Agricultural Economics Report No. 374 April 1997

Factors Affecting the Supply of Quality Characteristics in Spring Wheats: Comparisons Between the United States and Canada

Bruce L. Dahl
William W. Wilson

Department of Agricultural Economics • Agricultural Experiment Station
North Dakota State University • Fargo, ND 58105-5636

ACKNOWLEDGMENTS

This project was supported under USDA/CSRS Agreement No. 91-34192-6204 titled "Economic Growth via Exports of Northern Plains Agricultural Products," Agricultural Experiment Station, North Dakota State University, Fargo, and the North Dakota State Wheat Commission. Constructive comments were received from George Flaskerud, D. Demcey Johnson, Vidya Satanarayana and Charlene Lucken. Thanks also to Donna Adam, who helped in the preparation of this document. However, errors and omissions remain the responsibility of the authors.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURES (Continued)

ABSTRACT

The demand for high quality hard wheats has been increasing. In this paper, factors affecting the supply and consistency of high quality wheats in Canada and North Dakota were compared and contrasted. Differences exist in the development and release of new varieties which affect the number and quality of hard wheats produced. Variety numbers and concentration were examined with a range of measures. Wheat area in Canada was found to be concentrated in fewer varieties than in North Dakota. These results were more apparent for durum than for hard red spring wheats. However, there was a trend toward more concentration in North Dakota and less in Canada. Protein, yield, and trade-offs were compared. Alberta appears to have a comparative advantage in the production of higher protein wheats. Farmers there have less of a yield loss penalty for increasing protein, compared to other regions. Varietal selection models were developed to analyze factors affecting variety choice. In Canada, agronomic factors including, relative yields, were significant variables affecting variety choice. In North Dakota, agronomic factors other than years since release generally had less effect on adoption rates. Varieties in North Dakota and Manitoba were found to have shorter life cycles and reached their maximum utilization by farmers faster than in Alberta or Saskatchewan.

Key Words: Varieties, HRS, Supply, Protein, Yields, Variety Adoption, End-use Quality, Variety Release, United States and Canada.

HIGHLIGHTS

The increasing demand for quality wheat has focused attention on the factors affecting the supply and consistency of high quality wheats. Factors influencing the quality of wheat in Canada and the United States are affected by the types of varieties grown, their inherent quality, their adoption rates, the extent that intervarietal differences are blended within the marketing system, and agronomic practices and environment. Changes are also occurring in Canada and the United States that affect the types of varieties grown and the extent of their adoption. In this study, variety development and adoption were compared among North Dakota, Saskatchewan, Alberta, and Manitoba utilizing a number of measures. Second, protein/yield trade-offs were examined. Third, adoption of varieties based on end-use quality was examined. Fourth, varietal selection models were developed to identify factors important for determining adoption rates. Finally, proposed changes in policy were presented.

Overall comparisons of variety adoption among North Dakota, Saskatchewan, Alberta, and Manitoba indicated a number of things. First, the number of hard red spring (HRS) and durum wheat varieties grown in North Dakota is larger than in the Canadian Provinces. Second, in the Canadian Provinces, varieties grown have been concentrated in fewer varieties with larger shares of planted acres than in North Dakota. Third, varieties planted in Alberta and Saskatchewan have had a greater longevity than varieties planted in North Dakota and Manitoba. All of these factors suggest that the variability of end-use quality characteristics of HRS wheat and durum grown in Canada should be lower than for production in North Dakota. The extent and degree of lower variability also depends on other factors (end-use characteristics of individual varieties, the degree of intervarietal differences and the extent that they are blended throughout the marketing system, effects of environment on specific varieties, etc.). Fourth, the trend primarily in HRS wheat is toward fewer varieties grown. In the middle 1990s, there have been fewer varieties grown in North Dakota each with larger shares of planted acres. In contrast, growers in the Canadian Provinces are planting a greater number of varieties, spreading area over more varieties with smaller shares of planted acres. One possible explanation for the increased concentration for North Dakota is that few varieties released have disease resistance/tolerance for wheat scab/Vomitoxin, which was a significant problem in North Dakota in 1993-1995. Therefore, planted varieties with resistance/tolerance are adopted on more acres than normal.

Comparisons of yield/protein trade-offs indicated South Dakota, Alberta, Montana, and Saskatchewan have a comparative advantage over North Dakota and Minnesota in the production of higher protein wheats. Farmers in these regions give up less yield to increase protein.

Comparisons of variety adoption by end-use quality indicated that farmers in western North Dakota were more likely to plant varieties that have good end-use quality characteristics, and this trend has been increasing. Farmers in eastern North Dakota have tended to adopt varieties with average or poor (primarily in the middle 1980s) end-use quality; however, the trend has been toward increased production of average end-use quality varieties.

Proposed changes in policies affecting the quality of grains have been advanced. The changes proposed would tend to equalize both countries' market systems and variety controls.

FACTORS AFFECTING THE SUPPLY OF QUALITY CHARACTERISTICS IN SPRING WHEATS: COMPARISONS BETWEEN THE UNITED STATES AND CANADA

INTRODUCTION

During the late 1980s and 1990s, exports of higher quality hard wheats from the United States and Canada have been increasing. Dahl and Wilson (1996) found an increase in the value and share of higher quality hard wheat exports purchased, and hard wheat importers are becoming more differentiated. One of the driving forces in this trend is the privatization of many wheat purchasing organizations. In many countries, firms which had previously purchased wheat primarily through state agencies now purchase privately. This is fundamentally important because it allows importing firms to transmit desired quality characteristics more efficiently to exporting firms. In addition, as buyers become more discriminating, they become more concerned with the levels of specific quality factors and the consistency of quality. Many buyers of U.S. wheats have voiced concerns over the consistency of quality within shipments (Minnesota Wheat and Mercier p. 15). This increased demand for higher quality wheat has focused attention on factors influencing the supply and consistency of higher quality hard wheats.

Hard red spring wheat is a high quality hard wheat produced in the Northern Prairies of the United States (primarily North Dakota) and Canada. Agronomic conditions and practices are similar across these regions (Wilson, 1989). Supplies of high quality hard red wheat are affected by a number of factors, including environment, varieties planted, and intervarietal differences. Differences exist between the United States and Canada in how varieties are released and these affect the supply of high quality wheats from each country. The distribution of varieties within production areas is important because intervarietal differences can account for inconsistency in end-use performance.

In this paper, selected attributes of the supply and consistency of higher quality hard red spring wheats were examined. Particular focus was paid to differences in wheat variety adoption, variety distribution, and protein/yield tradeoffs between Canada and the United States. This paper is divided into six sections. First, factors affecting the supply of high quality hard wheats, including varietal development and release procedures, grades and standards, and incentive structures, are examined. Second, the number and distribution of varieties adopted are examined. Third, average characteristics for yields, protein, and yield/protein tradeoffs are contrasted. Fourth, adoption of varieties in North Dakota are compared, based on end-use quality ratings. Fifth, varietal selection models are developed to determine factors important for varietal adoption. Sixth, proposed changes in regulations affecting the supply of quality wheat are examined.

FACTORS AFFECTING SUPPLY AND CONSISTENCY OF WHEAT QUALITY

Important differences exist between the United States and Canada in variety development and release, grades and standards, and incentives. These differences have an impact on the number and quality of wheat varieties released, which in turn affect the quality and consistency of wheat produced. In this section, differences between Canada and the United States are reviewed for varietal development and release, specification of wheat classes and grades, and incentives.

Varietal Development and Release

Varietal development and release mechanisms differ between the United States and Canada. In Canada, varietal development and release is controlled by law. In the United States, varietal development and release is a less formal process. Variety release mechanisms are not regulated nationally or on a state basis, but are subject to intense examination from breeders and industry and are influenced to some extent by land grant universities. These differences have affected the development and release of varieties in Canada and the United States.

To put some of these issues of variety release in perspective, Figures 1-3 show actual and cumulative numbers of varieties released in Canada and North Dakota. Values for numbers of varieties released per year in North Dakota from 1974 to 1992 represent varieties released that were planted on more than 1 percent of wheat acres in any year throughout the period. However, the number of varieties released in 1993-1995 are actual numbers of varieties released regardless of adoption rates. This is one potential explanation for the large numbers of varieties observed in 1995. All Canadian numbers represent actual releases. The important point is that over time there have been more varieties released in North Dakota than Canada. From 1974 to 1995, twice as many varieties were released in North Dakota than for the Canadian provinces (Figure 3).

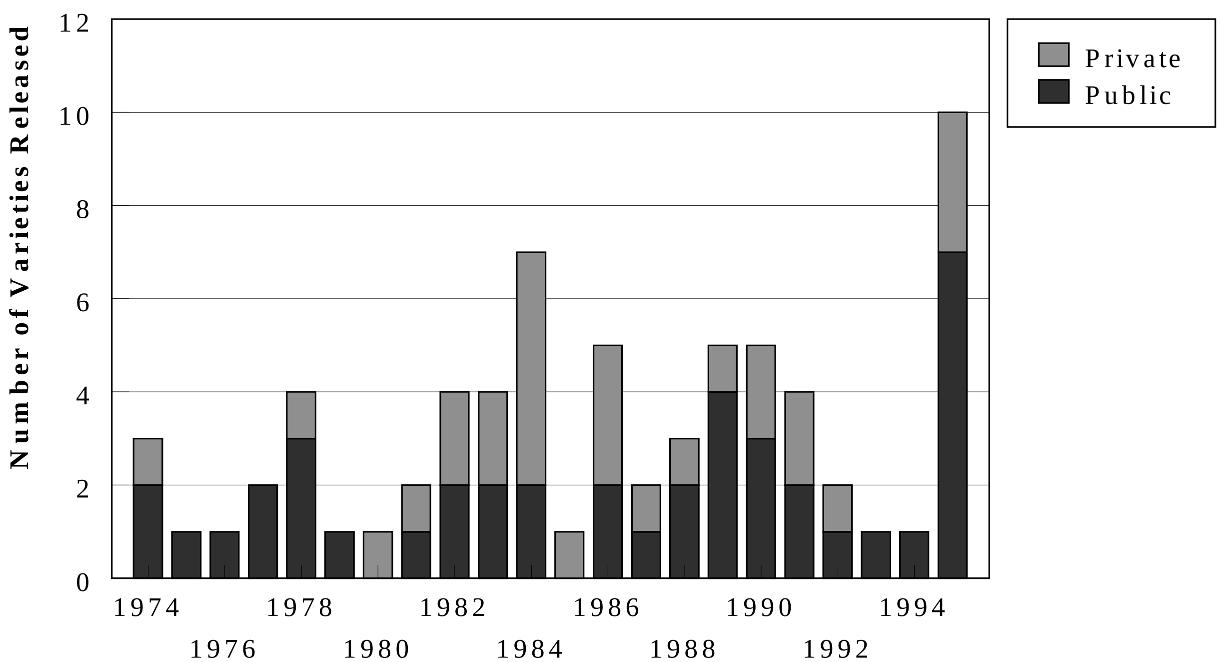

Figure 1. Number of Varieties Released for North Dakota Production, by Agency, 1974-1995.

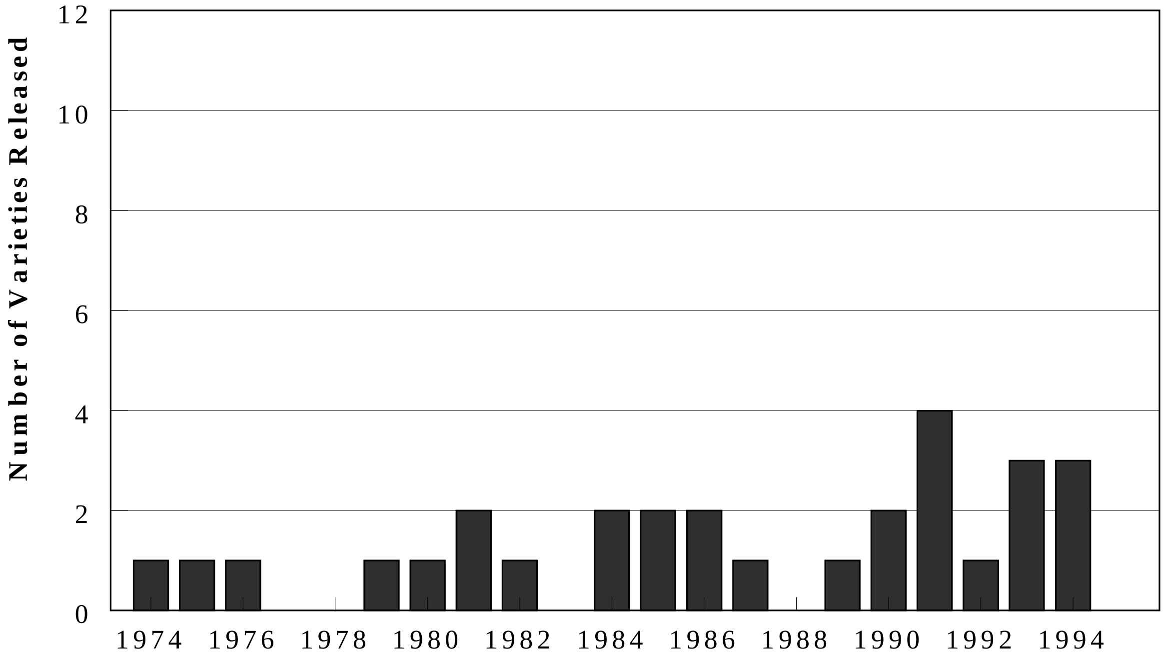

Figure 2. Number of Varieties Released for Canadian Production, 1974-1994.

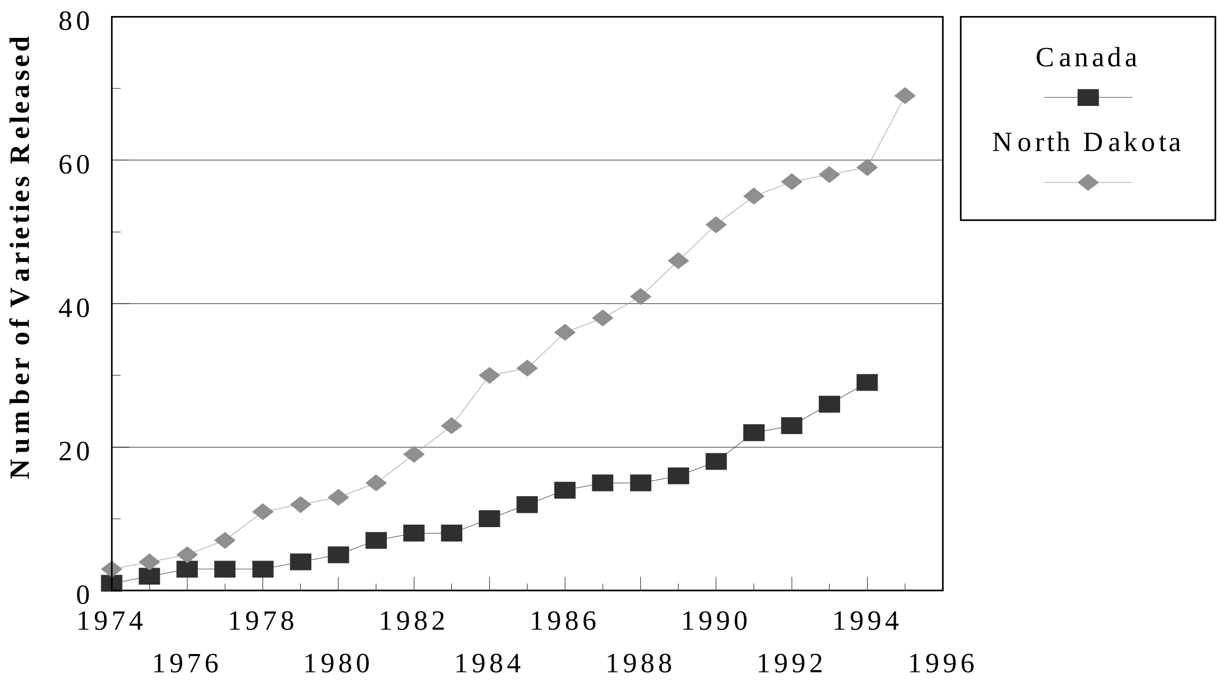

Figure 3. Cumulative Varieties Released, Canada and North Dakota, 1974-1995.

