83
9331	0.43	235.00	276.15	269.46	41.15	34.46	6.69
9341	0.49	234.66	276.95	275.97	42.29	41.31	0.98
9411	0.50	238.50	279.53	279.53	41.03	41.03	0.00
9421	0.47	240.50	283.47	280.40	42.97	39.90	3.07
9431	0.47	245.50	288.42	285.30	42.92	39.80	3.12
9441	0.51	244.83	289.45	290.53	44.62	45.70	-1.08
9511	0.50	235.33	273.71	273.71	38.38	38.38	0.00
9521	0.47	238.33	277.09	274.15	38.76	35.82	2.94
9531	0.49	247.66	288.36	287.32	40.70	39.66	1.04
9541	0.49	239.33	278.44	277.44	39.11	38.11	1.00

Appendix B-1 No.1 CWRS (14.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
9611	0.47	237.92	276.92	273.98	39.00	36.06	2.94
9621	0.48	271.54	319.32	316.93	47.78	45.39	2.39
9631	0.48	266.25	311.39	309.10	45.14	42.85	2.29
9641	0.48	243.91	283.94	281.92	40.03	38.01	2.02
9711	0.47	198.83	228.07	225.87	29.24	27.04	2.20
9721	0.47	190.17	219.28	217.18	29.11	27.01	2.10
AVERAGE	0.47	241.55	283.13	268.66	41.58	37.89	3.69
STD.DEV	0.02	20.11	25.76	60.18	5.90	5.37	2.94

Source: Spreadsheet calculations.

Appendix B.2 No.1 CWRS (13.5) Price Differences

WESTERN PORTS

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8112	0.44	269.00	320.01	312.96	51.01	43.96	7.05
8122	0.43	282.00	336.99	328.23	54.99	46.23	8.76
8132	0.42	273.66	326.88	317.27	53.22	43.61	9.61
8142	0.45	267.33	318.82	312.92	51.49	45.59	5.90
8212	0.45	249.33	293.06	285.81	43.73	36.48	7.25
8222	0.46	237.33	277.64	269.93	40.31	32.60	7.71
8232	0.46	241.66	281.66	277.67	40.00	36.01	3.99
8242	0.47	241.00	280.27	275.37	39.27	34.37	4.90
8312	0.48	234.66	273.19	271.27	38.53	36.61	1.92
8322	0.44	230.33	270.29	264.69	39.96	34.36	5.60
8332	0.47	235.33	275.57	272.66	40.24	37.33	2.91
8342	0.47	238.00	277.32	274.42	39.32	36.42	2.90
8412	0.49	241.66	281.61	280.61	39.95	38.95	1.00
8422	0.46	235.66	274.90	271.03	39.24	35.37	3.87
8432	0.48	243.66	286.86	284.78	43.20	41.12	2.08
8442	0.51	254.33	296.32	297.41	41.99	43.08	-1.09
8512	0.49	251.00	292.82	291.75	41.82	40.75	1.07
8522	0.47	248.00	288.20	285.12	40.20	37.12	3.08
8532	0.46	253.33	299.97	295.57	46.64	42.24	4.40

Appendix B-2 No.1 CWRS (13.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8542	0.49	248.66	293.47	292.39	44.81	43.73	1.08
8612	0.46	237.66	278.73	274.79	41.07	37.13	3.94
8622	0.47	262.33	312.55	309.10	50.22	46.77	3.45
8632	0.46	263.00	314.83	310.23	51.83	47.23	4.60
8642	0.45	224.00	264.66	260.19	40.66	36.19	4.47
8712	0.46	201.67	234.17	231.17	32.50	29.50	3.00
8722	0.46	202.00	233.27	230.25	31.27	28.25	3.02
AVERAGE	0.46	244.87	287.85	283.75	42.98	38.88	4.10
STD.DEV	0.02	18.60	24.22	23.27	5.89	5.09	2.49
				EASTERN PORTS			
9112	0.44	255.67	305.09	298.43	49.42	42.76	6.66
9122	0.43	286.00	343.46	334.41	57.46	48.41	9.05
9132	0.44	266.67	316.94	309.98	50.27	43.31	6.96
9142	0.44	253.33	299.93	293.47	46.60	40.14	6.46
9212	0.45	244.00	287.70	278.70	43.70	34.70	9.00
9222	0.45	243.33	285.97	280.89	42.64	37.56	5.08
9232	0.46	228.66	266.24	260.80	37.58	32.14	5.44
9242	0.46	226.66	264.03	256.92	37.37	30.26	7.11
9312	0.45	222.00	261.23	256.74	39.23	34.74	4.49