Development and Release Requirements in Canada

The Canada Grain Act and the Canada Seed Act are the basis for varietal control in western Canada. The objective of variety control is to provide a means to regulate quality for characteristics that are not easily measured in the market system. In Canada, varieties are registered by class and location. Thus, variety approval is essential in determining which class of wheat can be marketed. Varieties can have either a national or provincial registration. In addition, registered varieties of wheat of any class must be visually distinguishable from registered varieties of any other class of wheat. This requirement allows rapid recognition of wheat of specific classes throughout the grain handling system and allows segregation of wheat by class (Joint Commission P26-27). However, this requirement also imposes restrictions on new variety development which has resulted in lower numbers of varieties released. Use of this type of regulation also has the added benefit of reducing variability in end use (Wilson 1995).

In Canada, new varieties are registered after recommendations from a regional recommending committee. To be registered, varieties must be equal to or better than existing varieties within their class. Varieties are evaluated using four criteria: agronomic, disease resistance, end-use quality, and kernel visual distinguish ability (KVD). New varieties are evaluated in these four areas and may be rejected for failing in any of the four areas. Committees become involved in the registration process in the last three years of varietal development. An agronomic committee (plant breeding group) focuses on the development of new varieties with emphasis on agronomic characteristics. A disease resistance group evaluates the resistance of new varieties developed by the breeding group. The end-use quality group is involved in determining end-use quality and KVD of new varieties (Dexter, pp. 15-18; CWB and CGC).

Development and Release Requirements in the United States

In the United States, new varieties are developed and released from both public and private breeding programs. Public breeding programs receive guidance on release of new varieties from state agricultural experiment stations, who in turn base their recommendations on the national policy adopted by the Experiment Station Committee on Policy. This national policy provides guidance on release, and states may and do vary from it. Principles used to determine whether to release superior experimental genotypes are based on whether the candidate is better than a check or control variety on one or more agronomic or quality characteristic.

Private breeding programs are typically for profit operations with corporate funding. Release of varieties through private breeding programs are subject to decisions of breeders, administrators, and marketing departments. End-use characteristics are evaluated by the firm's lab, private or public agencies, or a cooperative facility.

In the United States, variety release and adoption is largely determined by the competitive pressures reflected in the market. Market incentives to farmers and breeders signal which factors are most important in advancement and release of new varieties. These incentives have in the past signaled advancement and release of higher yielding varieties that may or may not meet minimum standards for end-use characteristics. Market signals during the 1980s seldom rewarded farmers for production of varieties with excellent end-use characteristics (OTA, p. 106).

Major Differences Between the United States and Canada

Major differences exist between the way Canada and the United States develop and release varieties. In Canada varietal development and release is controlled by law. In the United States, varietal development and release is done by recommendation. In Canada, KVD is required for each class of wheat. Varieties in a class not meeting KVD can be rejected for registration even though they may have other desirable characteristics. In the United States, KVD is not considered. Another major difference is the way varieties are registered/released. In Canada, varieties can be released with a national registration and policies for release are consistent across the country. In the United States, policies vary both between private and public agencies as well as among agencies. Therefore, policies can differ from one area/state to another and the range of characteristics for varieties released can be larger. In addition, some varieties are developed and released for specific regions within states but are not restricted as to where they are grown or marketed.

Grades/Standards

In Canada, variety standards are included in official grade definitions for top grades of wheat. Only varieties equal to or superior in quality to the variety standards for a class of wheat are eligible to be registered for top milling grades. Unlicenced varieties are relegated to the lowest grade for the class (CWAD5 for durum and Canadian Feed for all other Canadian common wheat classes). In the case of Canadian Western Red Spring (CWRS), the standard variety is Neepawa, and for Canadian Western Amber Durum (CWAD), the standard variety is Hercules. These regulations introduce minimum end-use performance standards in addition to agronomic performance (CWB and CGC).

Protein segregations have become an important element in Canadian grading standards. Canada segregates grain meeting grade factor limits into different lots based on protein levels. Protein segregations were added for selected grades of wheat in 1980, 1988, 1994, 1995, and again for 1996/97. In 1980, a protein class of 13.5 percent or better CWRS was established for No. 1 CWRS. In 1988, the CWB introduced more payments for higher protein wheat with protein designations at .5 percent increments. Additional protein designations were added in 1994, 1995, and 1996. For 1996/97, there are protein designations for 12.0-15.0 percent by one-half percent for No. 1 CWRS and No. 2 CWRS; the only designation for No. 3 CWRS was for 13.0 percent.

Canadian western extra strong wheat (CWES) also has 12.5 percent protein segregations for No. 1 CWES and No. 2 CWES. Protein segregations are also specified for No. 1 CWAD, No. 2 CWAD which are designated as 12.5, 13, 13.5, and 14 percent and No. 3 CWAD designated as 13 percent. New initial payments were introduced for 1996/97 for No. 3 CWAD 13 percent and No. 1 CWES and No. 2 CWES 12.5 percent protein wheats (CWB July 29, 1996).

In the United States, grade standards include definitions for class and subclass where subclasses are determined by the amount of vitreous kernels. Varieties and protein for wheat are not part of the grade standards in the United States. However, protein level is a very important component of the marketing system. Grades, standards, associated trading practices, and prices customarily determine quality parameters through buyer-seller negotiation. Buyers and sellers determine which characteristics over and above grade requirements are significant/insignificant to the transaction. Factors are identified as being important by the placement of limits and/or premiums and discounts on grade/non-grade factors. For example, protein is a non-grade determining factor that is traded based on content (usually on 1/5 percent, e.g., 14.0 percent, 14.2 percent, 14.4 percent). Premiums/discounts are determined as part of the transaction in these increments.

Varieties are not included as part of the grading or wheat classification. If any reference to a variety is included, a class of wheat is generally mentioned. Grade standards include references for wheat classes and subclasses with a subclass determined by the amount of vitreous kernels. These practices result in fewer grades traded and exported. Dahl and Wilson found over 85 percent of United States HRS and HRW was exported as United States No. 2 or better from 1986 to 1994. However, significant numbers of shipments exceeded the No. 2 requirements. Dahl and Wilson also found that the percentage of annual United States HRS exports meeting standards for No.1 ranged from 20 percent to 70 percent from 1986 to 1994.

Changes in standards for grades have occurred in the United States and Canada. Canada has changed standards for fusarium and ergot on an annual basis. For 1996-97, CWRS No. 2 and No. 3 delivered to country elevators can contain a maximum of 5 percent fusarium. No. 2 CPSR, No. 2 CPSW, No. 2 CWES, and No. 3, 4, and 5 CWAD can contain up to 10 percent fusarium. Farmers are to be paid the initial payment for the grade less a deduction for the additional fusarium damage. Changes for ergot allow delivery of No. 2 CWRS with 10 pieces of ergot per 500 grams (CWB, October 1996). This increases the maximum amount acceptable from 6 to 10 pieces.

Grain standards in the United States were changed in 1993. Changes reduced the maximum allowable foreign material acceptable for the top 3 grades of wheat. Dockage reporting standards were also changed so that dockage is reported on a .1 percent basis rather than a .5 percent basis.

Scab is a component of damaged kernels.[1] Since Vomitoxin can be associated with scab, grade standards indirectly measure Vomitoxin levels. In addition, Vomitoxin levels are controlled by the Food and Drug Administration (FDA). The FDA establishes an advisory level of Vomitoxin for raw grains, product limits, and feed. Advisory levels were changed in 1993. The advisory level for raw grains was eliminated, product limits were retained at 1 ppm, and feed levels were changed with different levels for maximum ingestion for different species (Johnson et al.). However, Vomitoxin discounts are an important part of commercial contracts in individual transactions.

<u>Incentives</u>

Incentives exist within the marketing system for production of higher quality wheats. However, mechanisms differ between the United States and Canada. In the United States marketing system, premiums and discounts for grade and non-grade characteristics are used to adjust prices in individual transactions throughout the marketing system. In Canada, premiums and discounts are paid when buying from farmers for grade segregations, and have been introduced for protein segregations. In addition, the inclusion of variety standards in grade

---

[1] Visual apparent sprout damage is considered as a component of “damage.” However, in addition, a falling number specification is a frequently used measure as a means to control non-visible sprout damaged kernels.

specifications provides a big incentive to produce registered varieties in Canada as unregistered varieties must be sold as lower grades (CWAD5 or Canada Feed).

Incentives for changes in quality in the United States depend on price spreads (premiums and discounts). These premiums and discounts exist for many grade and non-grade factors for hard red spring wheat, and durum. They are generally specified in relation to a standard grade. For hard red spring wheat this is No. 1 DNS 14 percent protein and for durum No. 1 HAD. These premiums and discounts have varied substantially over time and location (Wilson, 1995). Further, since, they are generally negotiated between the buyer and seller, they are rarely reported publicly. This reduces information on premiums and discounts to potential outside traders.

Premiums and discounts are applied to adjust quality throughout the marketing channel. This can be achieved by influencing changes in technology (changing settings on combines or varieties planted) and conditioning (cleaning or blending grain before it is shipped) among others. Grade standards also provide incentives because they present blending opportunities for both minimum and maximum factor limits. For example, minimum factor limits like defects, damaged kernels, or test weight influence farmers to supply grains just under grade breaks. Similarly, it influences elevators shipping grain to blend or clean to maintain factor limits just under grade breaks throughout the marketing system (OTA, p. 204).

The absence of incentives can also work against improving quality. For example, when premiums or discounts do not exist for dockage, farmers may not take the time to adjust combine settings, or elevators may decide against cleaning grain before shipment. This in effect reduces the incentive for providing higher quality wheat and may become a more important factor in incentive transmission as buyers of wheat become more discriminating. The next sections examine historical premiums and discounts for grade differences and protein.

Premiums and Discounts for Grade Differences

Premiums and discounts for grades of wheat in the United States and Canada vary over time. Annual marketing year spreads between United States No 1. hard red spring wheat and United States No. 2 have increased from 1980 to 1995 (Figure 4). This increase in the spread between grades came at a time when the percent of North Dakota hard red spring wheat production meeting United States No. 2 or better was low due to disease problems experienced in the state (Figure 5). Average spreads between United States No. 1 and No. 2 HRS increased to over 90 cents per bushel in 1993.

In comparison, spreads in Canada are the implied difference between CWRS No. 1 and CWRS No. 2. These have been fairly constant, averaging between 5 and 19 cents per bushel (Figure 6). The large decline in the percent of CWRS grading No. 1 or No. 2 in 1993 had little impact on spreads compared to the large changes that occurred in the United States (Figure 7). Thus, the spread between No. 1 and No. 2 has been greater in the United States than in Canada (Figure 8). Further, more volatility in the Canadian spreads between grades has been present for the lower grades (grade 2 versus grade 3) than for the higher grades (grades 1 versus grade 2).

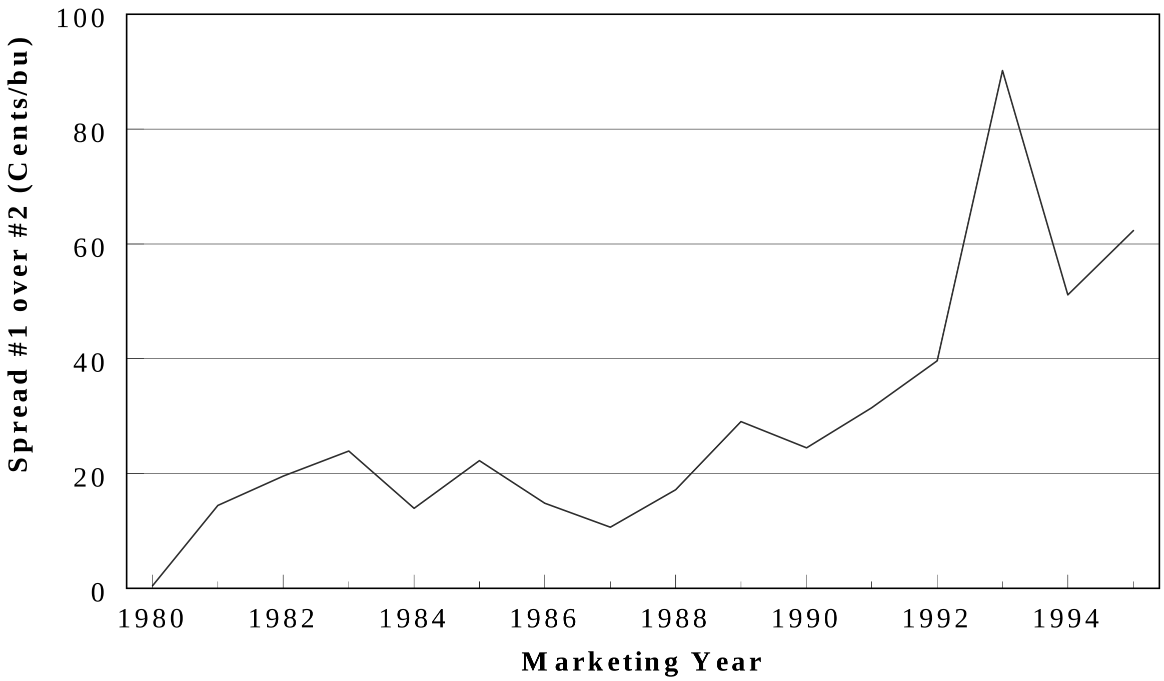

Figure 4. Average Marketing Year Spread No. 1 over No. 2, Mpls, 1980-1995.

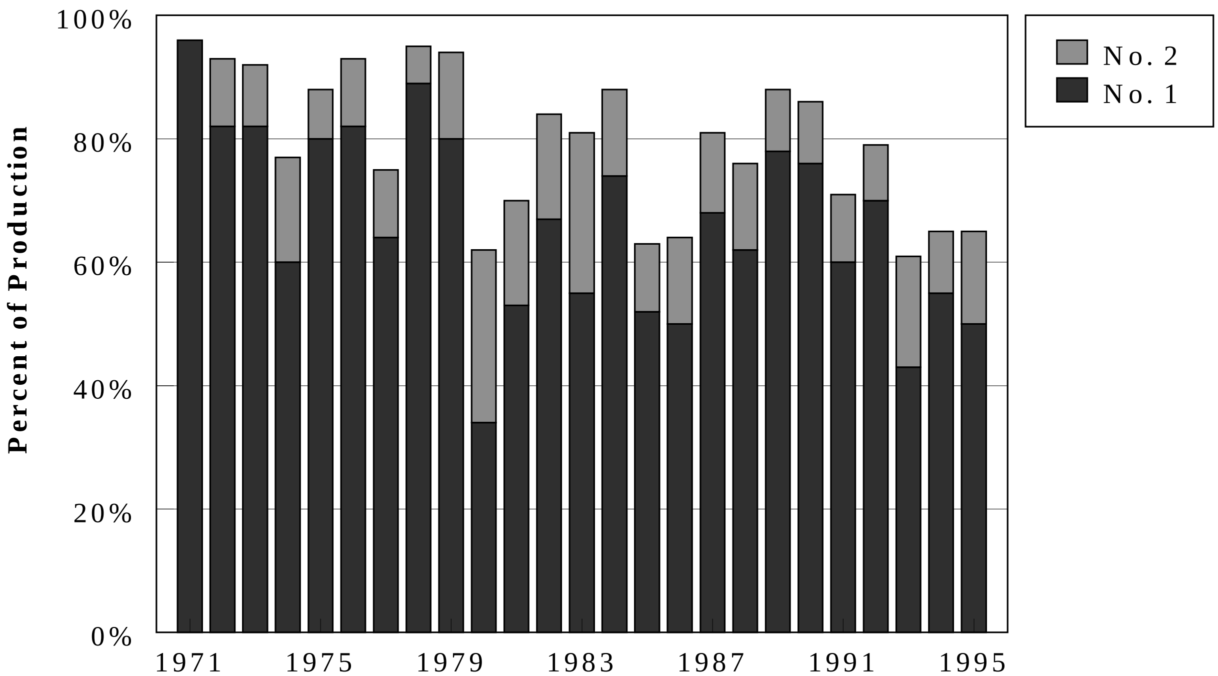

Figure 5. Percent of North Dakota HRS Production by Grade, 1971-1995.