Appendix B-2 No.1 CWRS (13.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
9322	0.45	228.00	267.81	263.19	39.81	35.19	4.62
9332	0.47	230.67	270.81	267.98	40.14	37.31	2.83
9342	0.49	230.33	270.14	269.19	39.81	38.86	0.95
9412	0.49	235.00	275.23	274.26	40.23	39.26	0.97
9422	0.47	237.00	278.67	275.70	41.67	38.70	2.97
9432	0.46	242.00	286.46	282.33	44.46	40.33	4.13
9442	0.52	241.33	286.01	288.14	44.68	46.81	-2.13
9512	0.52	232.00	270.07	271.99	38.07	39.99	-1.92
9522	0.50	235.00	270.18	270.18	35.18	35.18	0.00
9532	0.51	244.33	285.28	286.32	40.95	41.99	-1.04
9542	0.50	236.00	275.24	275.24	39.24	39.24	0.00
9612	0.46	234.65	274.64	270.77	39.99	36.12	3.87
9622	0.46	268.33	318.83	314.11	50.50	45.78	4.72
9632	0.48	263.00	313.25	310.92	50.25	47.92	2.33
9642	0.47	240.66	287.97	284.89	47.31	44.23	3.08
9712	0.47	186.66	217.47	215.43	30.81	28.77	2.04
9722	0.47	187.00	217.13	215.07	30.13	28.07	2.06
AVERAGE	0.47	238.40	280.61	277.16	42.21	38.76	3.45
STD.DEV	0.02	20.89	26.71	25.66	6.12	5.45	3.04

Source: Spreadsheet calculations.

Appendix B.3 No.1 CWRS (12.5) Price Differences

WESTERN PORTS

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8113	0.45	265.33	319.40	313.46	54.07	48.13	5.94
8123	0.45	277.00	329.11	322.99	52.11	45.99	6.12
8133	0.44	270.00	322.82	315.64	52.82	45.64	7.18
8143	0.45	266.00	317.81	311.94	51.81	45.94	5.87
8213	0.47	245.66	289.66	282.50	44.00	36.84	7.16
8223	0.46	234.00	273.05	265.52	39.05	31.52	7.53
8233	0.46	238.33	276.08	272.19	37.75	33.86	3.89
8243	0.49	237.66	276.06	271.25	38.40	33.59	4.81
8313	0.48	231.66	268.47	266.60	36.81	34.94	1.87
8323	0.47	227.00	267.35	264.54	40.35	37.54	2.81
8333	0.49	230.33	270.82	269.86	40.49	39.53	0.96
8343	0.50	240.00	281.50	281.50	41.50	41.50	0.00
8413	0.48	238.66	278.58	276.63	39.92	37.97	1.95
8423	0.48	232.33	272.60	270.67	40.27	38.34	1.93
8433	0.51	240.00	281.61	282.63	41.61	42.63	-1.02
8443	0.53	250.66	295.16	298.43	44.50	47.77	-3.27
8513	0.50	247.00	290.06	290.06	43.06	43.06	0.00
8543	0.52	245.00	289.21	291.35	44.21	46.35	-2.14
8613	0.47	234.00	272.86	269.99	38.86	35.99	2.87
8623	0.45	259.66	305.89	300.48	46.23	40.82	5.41
8633	0.46	259.00	308.86	304.40	49.86	45.40	4.46
8643	0.45	220.00	258.49	254.19	38.49	34.19	4.30

Appendix B-3 No.1 CWRS (12.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8713	0.46	197.67	228.49	225.59	30.82	27.92	2.90
8723	0.48	198.67	228.51	227.04	29.84	28.37	1.47
AVERAGE	0.48	241.07	283.44	280.39	42.37	39.33	3.04
STD.DEV	0.02	19.26	25.24	24.45	6.22	5.91	2.93
			EASTERN PORTS				
9113	0.46	252.33	299.97	295.61	47.64	43.28	4.36
9123	0.46	282.33	341.73	336.48	59.40	54.15	5.25
9133	0.45	263.66	309.95	304.35	46.29	40.69	5.60
9213	0.47	241.00	283.94	277.01	42.94	36.01	6.93
9223	0.46	240.00	284.86	280.76	44.86	40.76	4.10
9233	0.47	224.67	260.59	256.16	35.92	31.49	4.43
9243	0.48	223.00	260.59	255.30	37.59	32.30	5.29
9313	0.46	217.67	254.47	251.02	36.80	33.35	3.45
9323	0.46	225.00	264.71	261.06	39.71	36.06	3.65
9333	0.48	224.67	263.25	261.44	38.58	36.77	1.81
9343	0.50	226.33	265.37	265.37	39.04	39.04	0.00
9413	0.49	231.67	272.01	271.05	40.34	39.38	0.96
9423	0.48	233.67	275.43	273.47	41.76	39.80	1.96
9443	0.53	238.00	282.24	285.37	44.24	47.37	-3.13
9513	0.53	228.67	266.43	269.27	37.76	40.60	-2.84
9543	0.50	232.33	269.82	269.82	37.49	37.49	0.00

Appendix B-3 No.1 CWRS (12.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
9613	0.47	231.67	271.84	268.97	40.17	37.30	2.87
9623	0.46	265.00	319.69	314.96	54.69	49.96	4.73
9633	0.48	259.66	313.62	311.29	53.96	51.63	2.33
9713	0.48	183.66	213.05	211.73	29.39	28.07	1.32
9723	0.47	183.33	211.94	209.97	28.61	26.64	1.97
AVERAGE	0.48	233.73	275.50	272.88	41.77	39.15	2.62
STD.DEV	0.02	23.01	30.17	29.41	7.44	7.04	2.57

Source: Spreadsheet calculations.

Appendix B.4 No.2 CWRS (13.5) Price Differences

WESTERN PORTS

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8214	0.48	246.74	294.15	286.19	47.41	39.45	7.96
8224	0.47	234.74	277.69	269.19	42.95	34.45	8.50
8234	0.49	238.07	279.35	278.09	41.28	40.02	1.26
8244	0.49	238.41	279.07	272.96	40.66	34.55	6.11
8314	0.49	229.71	270.68	269.46	40.97	39.75	1.22
8324	0.46	225.38	267.26	262.57	41.88	37.19	4.69
8334	0.49	230.38	274.19	272.96	43.81	42.58	1.23
8344	0.50	233.05	274.72	274.72	41.67	41.67	0.00
8414	0.49	237.91	281.30	280.04	43.39	42.13	1.26
8424	0.46	231.91	277.60	272.61	45.69	40.70	4.99
8434	0.48	239.91	290.20	287.51	50.29	47.60	2.69
8444	0.48	250.58	301.61	298.81	51.03	48.23	2.80
8514	0.49	248.54	298.58	297.18	50.04	48.64	1.40
8524	0.45	245.54	294.05	287.38	48.51	41.84	6.67
8534	0.47	250.87	300.12	295.96	49.25	45.09	4.16
8544	0.49	246.20	293.24	291.88	47.04	45.68	1.36
8614	0.46	231.87	276.82	271.91	44.95	40.04	4.91
8624	0.46	256.54	310.81	305.07	54.27	48.53	5.74
8634	0.45	257.21	312.08	304.90	54.87	47.69	7.18
8644	0.46	218.21	259.35	254.93	41.14	36.72	4.42