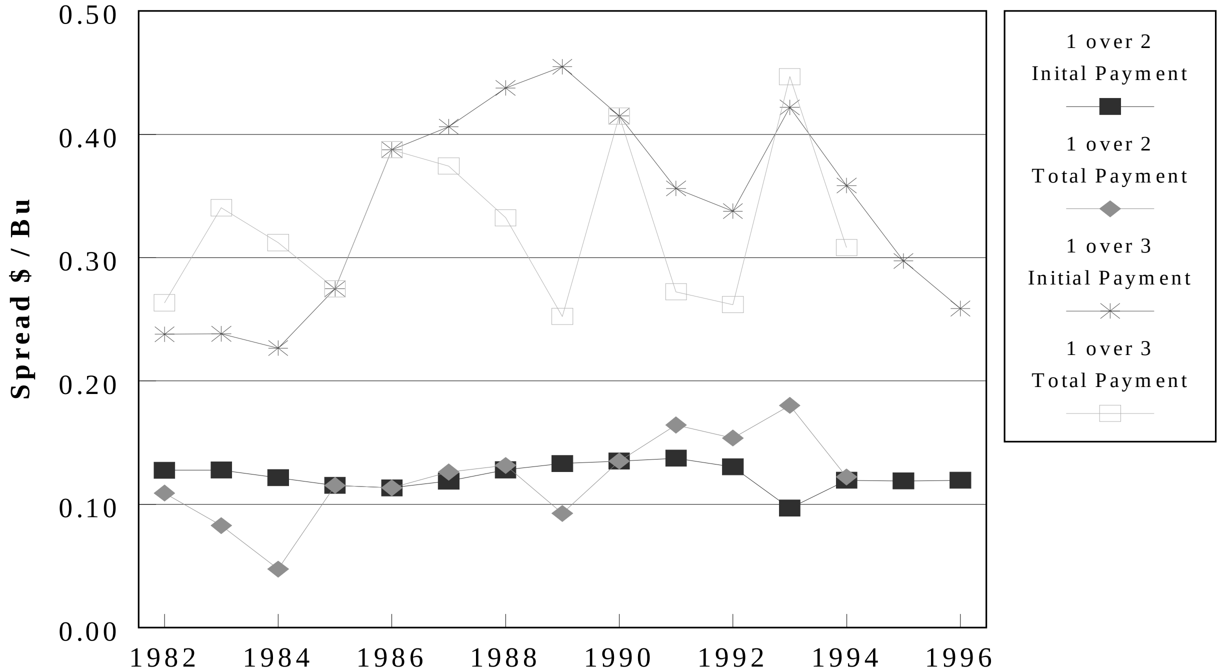

Figure 6. Initial and Final Price Spreads for CWRS Wheat, 1982-1996.

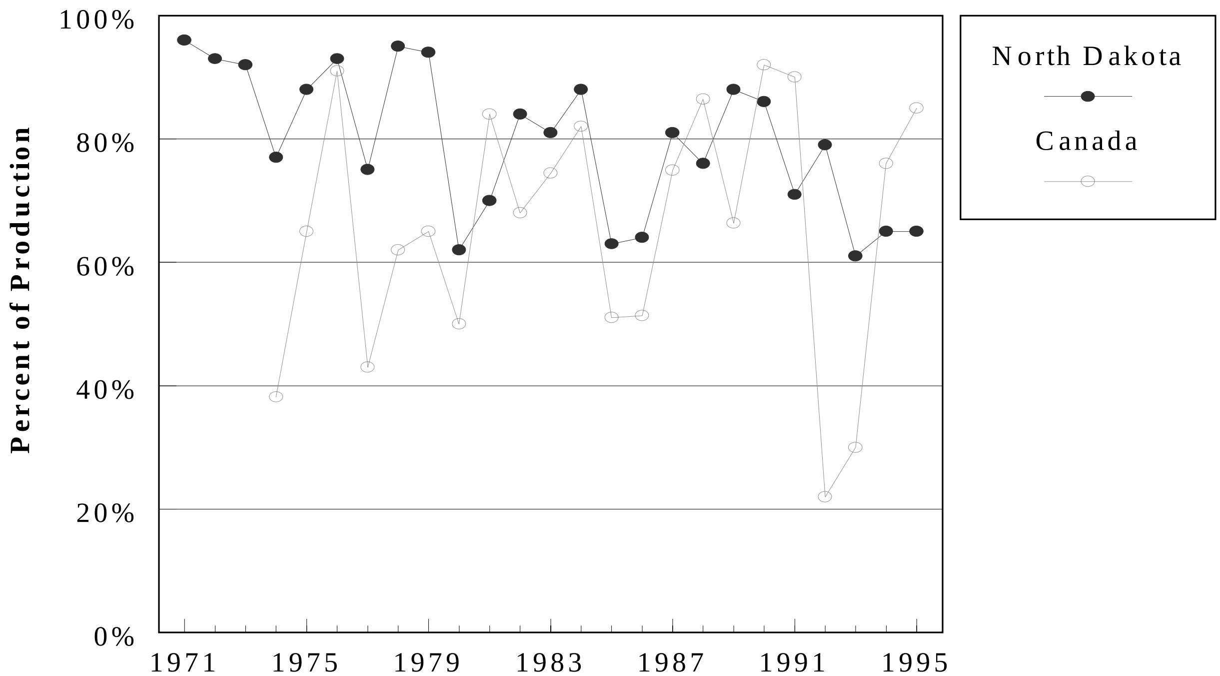

Figure 7. Percent of Hard Red Wheat Production Grading No. 1 or No. 2, by Area, 1971-1995.

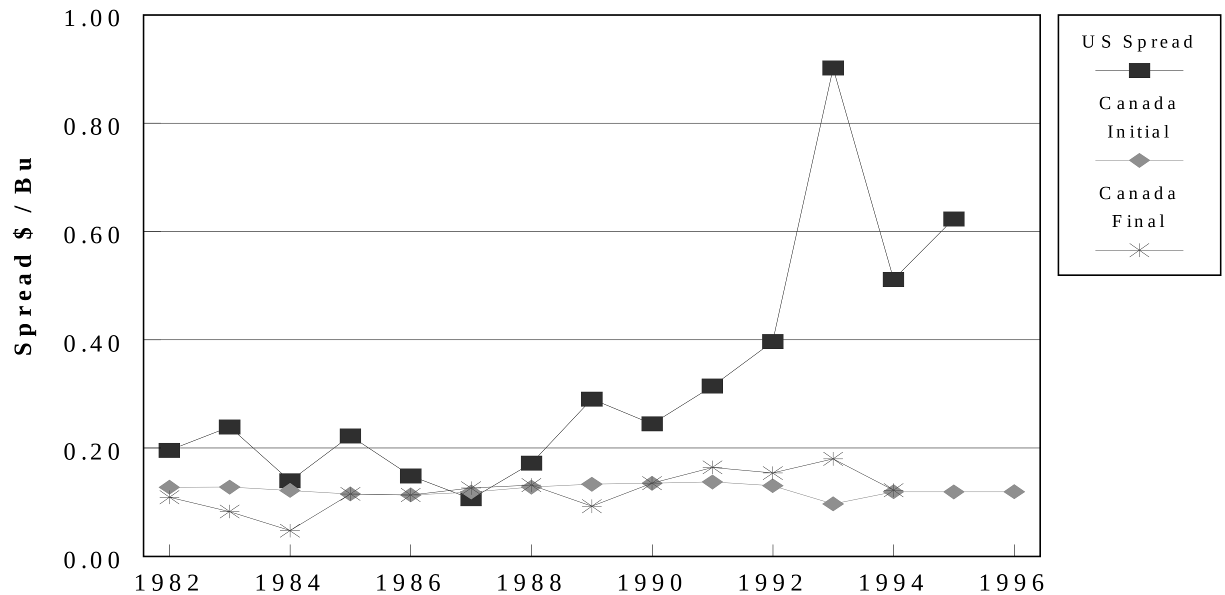

Figure 8. U.S. and Canadian Spreads Grade 1 over Grade 2, 1982-1996.

<u>Premiums and Discounts for Protein</u>.

Protein is one of the characteristics for which premiums and discounts are normally applied. In the United States, protein is a non-grade determining factor. Protein has traded on segregations down to 1/5 percentage points, and premiums have varied substantially over time (Figure 9). In effect, premiums and discounts ration or allocate the quality (protein) wheat produced within the year. For example, in years when high protein wheat is abundant like 1991 and 1992, premiums are minimal. In years when high protein wheat is limited, premiums are high (Figures 9-10).

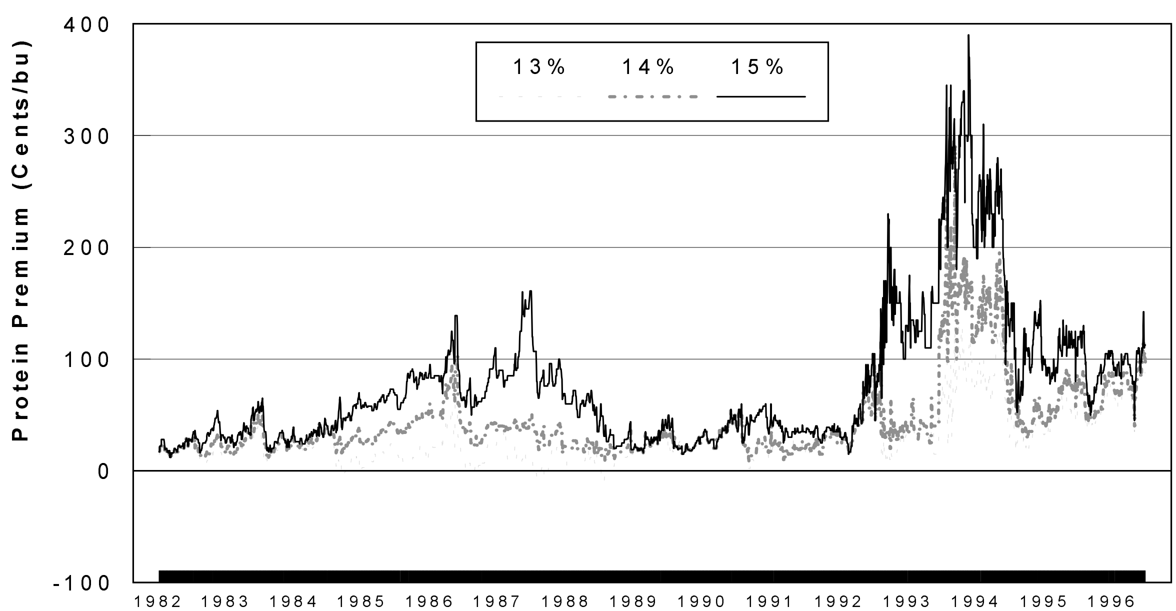

Figure 9. Protein Premiums for Hard Red Spring Wheat, by Protein Level, Mpls. 1982-1996.

Protein premiums have not been utilized as fully or as long in Canada as in the United States. In Canada, premiums are pooled over the marketing year, unlike the United States where premiums vary daily. Therefore, protein premiums are less volatile in Canada than in the United States. However, protein premiums in the middle 1990s appear to be similar in direction and somewhat similar (generally slightly lower) in magnitude to average marketing year protein premiums in the United States (Figures 10-11). Average marketing year protein spreads from 1988 to 1995 for 15% protein HRS over 14% HRS was 37.6 cents per bushel. This compares to 23.7 cents per bushel for 14.5% protein CWRS over 13.5% protein CWRS for initial payments and 29.9 cents per bushel for the total payment[2]. Therefore, the spread for higher protein wheats has been higher in the U.S. from 1988 to 1995 on average by 13.9 cents per bushel over Canada's initial payment and 7.7 cents per bushel over Canada's final payment. The incentives associated with protein premiums in Canada are not translated fully to farmers till after receiving the final payments for wheat delivered.[3] The development of increased segregations for protein levels have also come about as a response to inadequate transmission of returns/incentives to producers (Canada Grains Council).

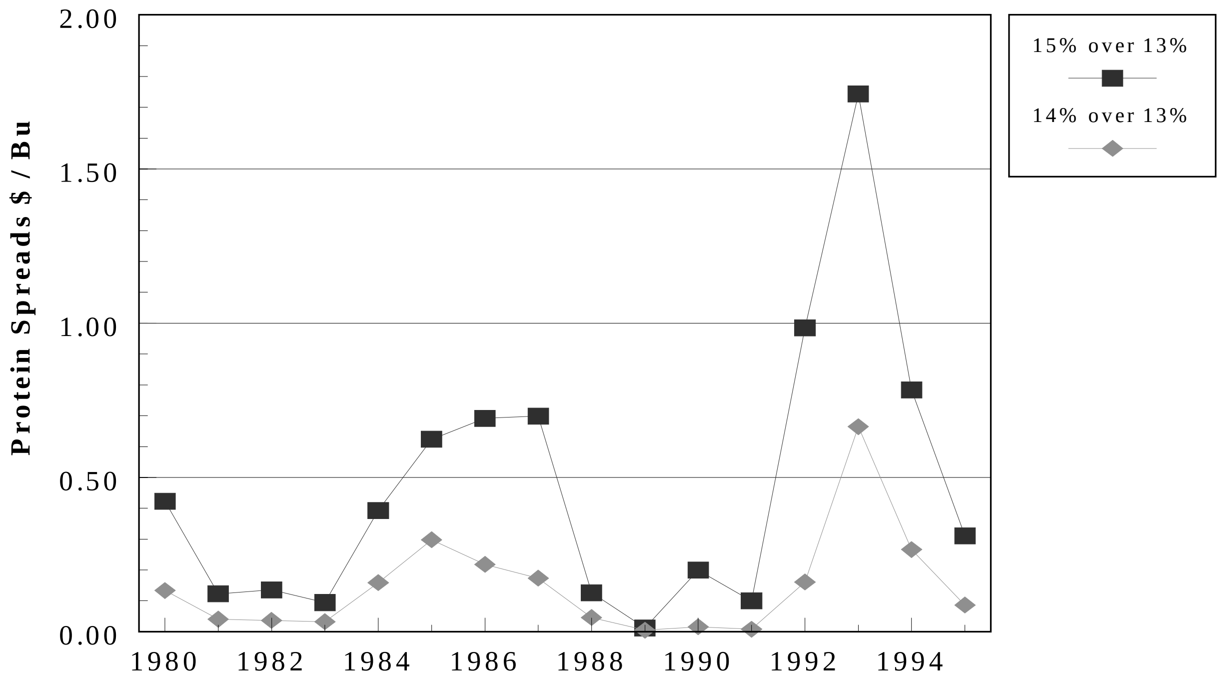

Figure 10. Average Marketing Year Hard Red Spring Wheat Protein Spreads, Mpls., 1980-1995.