Appendix B-4 **No.2 CWRS (13.5) Price Differences**
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8714	0.46	195.88	230.14	226.43	34.26	30.55	3.71
8724	0.47	196.21	231.08	228.23	34.87	32.02	2.85
AVERAGE	0.47	235.63	280.64	276.77	45.01	41.14	3.87
STD.DEV	0.01	15.86	20.78	20.42	5.33	5.27	2.41
			EASTERN PORTS				
9114	0.46	251.50	302.38	296.79	50.88	45.29	5.59
9124	0.43	281.83	344.27	332.78	62.44	50.95	11.49
9134	0.45	262.50	313.27	306.08	50.77	43.58	7.19
9144	0.46	249.16	296.90	292.81	47.74	43.65	4.09
9214	0.49	241.41	287.99	281.55	46.58	40.14	6.44
9224	0.47	240.74	284.79	280.95	44.05	40.21	3.84
9234	0.47	226.07	265.91	257.96	39.84	31.89	7.95
9244	0.48	224.07	263.66	256.89	39.59	32.82	6.77
9314	0.48	217.05	256.37	254.14	39.32	37.09	2.23
9324	0.46	223.05	264.98	260.36	41.93	37.31	4.62
9334	0.48	225.72	269.32	266.93	43.60	41.21	2.39
9344	0.51	225.38	265.96	267.14	40.58	41.76	-1.18
9414	0.50	231.34	275.79	275.79	44.45	44.45	0.00
9424	0.48	233.65	278.28	275.76	44.63	42.11	2.52
9434	0.46	238.25	287.04	281.78	48.79	43.53	5.26
9444	0.49	237.58	286.68	285.34	49.10	47.76	1.34

Appendix B-4 **No.2 CWRS (13.5) Price Differences**
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
9514	0.53	229.54	272.15	275.92	42.61	46.38	-3.77
9524	0.48	241.84	286.13	283.53	44.29	41.69	2.60
9614	0.47	227.88	269.33	265.73	41.45	37.85	3.60
9624	0.48	262.54	313.79	310.90	51.25	48.36	2.89
9634	0.49	257.21	310.11	308.67	52.90	51.46	1.44
9644	0.50	234.87	280.55	280.55	45.68	45.68	0.00
9714	0.48	180.87	209.54	207.92	28.67	27.05	1.62
AVERAGE	0.48	236.70	281.96	278.53	45.27	41.84	3.43
STD.DEV	0.02	19.52	25.66	24.50	6.35	5.91	3.2

Source: Spreadsheet Calculations.

Appendix B.5 No.2 CWRS (12.5) Price Differences

WESTERN PORTS

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8115	0.46	261.33	316.29	310.37	54.96	49.04	5.92
8125	0.44	272.83	330.12	320.83	57.29	48.00	9.29
8135	0.45	265.83	322.21	314.62	56.38	48.79	7.59
8145	0.46	261.83	313.18	307.39	51.35	45.56	5.79
8215	0.47	243.07	288.51	279.60	45.44	36.53	8.91
8225	0.48	231.46	272.59	270.16	41.13	38.70	2.43
8235	0.48	235.74	274.57	272.14	38.83	36.40	2.43
8245	0.48	235.07	274.23	267.13	39.16	32.06	7.10
8315	0.49	226.71	267.14	265.95	40.43	39.24	1.19
8325	0.47	222.05	263.35	259.88	41.30	37.83	3.47
8335	0.50	225.38	266.61	266.61	41.23	41.23	0.00
8345	0.51	229.05	270.10	271.31	41.05	42.26	-1.21
8415	0.50	234.91	278.67	278.67	43.76	43.76	0.00
8425	0.48	228.58	273.39	270.94	44.81	42.36	2.45
8435	0.50	236.25	282.08	282.08	45.83	45.83	0.00
8445	0.51	246.91	297.94	299.35	51.03	52.44	-1.41
8515	0.51	244.54	293.89	295.27	49.35	50.73	-1.38
8525	0.46	242.20	293.11	287.74	50.91	45.54	5.37
8535	0.46	247.54	294.12	288.78	46.58	41.24	5.34
8545	0.53	242.54	292.84	296.99	50.30	54.45	-4.15

Appendix B-5 No.2 CWRS (12.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8615	0.48	228.21	272.31	269.89	44.10	41.68	2.42
8625	0.46	253.87	305.30	299.75	51.43	45.88	5.55
8635	0.45	253.21	306.62	299.63	53.41	46.42	6.99
8645	0.45	214.21	253.31	248.01	39.10	33.80	5.30
8715	0.46	191.67	223.91	220.37	32.24	28.70	3.54
8725	0.52	192.88	226.72	228.61	33.84	35.73	-1.89
AVERAGE	0.48	237.23	282.81	279.70	45.59	42.47	3.12
STD.DEV	0.02	19.08	25.28	23.97	6.57	6.28	3.57
				EASTERN PORTS			
9115	0.45	248.16	300.44	293.52	52.28	45.36	6.92
9215	0.48	238.41	287.02	284.38	48.61	45.97	2.64
9245	0.48	220.41	258.32	251.79	37.91	31.38	6.53
9325	0.47	220.05	260.77	257.38	40.72	37.33	3.39
9335	0.47	219.72	256.97	253.67	37.25	33.95	3.30
9345	0.52	221.38	260.91	263.22	39.53	41.84	-2.31
9415	0.50	227.92	271.34	271.34	43.42	43.42	0.00
9445	0.51	234.25	281.80	283.10	47.55	48.85	-1.30
9515	0.52	226.21	270.04	272.50	43.83	46.29	-2.46
9525	0.47	229.54	272.27	268.71	42.73	39.17	3.56
9615	0.47	225.38	273.50	269.81	48.12	44.43	3.69

Appendix B-5 No.2 CWRS (12.5) Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
9625	0.50	259.21	312.23	312.23	53.02	53.02	0.00
9635	0.47	253.87	306.88	302.64	53.01	48.77	4.24
9645	0.49	231.54	277.80	276.55	46.26	45.01	1.25
9715	0.48	177.87	206.99	205.41	29.12	27.54	1.58
9725	0.49	177.54	207.21	206.40	29.67	28.86	0.81
AVERAGE	0.49	225.72	269.03	267.04	43.31	41.32	1.99
STD.DEV	0.02	21.55	28.45	28.19	7.17	7.33	2.72

Source: Spreadsheet calculations.

Appendix B.6 No.3 CWRS Price Differences

WESTERN PORTS

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8117	0.49	254.47	312.50	310.93	58.03	56.46	1.57
8127	0.47	266.30	327.76	322.81	61.46	56.51	4.95
8137	0.47	259.13	320.13	315.30	61.00	56.17	4.83
8147	0.47	235.97	287.16	283.02	51.19	47.05	4.14
8217	0.50	235.63	284.04	278.69	48.41	43.06	5.35
8227	0.47	223.81	265.67	262.03	41.86	38.22	3.64
8237	0.50	228.14	268.95	268.95	40.81	40.81	0.00
8247	0.51	227.47	268.75	265.05	41.28	37.58	3.70
8317	0.50	221.20	262.09	262.09	40.89	40.89	0.00
8327	0.49	216.17	260.88	259.66	44.71	43.49	1.22
8337	0.54	220.87	267.07	272.26	46.20	51.39	-5.19
8347	0.54	224.04	270.79	276.06	46.75	52.02	-5.27
8417	0.52	224.74	270.60	273.19	45.86	48.45	-2.59
8427	0.49	218.58	266.97	265.70	48.39	47.12	1.27
8437	0.49	257.74	318.07	316.47	60.33	58.73	1.60
8447	0.52	237.08	290.07	292.95	52.99	55.87	-2.88
8517	0.52	234.13	285.56	288.37	51.43	54.24	-2.81
8527	0.48	231.46	281.18	278.52	49.72	47.06	2.66
8537	0.48	236.80	289.05	286.26	52.25	49.46	2.79
8547	0.51	231.96	282.66	284.04	50.70	52.08	-1.38