---

[2] Comparison of spreads between U.S. 15% protein over 14% protein HRS with Canadian CWRS 14.5% protein and 13.5% protein are somewhat comparable due to differences in water content utilized for protein measurements (12% in U.S. and 13.5% moisture in Canada).

[3] The CWB has started to report projections of Pool Return Outlooks which inform farmers of the latest estimates for prospective total payments for individual grades/protein segregations, thus, reducing some of the uncertainty over prospective payments and potentially reducing the lag time in transmission of incentives.

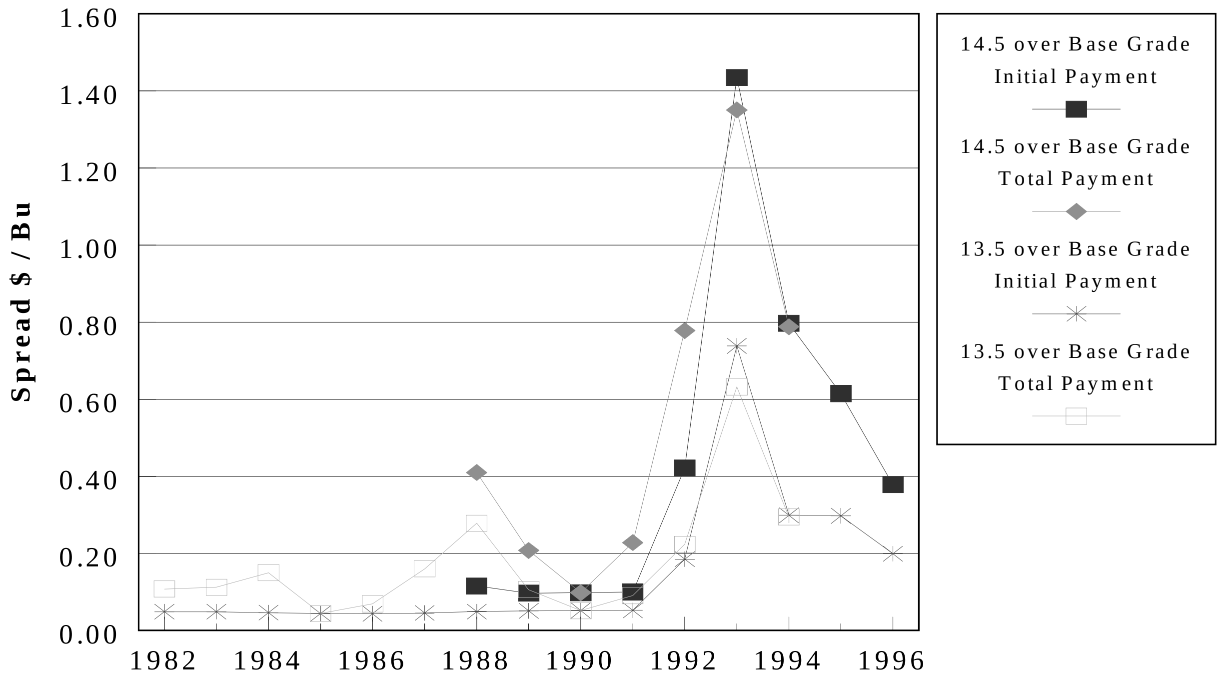

Figure 11. Initial and Total Protein Spreads Over Base Grade, CWRS, 1982-1996.

VARIETY ADOPTION

Inherent qualities of specific varieties and the extent that they are adopted by farmers affect the potential quality of wheat produced. For example, as the number of varieties grown increases, intervarietal differences are magnified. Fewer varieties adopted on larger proportions of planted acres reduces intervarietal differences. The magnitude of these effects depends on the size of intervarietal differences among varieties and the degree to which they are blended throughout the marketing system.

The adoption of varieties was examined and compared for hard red spring and durum wheat varieties in North Dakota, Manitoba, Saskatchewan, and Alberta. Adoption characteristics for varieties were examined using a several measures. First, the number of varieties planted was compared. Second, shares of acres planted to the dominant variety was compared. Third and fourth, two measures of concentration (N-firm market share and Herfindahl Index)[4] were utilized to compare the distribution of planted acres for varieties of durum and hard red spring wheat.

[4] N-firm and Herfindahl Index scores have been utilized extensively in the Industrial Organization literature to evaluate firm concentration. Herfindahl index scores are utilized for anti-trust determinations.

Number of Varieties Grown

Variety shares of planted acres for wheat were gathered from a range of sources (North Dakota Agricultural Statistics Service, Alberta Pool, Saskatchewan Wheat Pool, Manitoba Pool Elevators, and Manitoba Crop Insurance Corporation). The number of varieties with 1 percent or more of planted hard red wheat acres and durum was calculated for each state/province from 1974 to 1995. Observations for Canadian provinces from the annual pool surveys were discontinued in 1992 and supplemented with observations for Manitoba from the Manitoba Crop Insurance Corporation. Surveys for North Dakota were not conducted in 1981, 1983, or 1985 and were not available in 1976-1977.

The number of hard red spring wheat varieties grown in North Dakota were consistently greater than the number of varieties grown in Manitoba, Saskatchewan, or Alberta during the 1980s and early 1990s (Figure 12). North Dakota farmers planted a low of 9 varieties of spring wheat in 1979, 1980, and 1982 to a high of 16 varieties in 1988. The number of hard red spring wheat varieties grown in North Dakota has declined since 1988 to a low of 10 in 1995 and have increased to 12 in 1996.

Manitoba ranged from a low of 4 varieties in 1980 and 1981 to a high of 12 varieties in 1994. The number of varieties grown in Manitoba have been increasing since the middle 1980s. Increased numbers of varieties grown in Saskatchewan and Alberta are not as apparent. During the later 1980s, the number of varieties grown in Saskatchewan ranged from 4 to 6, significantly lower than the 10 to 11 varieties grown in 1985, 1991, and 1992.

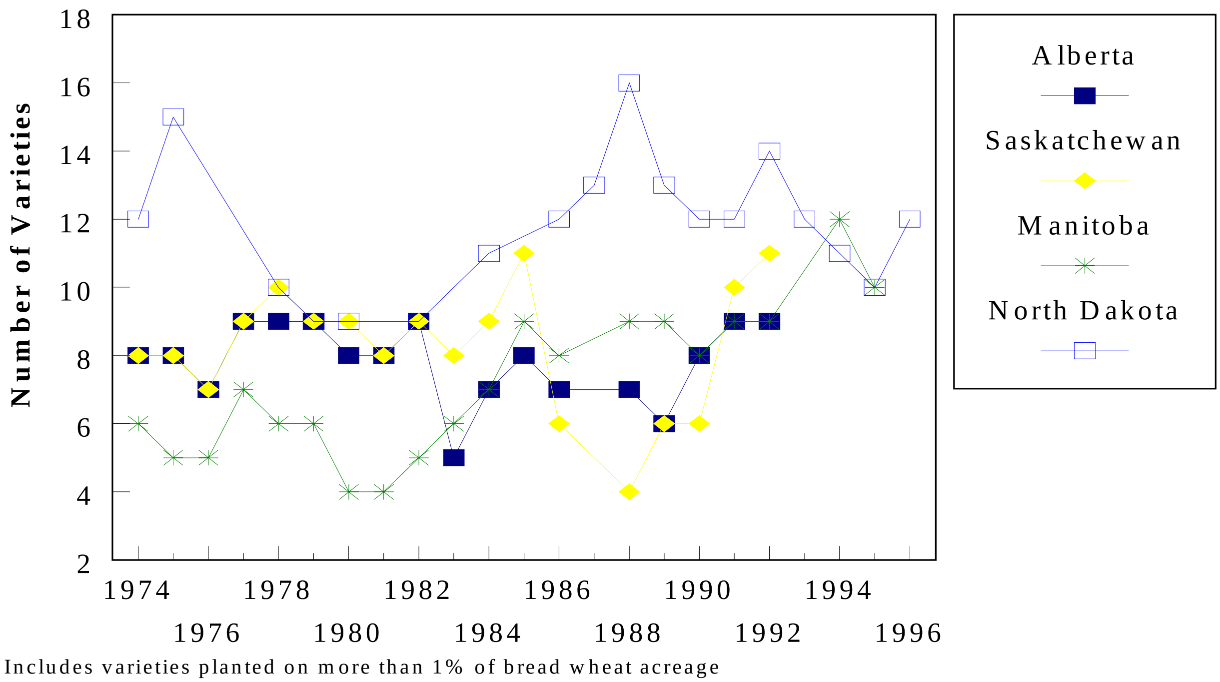

Figure 12. Number of Hard Red Spring Wheat Varieties by State/Province, 1974-1996.

The number of durum varieties grown exhibits a similar pattern to hard red spring wheat. The number of durum varieties in North Dakota was consistently greater than Manitoba, Saskatchewan, or Alberta from 1974 to 1995 (Figure 13). The number of durum varieties grown in North Dakota increased from 8 in the middle 1980s to 13 varieties in 1992 and declined to 10 varieties in 1995. However, this is still nearly twice as many varieties of durum as were grown in Manitoba in 1995. Canadian provinces varied from 2 to 8 varieties of durum grown from 1974 to 1995 with the lowest number of varieties grown in Manitoba, followed by Saskatchewan and Alberta.

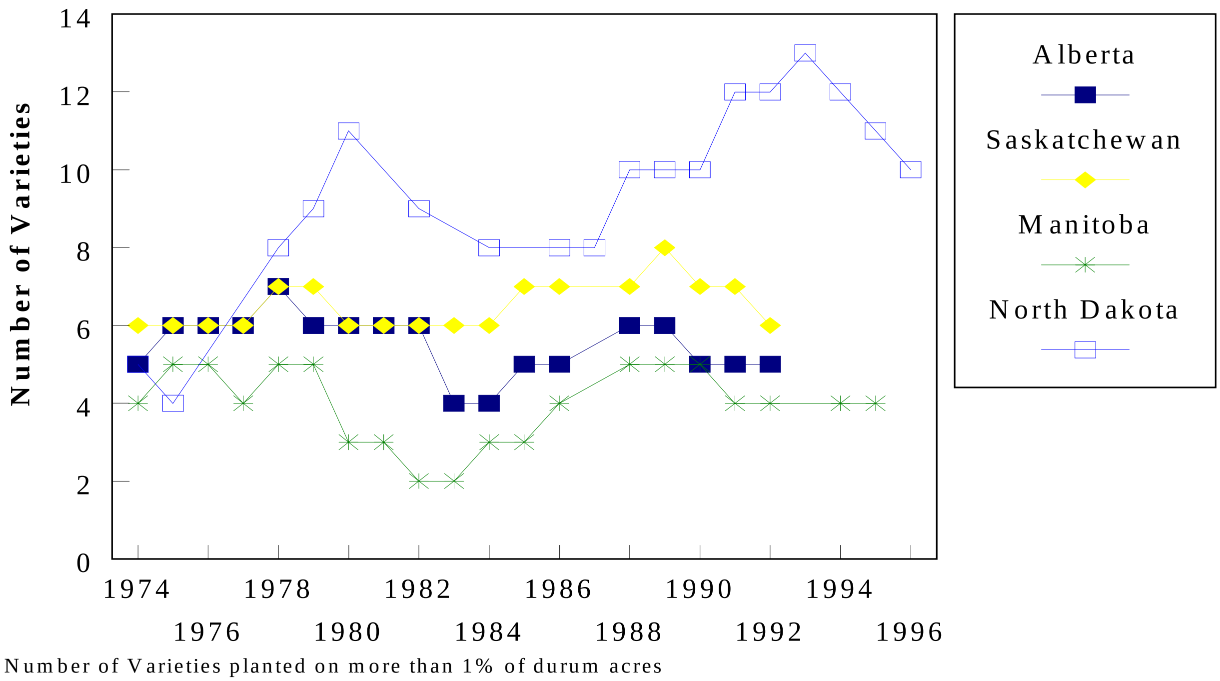

Figure 13. Number of Durum Wheat Varieties by State/Province, 1974-1996.

Shares of Planted Acres for Dominant Varieties

The share of planted acres was compared for the dominant variety of hard red spring and durum wheat grown in North Dakota, Manitoba, Saskatchewan, and Alberta from 1976-1996. Shares of planted acres for the dominant variety in North Dakota were generally smaller than for the Canadian provinces (Figure 14). In Saskatchewan, during the late 1970s and early 1980s, the dominant variety was planted on more than 50 percent of the wheat acres, reaching a high of 73.2 percent of wheat acres in 1982. The trend in shares of planted acres for the Canadian provinces has declined since 1989. However, shares for North Dakota have been increasing since 1992 and, in fact, were higher than in Manitoba in 1995 and 1996.

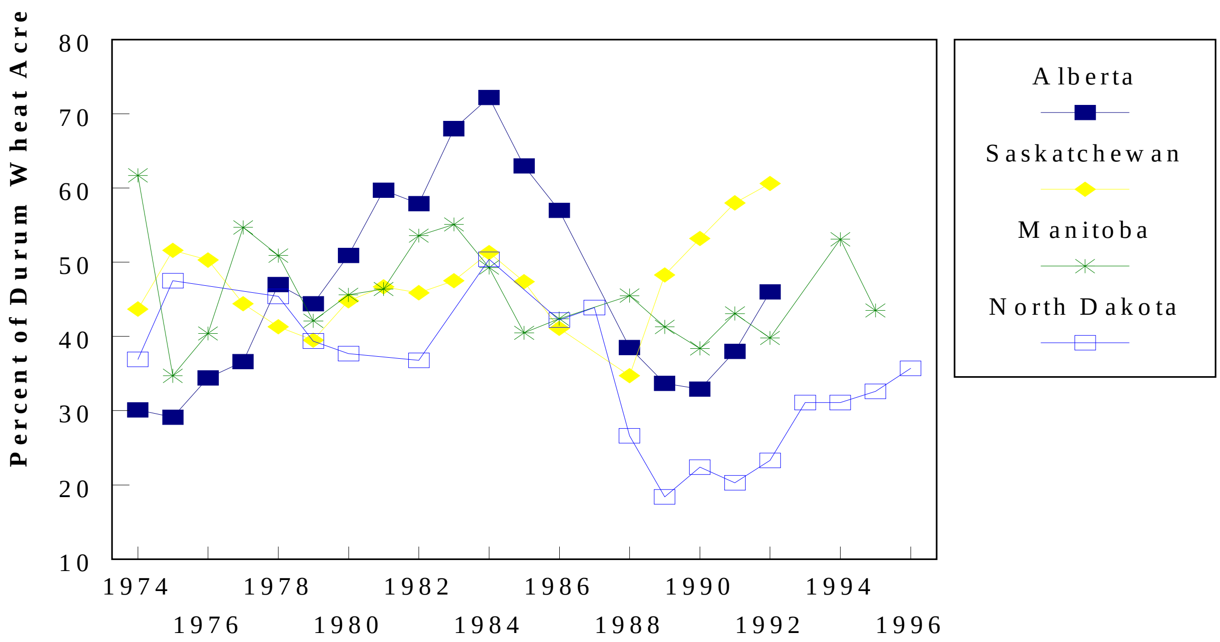

Figure 14. Shares of Planted Acres for Dominant Durum Wheat Variety by State/Province, 1974-1996.

Shares of planted acres for the dominant durum variety were lower in North Dakota than the Canadian provinces for most of 1974 to 1996 (Figure 15). Shares for the dominant variety in Alberta ranged from a low of 29.1 percent of durum acres in 1995 to a high of 72.2 percent of durum acres in 1984. Shares for North Dakota during this period ranged primarily from 20 to 40 percent of durum acres with only one year (1984) showing over 50 percent of durum acres.

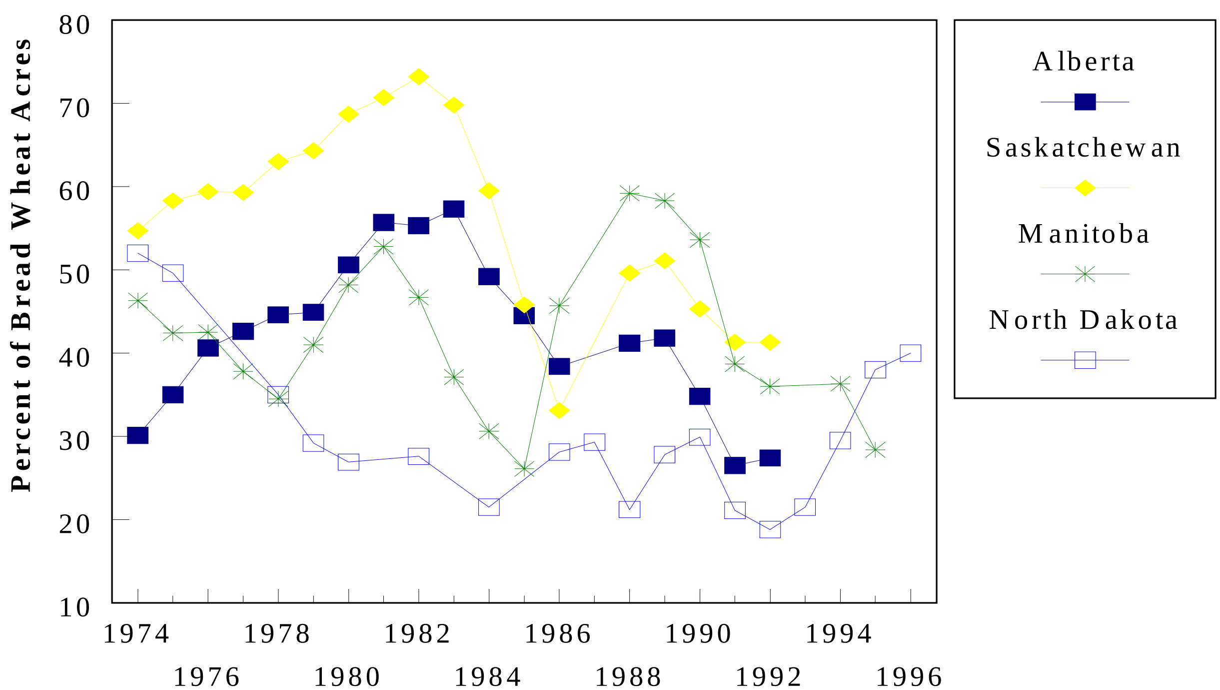

Figure 15. Shares of Planted Acres for Dominant Hard Red Spring Wheat Variety by State/Province, 1974-1996.

Adoption of Top Varieties

The areas shares for the top four varieties planted were also compared across North Dakota, Manitoba, Saskatchewan, and Alberta. This four-variety market share provides a measure of the concentration of planted acres in the top four varieties.[5]

Four-variety area shares for hard red spring wheat in the Canadian provinces were consistently larger than those for North Dakota from 1974-1995 (Figure 16). In fact, 4-variety area shares for Saskatchewan and Manitoba generally exceeded 85 percent of the hard red wheat acres. In contrast, 4-variety shares for North Dakota were consistently lower than 80 percent of the spring wheat acres. Alberta formed a middle ground where market shares were lower than for North Dakota in a few years while approaching the largest shares in other years.

Four-variety shares for durum were higher than for hard red spring wheat from 1974-1995. Again, the Canadian provinces had the highest 4-variety shares averaging between 80 and 100 percent of durum acres (Figure 17). Meanwhile, 4-variety shares for durum in North Dakota ranged from a high of 97 percent in 1974 to a low of 63 percent in 1990. During the late 1980s, 4-variety shares declined dramatically for North Dakota to a low in 1990 and increased up 75 percent of durum acres in 1994. The 4-variety shares indicates that there is more of a divergence in the reliance on the top 4-varieties between North Dakota and the Canadian provinces for durum than there is for hard red spring wheat.

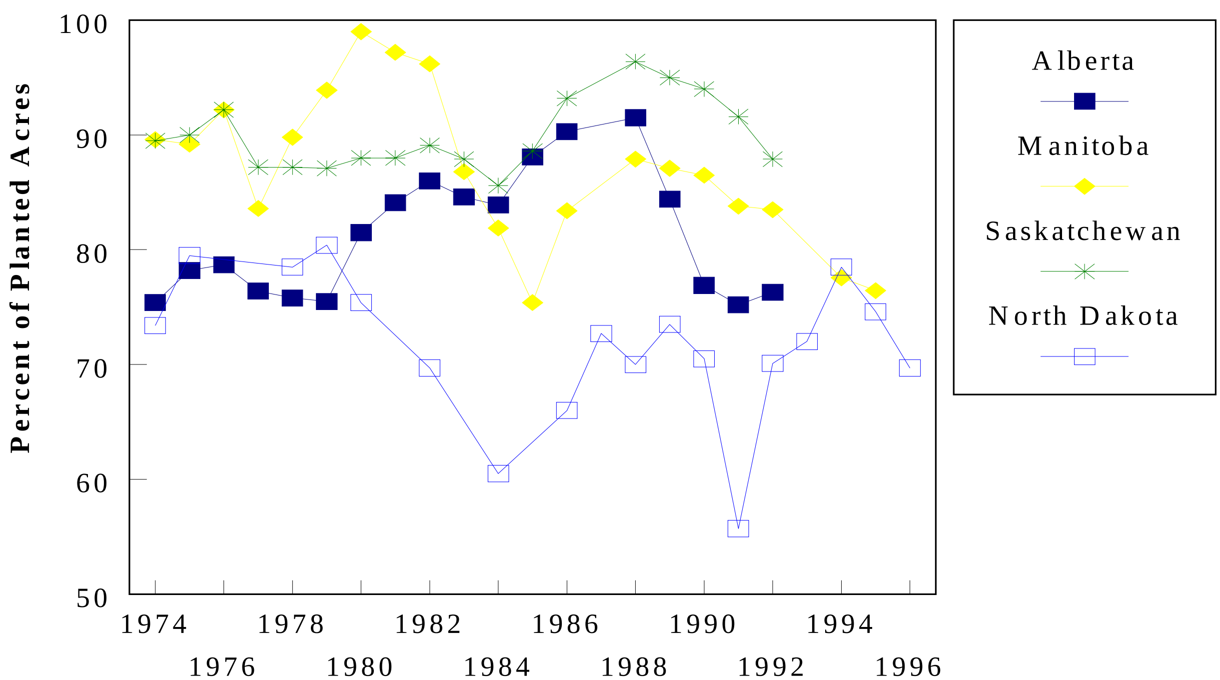

Figure 16. Varietal Adoption Shares for Top 4 Hard Red Spring Wheat Varieties, by State/Province, 1974-1996.

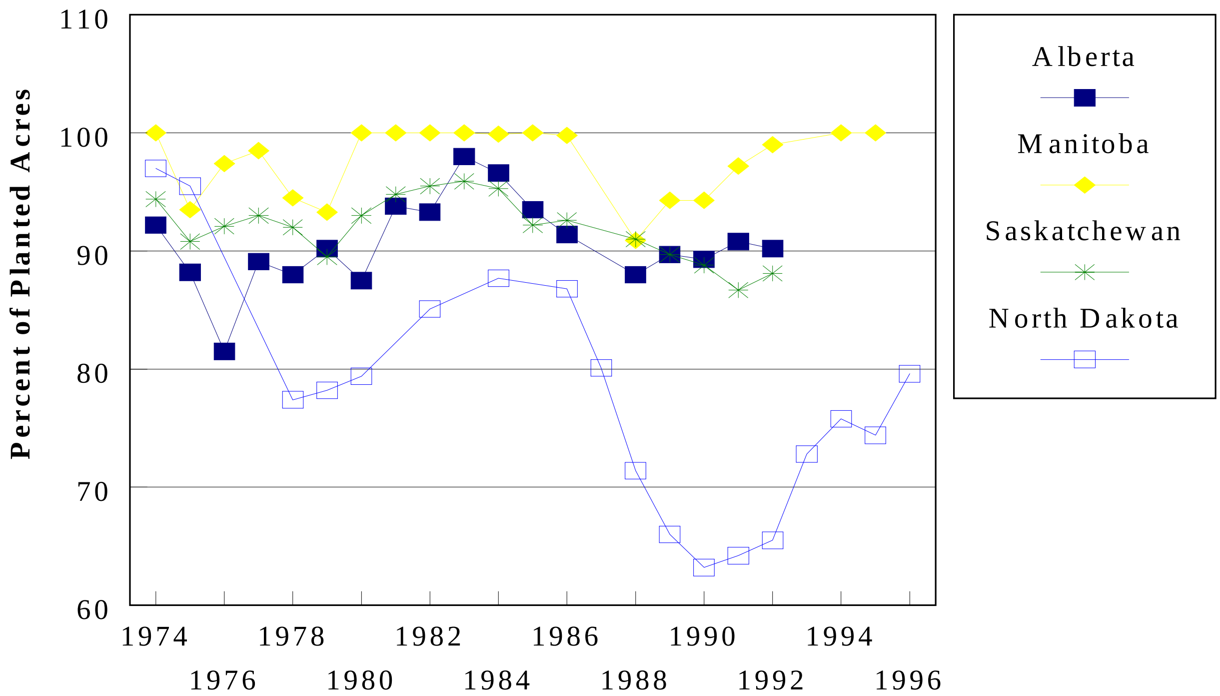

Figure 17. Varietal Adoption Shares for Top 4 Durum Wheat Varieties, by State/Province, 1974-1996.

These results further indicate that durum and hard red spring wheat acres in Canada are concentrated in fewer dominant varieties, while in North Dakota, there is less reliance on dominant varieties. To the extent that there are inter-varietal differences in quality that end up being combined within the marketing system, one would expect quality in Canada should be more consistent than in the United States.

Herfindahl Index

The Herfindahl index is a measure of concentration that has been utilized in the Industrial Organization literature to assess concentration within an industry. This measure takes into account both the size and distribution of market shares by firms. The Herfindahl Index score is calculated as follows:

$$HerfindahlIndex = [\Sigma(ms_i)^2] * 10{,}000$$

where

ms_i is the market share for firm I.

This measure of concentration was applied to the shares of planted acres for hard red spring and durum varieties in North Dakota, Manitoba, Saskatchewan, and Alberta. Large values for the index score indicate greater concentration in a few dominant varieties.

Herfindahl index scores for hard red spring wheat varieties were lower for North Dakota and decreased from a high of 3000 in 1974 to a low of 1147 in 1990 (Figure 18). In 1994 and 1995, index scores increased to 2000. Herfindahl scores for Saskatchewan were generally the highest from 1974 to 1992, ranging from a high of 5468 in 1982 to a low of 2530 in 1992. Alberta and Manitoba in 1974 had lower Herfindahl scores than North Dakota and increased during the middle to late 1980s. Scores for Manitoba have declined for hard red spring wheat to a lower rating than for North Dakota in 1995. Thus, the immediate trend is for lower concentrations of varieties with market shares spread more evenly over more varieties in Manitoba and for increasing concentration in a few varieties with large shares of planted acres in North Dakota.

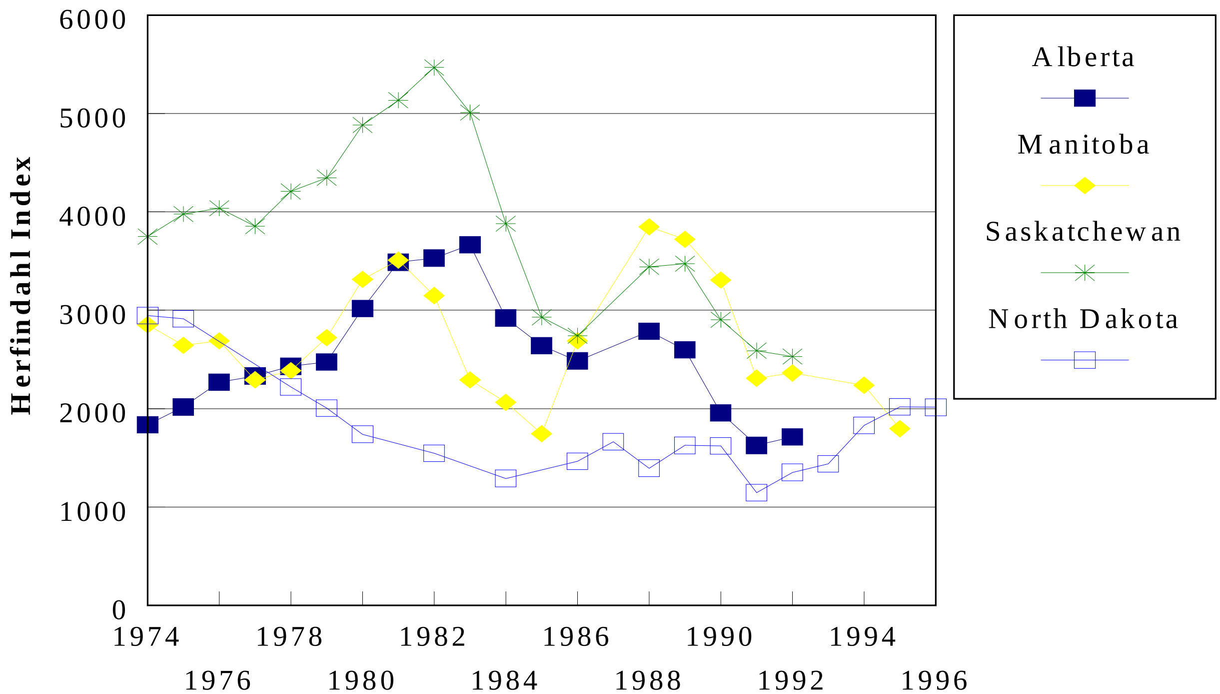

Figure 18. Concentration of Hard Red Spring Wheat Variety Adoption, by State/Province, 1974-1996.

Herfindahl index scores for durum exhibit a similar pattern as hard red spring wheat. North Dakota generally has the lowest score, although scores are higher than for hard red spring up to 1987 when they declined to levels comparable to hard red spring wheat for North Dakota (Figure 19). In addition, North Dakota durum scores show the same increase in concentration of varieties in the 1990s that is present in hard red spring wheat scores for North Dakota. Canadian provinces increased their concentration of varieties up to 1983-1984. Since then, concentrations declined in 1988 and rose again in 1992. Observations for Alberta and Saskatchewan in 1992 (the last year comparable data were available) were about twice that of Herfindahl scores for North Dakota. Again, using this measure, durum acres in the Canadian provinces are more concentrated in a few varieties that dominate durum production. North Dakota durum production is spread out more evenly over more varieties that have lower shares of planted acres.