Appendix B-6 No.3 CWRS Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
8617	0.50	222.04	269.75	269.75	47.71	47.71	0.00
8627	0.48	247.20	301.24	298.32	54.04	51.12	2.92
8637	0.48	247.21	303.42	300.45	56.21	53.24	2.97
8647	0.49	208.21	249.43	248.31	41.22	40.10	1.12
8717	0.50	179.82	211.48	211.48	31.66	31.66	0.00
8727	0.48	180.55	214.70	212.90	34.15	32.35	1.80
AVERAGE	0.50	229.64	278.08	277.06	48.43	47.42	1.02
STD.DEV	0.02	20.01	27.20	26.48	7.56	7.42	2.90
				EASTERN PORTS			
9117	0.48	241.30	297.98	295.02	56.68	53.72	2.96
9127	0.45	271.47	337.95	329.41	66.48	57.94	8.54
9137	0.46	252.47	310.14	304.07	57.67	51.60	6.07
9147	0.48	239.13	297.92	289.83	58.79	50.70	8.09
9217	0.49	230.64	277.09	275.78	46.45	45.14	1.31
9227	0.46	229.81	276.01	270.87	46.20	41.06	5.14
9237	0.47	214.81	254.22	246.42	39.41	31.61	7.80
9247	0.49	212.97	251.99	246.43	39.02	33.46	5.56
9317	0.49	207.88	267.17	265.93	59.29	58.05	1.24
9327	0.48	214.50	257.03	254.67	42.53	40.17	2.36

Appendix B-6 No.3 CWRS Price Differences
(continued)

WHEAT NUMBER	ASH CONTENT	WHEAT SELLING PRICE A	UNCORR FLOUR COST B	CORR FLOUR COST C	PRICE LESS UNCORR FL. COST (B-A)	PRICE LESS CORRECT FL.COST (C-A)	COST DIFFER (B-C)
	percent			dollars per tonne			
9337	0.52	215.71	259.11	261.57	43.40	45.86	-2.46
9347	0.53	216.37	261.39	265.16	45.02	48.79	-3.77
9417	0.52	217.92	261.01	263.46	43.09	45.54	-2.45
9427	0.48	219.92	267.49	264.97	47.57	45.05	2.52
9437	0.48	224.58	271.93	269.38	47.35	44.80	2.55
9447	0.51	224.25	270.98	272.27	46.73	48.02	-1.29
9517	0.52	215.47	258.67	261.10	43.20	45.63	-2.43
9527	0.49	218.63	260.22	259.03	41.59	40.40	1.19
9537	0.51	227.80	275.61	276.94	47.81	49.14	-1.33
9547	0.49	219.30	264.91	263.68	45.61	44.38	1.23
9617	0.48	219.38	265.45	262.99	46.07	43.61	2.46
9627	0.49	252.88	306.35	304.86	53.47	51.98	1.49
9637	0.46	247.34	302.19	296.40	54.85	49.06	5.79
9647	0.47	224.21	270.35	266.62	46.14	42.41	3.73
9717	0.48	165.37	192.18	190.71	26.81	25.34	1.47
9727	0.46	165.38	193.14	190.18	27.76	24.80	2.96
AVERAGE	0.49	222.67	269.56	267.22	46.88	44.55	2.34
STD.DEV	0.02	22.17	30.08	29.08	8.73	8.25	3.32

Source: Spreadsheet calculations.