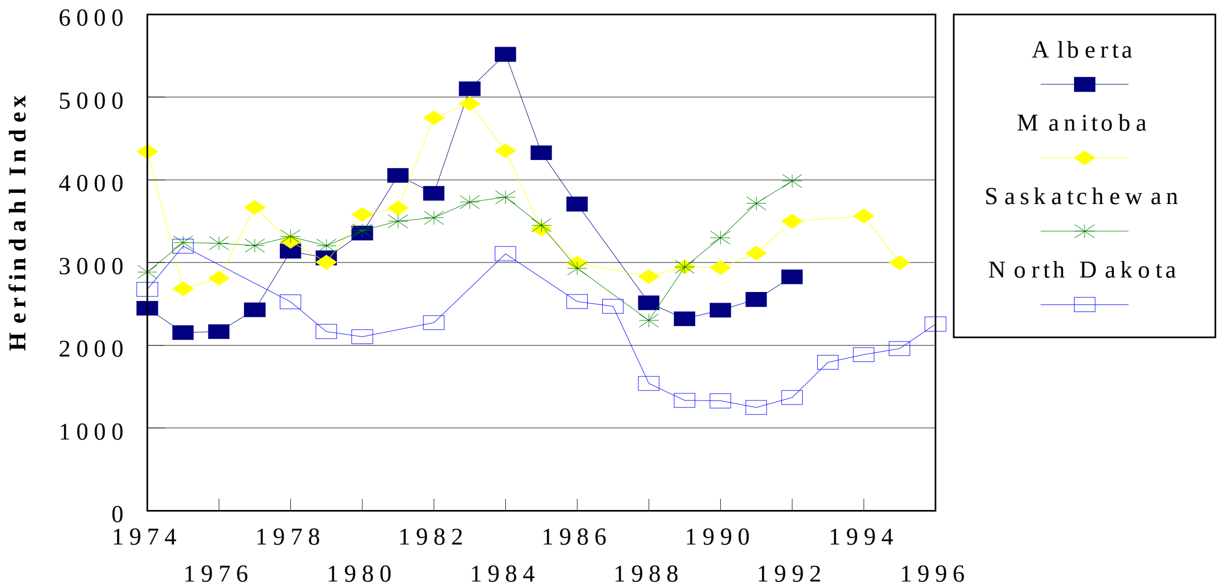

Figure 19. Concentration of Durum Wheat Variety Adoption, by State/Province, 1974-1996.

Results for each of the measures of the distribution of variety adoption have implications for the supply of quality hard wheats. The lower numbers of varieties grown in the Canadian provinces are likely a result of variety development and release regulations and suggests that there should be less variability in quality for both hard red spring and durum wheats in Canada than in North Dakota. Similarly, the results for the shares for the dominant variety and for the top 4-varieties indicate a higher reliance on the dominant varieties in Canada than in North Dakota for HRS and durum wheats. The results from the Herfindahl index scores indicate that production of HRS and durum is more concentrated in a few varieties with large shares of planted acres in Canada than in North Dakota. All of these suggest that quality variability should be less in Canada than in North Dakota. The degree to which quality variability is affected by the distribution of varieties depends on other factors as well, including the degree to which intervarietal differences are blended within the marketing system, the amount of intervarietal differences, and environmental effects, among others.

Trends in the number of varieties of hard red spring wheat are toward fewer numbers in North Dakota and higher numbers in Canada. This suggests a move toward less indigenous quality variability in North Dakota and more in Canada. Similarly, trends for the dominant variety and 4-variety shares of planted acres for HRS are increasing in North Dakota and appear to be declining in the Canadian provinces. Trends for the Herfindahl index scores indicate production of HRS is becoming more dominated by fewer varieties in North Dakota and less in the Canadian provinces. This again suggests that to the extent that intervarietal differences are mixed within the marketing system, quality variability should be declining in North Dakota and increasing in the Canadian provinces. One possible explanation for the trend toward more reliance on fewer varieties in North Dakota may be the lack of resistance to scab by most of the varieties released for production.[5]

---

[5] Schneiter indicated that the variety Pioneer 2375 which was planted on 40 percent of North Dakota wheat acres in 1996 owes much of its popularity to fact that this variety has more resistance and tolerance to scab than some of the other varieties (Menke).

Comparison of the various methods used to examine the distribution of variety adoption indicate several things. First, with the Herfindahl index, all states/provinces showed a decline in the concentration variety shares of hard red spring wheat planted acres. The 4-variety market shares indicated increased concentration in North Dakota and Manitoba while Saskatchewan and Alberta declined. This suggests that these methods are capturing different aspects of the distribution of variety shares of planted acres. Variety shares for the dominant variety appear to be capturing one aspect of variety distribution. Meanwhile, the Herfindahl index and 4-variety shares appear to reflect other aspects of variety concentration.

Second, the Herfindahl index scores primarily for hard red spring wheat indicate that both Canadian provinces and North Dakota are becoming more similar in their distribution of varieties across planted acres. Canadian provinces have been reducing reliance on a few varieties, while North Dakota has been increasing reliance on fewer varieties. This is not as prevalent for durum wheat. North Dakota has been increasing Herfindahl scores for durum varieties; however, changes in Canadian provinces are not observable because of the unavailability of data past 1992.

COMPARISON OF AVERAGE YIELD/PROTEIN RELATIONSHIPS

Increases in protein for wheat varieties generally comes at the cost of higher yields. In Canada, an increase in protein of 1 percent is thought to come at the cost of 10 percent in yield (CWB and CGC). Conceptually, the protein/yield tradeoff can be described by an "efficient frontier. As new improved varieties are released, this frontier is expected to shift up and outward. This section analyzes crop quality parameters for yields and protein in wheat to discern the size and shape of the frontier for yield/protein relationships in wheat for spring wheat production areas in Canada and the United States.

Average yield and protein levels were collected for the northern spring wheat production areas of the United States and Canada. The United States region included the individual states of North Dakota, Minnesota, South Dakota, and Montana. Canada included the provinces of Manitoba, Saskatchewan, and Alberta. Yields in the United States were gathered on a crop reporting district level from publications by the state agricultural statistical services. Protein levels in the United States were collected from regional annual crop quality surveys (Moore et al.). In Canada, yields and protein values were gathered from annual crop quality surveys (Canadian Grain Commission-Grain Research Laboratory) and statistical annuals (Canadian Grain Commission). Canadian protein levels were converted to a 12 percent moisture basis to be consistent across countries.

Yields and protein were averaged for two periods: 1980-1982 and 1993-1995 (Table 1). In 1980-1992, Minnesota had the highest average yield followed by Alberta, Manitoba, Montana, Saskatchewan, North Dakota, and South Dakota (Figure 20). Average yields increased for all states/provinces from the earlier period to 1993-1995, except for Minnesota which declined from 38.1 bu/a to 32.0 bu/a.[6] In 1980-1982, average protein levels ranged from 13.5 to 14.6 percent with the highest average protein levels in North and South Dakota followed by Manitoba, Montana, Saskatchewan, Minnesota, and Alberta (Figure 21). Average protein levels for most states/provinces were lower in 1993-1995 than for 1980-1982, except for Minnesota which was higher in 1993-1995. These results are consistent with yield increases experienced during the

[6] One possible explanation for the decline in yields is the incidence of unfavorable growing conditions which included outbreaks of wheat scab/Vomitoxin in the 1993-1995 crop years.

same intervals and traditional trade-off of protein for yield. Average protein levels declined the most for Alberta and Saskatchewan which both had protein levels 1.4 percentage points lower in 1993-1995 than in 1980-1982.[7] Other areas experienced changes in average protein levels of +.5 to -.6 percentage points.

Table 1. Average Yield and Protein, Growth Rates, and Yield Protein Tradeoffs, by State/Province for Hard Red Spring Wheat

	Average Yield			Average Protein		
	1980-1982	1993-1995	Change	1980-1982	1993-1995	Change
	------ (Bu / A) ------			------ (percent) ------		
North Dakota	24.7	31.6	6.90	14.6	14.0	-0.60
Minnesota	38.1	32.0	-6.10	13.6	14.1	0.50
South Dakota	21.8	26.0	4.20	14.6	14.1	-0.50
Montana	27.8	33.6	5.80	13.8	13.5	-0.30
Manitoba	29.0	30.5	1.50	13.8	13.5	-0.30
Saskatchewan	27.1	29.2	2.10	13.7	12.3	-1.40
Alberta	33.0	38.0	5.00	13.5	12.1	-1.40

	Growth Rates	
	Yield	Protein
	(percent per Year)	
North Dakota	1.69*	-0.27*
Minnesota	-1.21ns	0.49*
South Dakota	1.36ns	-0.20ns
Montana	2.43*	-0.25*
Manitoba	1.29ns	0.18ns
Saskatchewan	0.47ns	-0.14ns
Alberta	1.28*	-0.18ns

	Yield Protein Trade-off			
	1980-1982	1993-1995	1980-1982	1993-1995
	((Bu/A) / percent Protein)		(percent Yield/ percent Protein)	
North Dakota	-6.06	-5.81	-24.5	-18.4
Minnesota	-7.65	-7.85	-20.1	-24.6
South Dakota	-4.68	-4.48	-21.4	-17.2
Montana	-5.72	-5.61	-20.6	-16.7
Manitoba	-5.74	-5.61	-19.8	-18.4
Saskatchewan	-5.67	-5.12	-20.9	-17.5
Alberta	-5.62	-5.02	-17.0	-13.2

* Significant at 95 percent confidence interval
ns - not significant

[7] Lower protein numbers for the Canadian Provinces in 1993-1995 were due to three years with lower-than-average protein levels. Levels for 1993 represented a 40-year low for average protein levels (CGC).

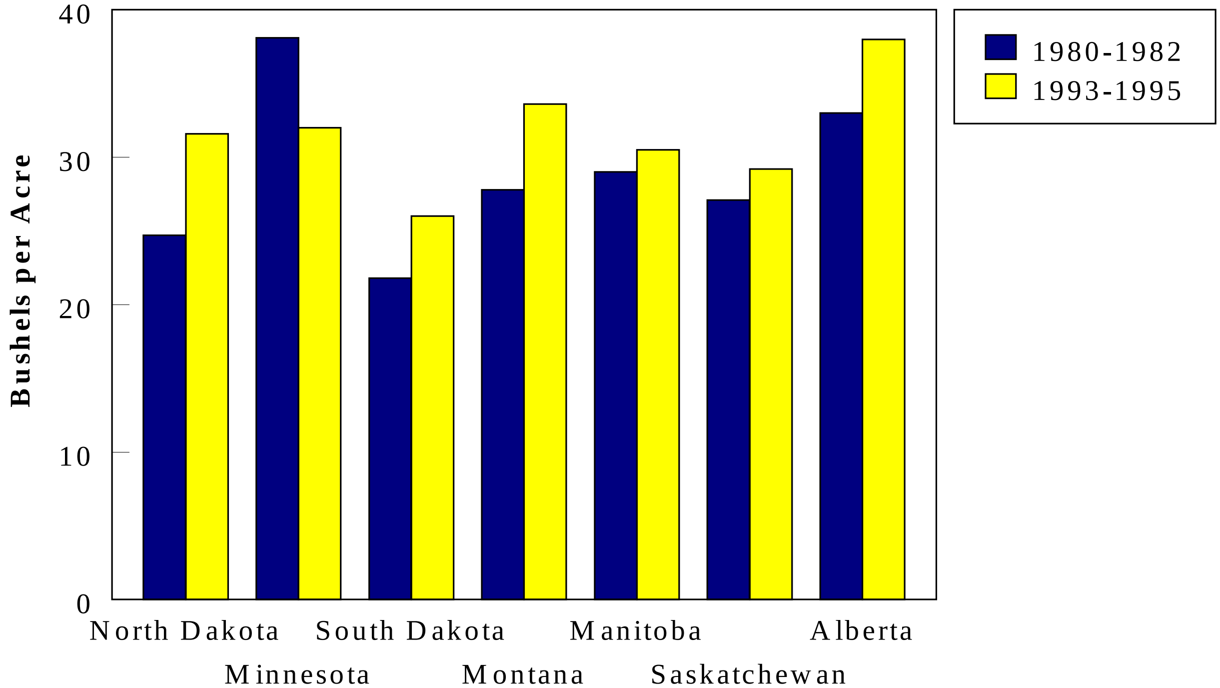

Figure 20. Average Yield by State/Province, 1980-1982 and 1993-1995.

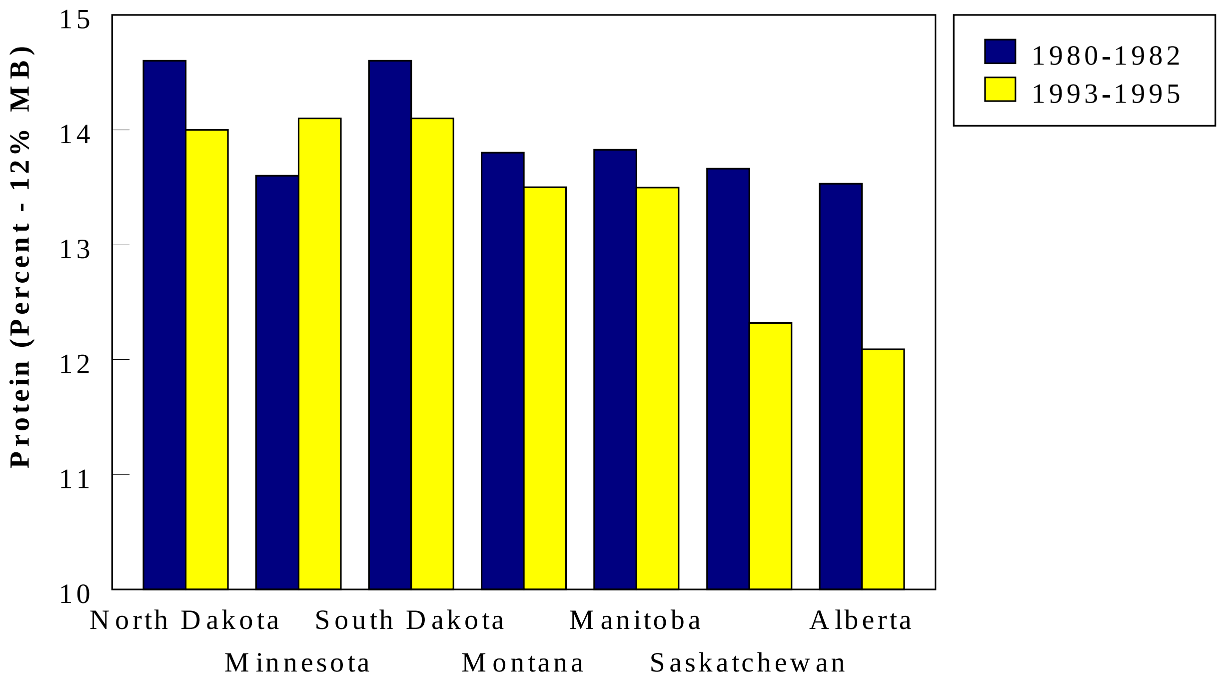

Figure 21. Average Protein by State/Province, 1980-1992 and 1993-1995.

Trends in Yield and Protein

Growth rates for protein and yields from 1980 to 1995 were estimated using regression and the following functional form: yield=a+b^t where t is time (See Table 1). Growth rates for wheat yields were significant and increasing in North Dakota, Montana, and Alberta. This indicates that the average rate of increases in yields in North Dakota was 1.69 percent per year (about .4 bushels per acre) throughout this period. In comparison, growth rates for yield were insignificant for Minnesota, South Dakota, Manitoba, and Saskatchewan, indicating that changes in yield may simply be due to the years chosen rather than exhibiting a trend over time.

Growth rates in protein were statistically significant and decreasing in North Dakota and Montana and increasing in Minnesota. For average protein levels in North Dakota declined 27 percent per year (.04 percentage points per year) from the 1980 to 1995. Growth rates for protein in Canada were not statistically significant. This indicates that changes in protein levels in Canada were random rather than due to a trend over time. However, there has been a trend toward higher yields and lower protein wheat in North Dakota and Montana.

Trade-off Between Protein and Yield

The trade-off between yield and protein was examined to determine which areas have a comparative advantage (lower yield penalty) for producing higher protein wheat and to ascertain changes in the trade-off over time. The trade-off between yield and protein was examined by comparing average protein levels and yields for North Dakota, Minnesota, South Dakota, Montana, Manitoba, Saskatchewan, and Alberta from crop quality surveys. Data for the United States were collected at the crop reporting district level, while observations for Canadian provinces were only available on a provincial level.

The relationship between yield and protein was examined to determine if a fixed effects model or a random effects model best fits the data. Results indicate that a fixed effects model with dummy variables for location and time was applicable. The random effects model was rejected. Models were then developed where yield = f ($protein^2$, location, year) and yield = f (protein, $protein^2$, location, year). The relationship between protein and yield was estimated using binary variables for both slope and interaction effects for region, protein, and year. Only significant effects were retained. The estimated parameters for the model are listed in Table 2. Estimated relationships were graphed for 1980 and 1995 (Figures 22-23).

Results indicate that the frontier for the trade-off between yield and protein has shifted up with more yield possible at the same protein level. Yields for a given protein level increased at the rate of .23 bu/a/year from 1980-1995 for many of the states/provinces. However, the increase in yields for a given level of protein was lower for South Dakota and Saskatchewan than for the other states/provinces.

Table 2. Estimated Parameters for Yield/Protein Relationships, by Region, 1980-1995.

Parameter	Value
Intercept	-388.770000
$Protein^2$	-0.207626
Year	0.232230
S2	32.459679
S4	-3.158560
S5	-4.359073
S7	-4.794248
S2*Protein	-1.996809
S3*Protein	1.382947
S3*Year	-0.011673
S6*Year	-0.004491
R-Square	.646000

where

$Protein^2$ is (Protein 12 percent MB)^2,
Year is year,
S2 is a Binary variable for Minnesota,
S4 is a binary variable for Montana,
S5 is a binary variable for Manitoba,
S7 is a binary variable for Alberta,
S2*Protein is a binary interaction term for Protein in Minnesota,
S3*Protein is a binary interaction term for Protein in South Dakota,
S3*Year is a binary interaction term for Year in South Dakota, and
S6*Year is a binary interaction term for Year in Saskatchewan.

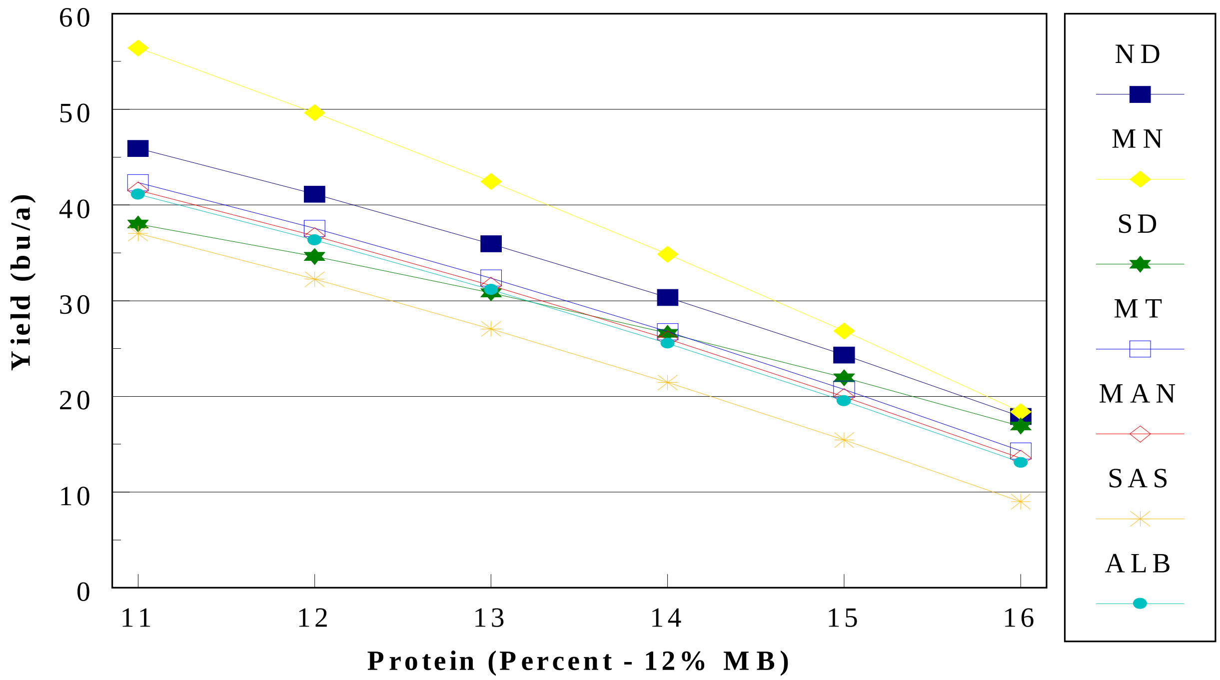

Figure 22. Estimated Relationship Between Protein and Yield, by State/Province, 1980.

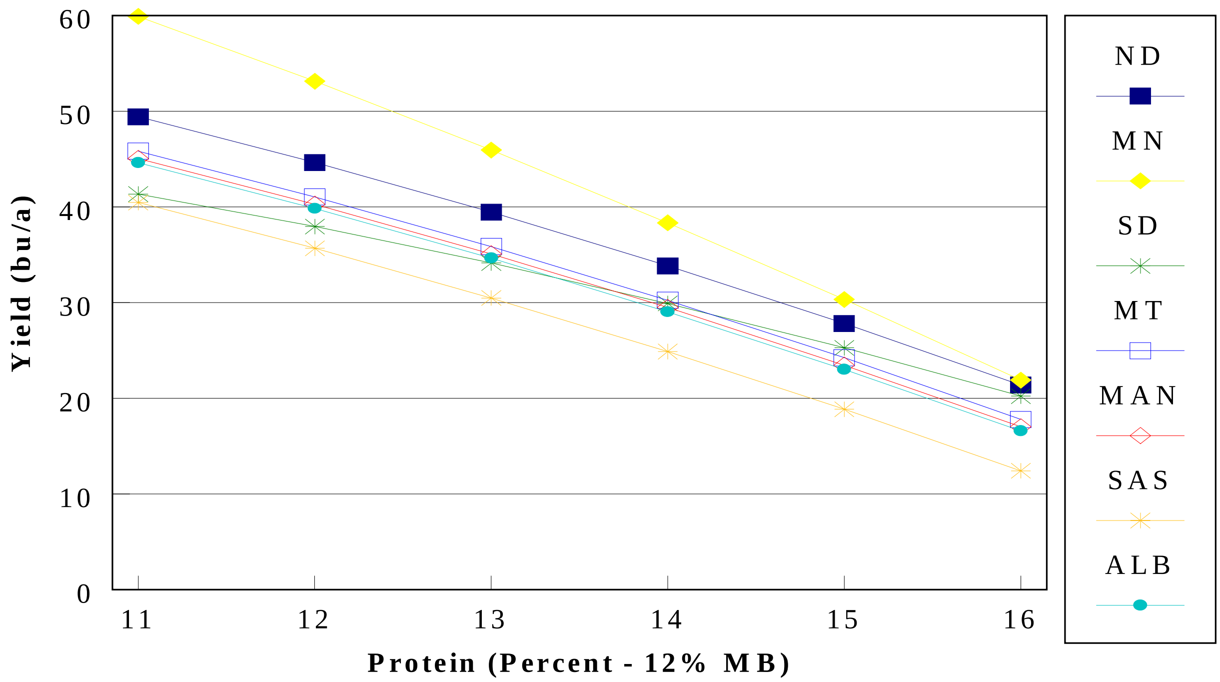

Figure 23. Estimated Relationship Between Protein and Yield, by State/Province, 1995.

The frontier or slope for the trade-off of yields for protein was highest for North Dakota and Minnesota. In contrast, Saskatchewan had the lowest slope followed by South Dakota for protein levels less than 13 percent and Alberta, Manitoba, and Montana for protein levels over 14 percent. This indicates that North Dakota and Minnesota should be able to produce 1) more wheat, 2) higher protein wheat, or 3) some combination of higher yielding, higher protein wheat than Saskatchewan.

Coefficients for protein/yield trade-offs were derived for 1980-1982 to 1993-1995.[8] Estimated tradeoff coefficients for 1980-1982 ranged from a low of 4.68 bushels per acre per percent of protein in South Dakota to a high of 7.65 bushels per acre per percent of protein in Minnesota. This indicates that increasing protein levels by 1 percent would result in yield losses of 4.68/A in South Dakota compared to losses of 7.65/A in Minnesota. Trade-off coefficients declined from 1980-1982 to 1993-1995, except for Minnesota which increased. This indicates that the penalty for increasing protein has declined over time, except for Minnesota where the penalty has actually increased.

These coefficients indicate that increases in protein could be achieved with a lower penalty for reduced yields in South Dakota, Alberta, Montana, Saskatchewan, and Manitoba. This indicates that these regions have a comparative advantage in production of high protein wheat since yield sacrificed to gain higher protein wheats would be less. Comparison of yield losses with an increase in protein on a percentage basis indicates that Alberta has a comparative advantage over the remaining regions (Table 1). Farmers in Alberta would sacrifice 17 percent yield in 1980-1982 to 13.2 percent of yield in 1993-1995 to increase protein 1 percent. This represents a smaller percentage of total yield lost to increase protein in Alberta than in the other regions. The range of protein/yield trade-offs on a percentage basis represent 13.2 to 20.9 percent yield reductions per 1 percent increase in protein for the Canadian provinces and are larger than the 10 percent yield reduction per 1 percent increase in protein reported by CWB and CGC, 1996, for Canada.

Estimated coefficients for North Dakota indicate that the yield penalty to increase protein has declined from 1980-1982 to 1993-1995. On a per bushel basis, yield losses at 5.81 bu/percent protein are slightly higher than for Manitoba and Montana, yet lower than for Minnesota. However, comparison on a percentage basis for 1993-1995 indicates that the penalty in North Dakota is similar to Manitoba and is actually higher than for Montana.

Performance of Licensed Versus Unlicenced Varieties

In Canada, only registered (licensed) varieties may be delivered for the top milling grades of wheat. Unlicenced varieties are relegated to the lowest grade for the class (CWAD5 for CWAD and Canada Feed for all other Canadian common wheat classes) (Dexter). Since United

[8] The trade-off coefficients were derived by taking the derivative of regression results with respect to protein and multiplying by average yields.

States and Canadian hard red wheat production regions are adjoining, this opens the possibility of higher yielding United States varieties migrating across the border and entering Canadian production. However, the yield increase of these non-licensed varieties comes with a price impact (they can only be sold for feed). In addition, one of the recommendations of the WGMP was to liberalize trade in unlicenced varieties. Thus, the performance of unlicenced varieties over licensed varieties could have an important effect on the supply of wheat. To examine the extent of yield differences between licensed and unlicenced varieties, yields for varieties planted in North Dakota and Canadian varieties were compared.

A number of Canadian varieties have been examined in North Dakota yield trials. Yields of these Canadian varieties for four years (1989, 1990, 1994, and 1995) were available when Canadian varieties were included in test plots. Average yields for the tested Canadian varieties were compared on a percentage basis to average yields for varieties tested that were released from United States agencies for North Dakota production. Results indicate that the Canadian varieties out yielded the average for North Dakota varieties in three cases: Langdon in 1995, Carrington in 1994, and Dickinson in 1989 (Figure 24). In all other cases, a significant yield penalty was present for Canadian varieties in all locations. These results are limited largely by location and a better measure of comparison would be between Canadian varieties and unlicenced varieties grown on Canadian locations.

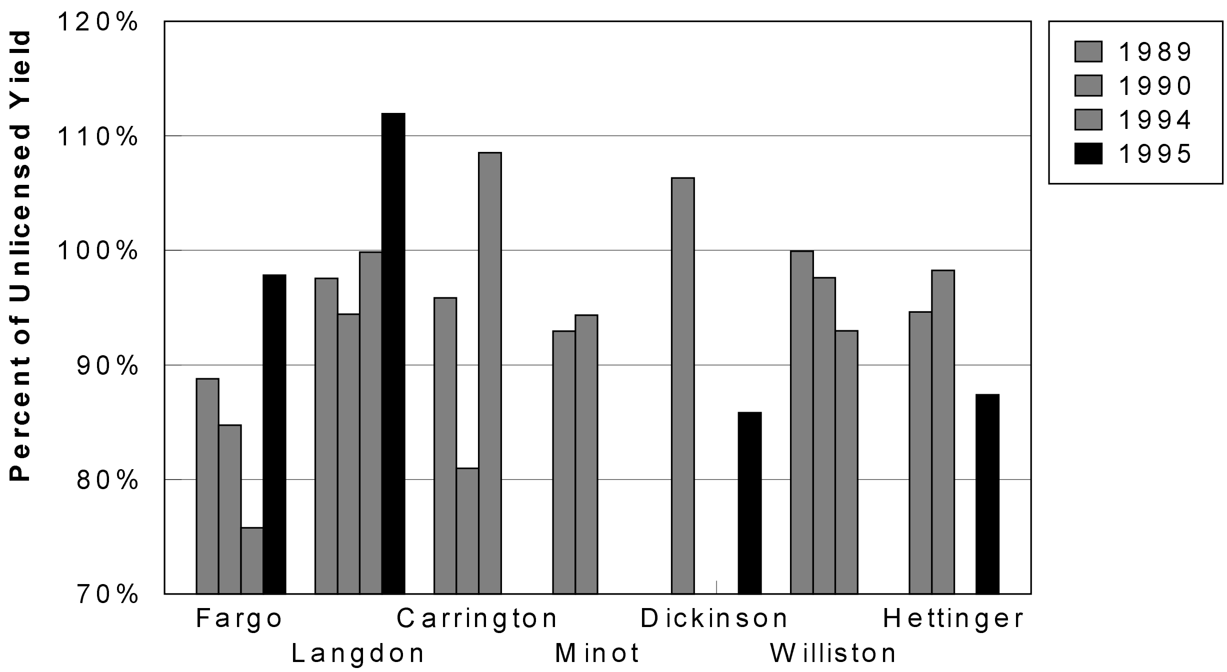

Figure 24. Performance of Canadian Licensed Varieties as a Percent of North Dakota Varieties, From North Dakota Yield Trials, by Location, Various Years.

CHARACTERISTICS OF END-USE QUALITY ADOPTION

To examine the extent that the quality of varieties has impacted the production of quality wheat, adoption of varieties across North Dakota was compared using the overall quality rating for varieties (Helm). This ranking is an assessment of overall end-use quality descriptions and is categorized as 4 = good quality, 3 = average quality, 2 = poor quality, and 1 = very poor quality. However, no varieties were classified as very poor quality. Average characteristics for varieties within a quality rating category were weighted by the shares of planted acres devoted to that variety to obtain an average value for characteristics of varieties within each group. Characteristics were obtained from Helm.

Average characteristics for the end-use quality rankings indicate that the poor and average end-use quality varieties had the highest relative yield while average and good end-use quality varieties were planted on the largest shares of wheat acres from 1979-1995 (Table 3). Good end-use quality varieties tended to be older varieties (more years since release). Varieties planted that were released from private firms were generally of poor end-use quality while 100 percent of good and 99.7 percent of average end-use quality varieties planted were public releases. Poor end-use quality varieties were later maturing than average or good end-use quality varieties and were more susceptible to stem and leaf rust.

Table 3. Weighted Average Characteristics for HRS Wheat, by Quality Rating, North Dakota, 1979-1995*

Characteristic	Quality Rating		
	Poor - 2	Average - 3	Good - 4
Variety Adoption (percent of Planted Acres) **	12.9a	36.5b	32.7b
Relative Yield (percent)	1.05a	1.03a	0.98b
Years Since Release	5.16a	5.50a	7.67b
Maturity (1=early, 3=medium, 5=very late)	3.00a	1.61b	2.04c
Straw Strength (1=very strong, 2=strong, 3=medium strong)	1.61a	2.89b	2.03c
Leaf Rust (1=resistant, 3=susceptible)	1.50a	1.09b	1.27c
Stem Rust (1=resistant, 3=susceptible)	1.04a	1.02ab	1.01b
Test Weight Rating (1=high, 2=medium, 3=low)	1.34a	1.12b	1.27a
Public Varieties (percent)	49.30a	99.70b	100.00b

* Varietal characteristics weighted by percent of variety adoption.
** percentages do not sum to 100 percent due to non-identification of minor varieties. Numbers for varietal characteristics of end-use groups followed by different letters are significantly different at 95 percent probability.

Shares of planted acres by end-use quality categories were compared for North Dakota as a whole and across crop reporting districts. Shares of planted acres for each of the categories from 1978-1995 have varied (Figure 25). Poor end-use quality varieties increased from 1978 to the middle 1980s and have fallen to minimal shares of planted acres in the 1990s. Since the middle 1980s, the proportion of wheat planted to end-use quality ratings 3 and 4 (average and good) have increased, with the largest shares planted to average (3) quality varieties.

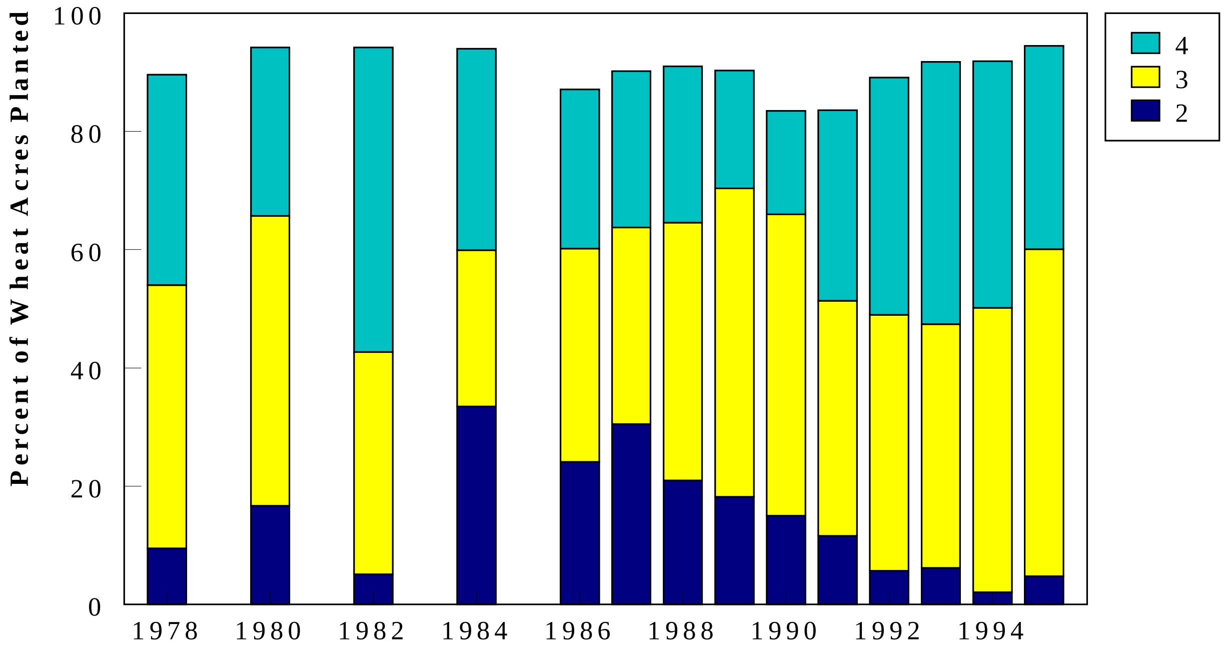

Figure 25. Variety Adoption by End-use Quality Rating, North Dakota, 1978-1995.

Adoption of varieties of different end-use quality was compared by CRDs. Shares of planted acres devoted to each of the categories of quality suggest a difference in adoption across North Dakota CRDs for 1978-1995. During the 1980s, farmers in all the CRDs increased their production of poor end-use quality varieties but, have since reduced acres to minimal levels in the 1990s. This increase in production of poor end-use quality varieties was most prevalent in the eastern CRDs (Regions 3, 6, and 9). Farmers in the northwestern regions of North Dakota are more likely to plant more of their wheat acres to varieties that have good end-use quality characteristics, as evidenced by the large shares of planted acres devoted to quality group 4 in Crop Reporting Districts 1, 2 and 4 (Figure 26). This trend toward higher production of good end-use quality varieties increased throughout the 1990s for these three northwestern regions. Farmers in the eastern portions of the state appear to favor planting varieties with average or poor end-use quality. All three of the eastern regions have decreased planting of poor end-use quality varieties in the 1990s in favor of average end-use quality varieties. Crop Reporting Districts 5, 7, and 8 have varied over time. The only apparent trend in these three districts is toward higher use of average end-use quality varieties in the central portion of the state (CRD 5). Thus, there is an increased trend toward production of good end-use quality wheat in the western portions of North Dakota than in to the eastern portion of the state, though in both regions there has been a shift from poor quality.

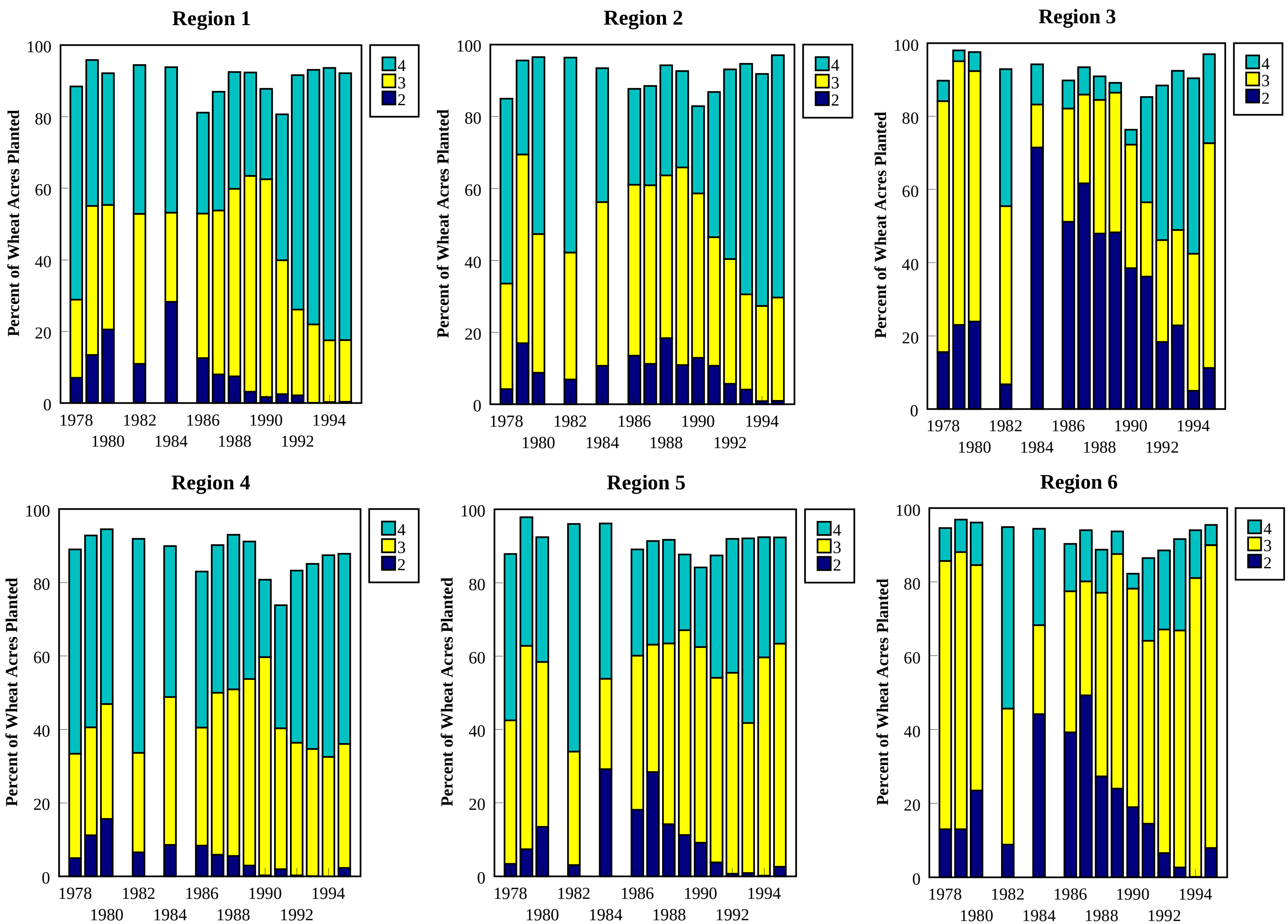

Figure 26. Variety Adoption by Quality Rating for North Dakota Crop Reporting Districts, 1978-1995.

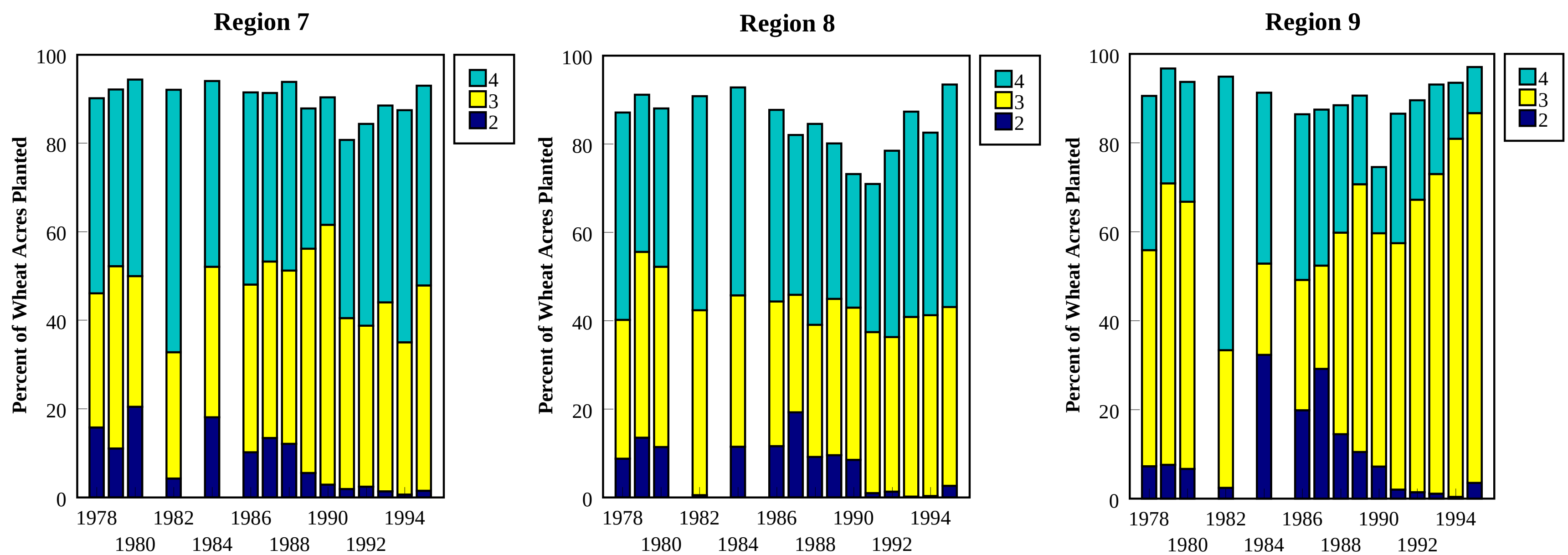

Figure 26 (Continued).

VARIETY SELECTION MODELS

Variety adoption in North Dakota, Alberta, Saskatchewan, and Manitoba has varied. In this section, econometric models of variety selection are developed to determine factors most important for varietal selection and to compare and contrast factors across North Dakota and the Canadian provinces.

Previous Studies

Research has generally examined variety selection in the context of adoption of new technologies (Lin, Pitt and Sumodiningrat, and Ito et al.). Barkley and Porter examined determinants of variety selection in Kansas. They developed an input characteristic model (ICM) to examine theoretical determinants of wheat variety choice. Their model of demand for variety (I) was represented as a function of wheat price, seed prices, costs of uncertainty, and production characteristics.

$$Xi = Xi\ (pw, w, \lambda, q1,...qn)$$

where

Xi is demand for variety (I),
pw is the price of wheat,
w is the price of seed,
λ is cost of uncertainty, and
q1,...qn are production characteristics.

They found Kansas producers consider end-use qualities, production characteristics, relative yields, yield stability, and past production decisions when selecting varieties.

Empirical Model

Following Barkley and Porter, a model of demand for variety (I) was represented as a function of wheat price, seed prices, costs of uncertainty, and production characteristics.

$$X_i = X_i\ (pw, w, \lambda, q1,...qn)$$

However, Barkley and Porter included parameters for variance of yields across variety trials. Because of the vast differences in environment (climate and soil types) across North Dakota, we identified those varieties that outperform in the eastern portion of the state and are generally lower in quality rather than identify some sort of variability for an area. Thus, parameter estimates were opposite in sign and generally not significant. In addition, no yields were reported for any of the Canadian provinces. For these reasons this effect was not included. All yields at a location are reported only as a percent of a base variety. Since the yields for the base variety changes from location to location, there was no reference. This might have been appropriate; however, due to significance problems, we dropped inclusion of the parameter for yield variability altogether. This reduces the Barkley and Porter model to.

$$X_i = X_i\ (pw, w, q1,...qn)$$

Data were collected on varietal shares of planted acres by crop reporting district for North Dakota and for crop districts in Alberta, Manitoba, and Saskatchewan (North Dakota Agricultural Statistics Service, Alberta Pool, Saskatchewan Wheat Pool, and Manitoba Pool Elevators). The variable explained by the models is the percent of crop acres planted to variety (I) in a crop district in year (t). Data were available for Canadian crop districts for Manitoba, Alberta, and Saskatchewan from 1976 to 1992 (data for 1987, though published, was not obtainable) and for Manitoba in 1994 and 1995. Data for North Dakota were available for the nine crop reporting districts from 1978-1995, except for 1981, 1983, and 1985 when variety surveys were not conducted.

North Dakota, Manitoba, Alberta, and Saskatchewan all conduct varietal trials and distribute yield results from the trials and information on agronomic traits to farmers. Results from varietal trials and published variety recommendations were collected for North Dakota, Manitoba, Saskatchewan, and Alberta (Manitoba Agriculture, Saskatchewan Agriculture, Alberta Agriculture, North Dakota State University). Yields in Canada were gathered for regions within the provinces and represent relative yield compared to a base variety grown at that location (Neepawa for most years). Relative yields were estimated for North Dakota by averaging yields for varieties at specific locations per year and calculating relative yields by variety in comparison to this station average.

Agronomic characteristics reported for North Dakota and Canadian provinces varied. North Dakota reported information on variety maturity, straw strength, stem rust, and leaf rust. The Canadian provinces reported information on maturity, stem rust, leaf rust, lodging, shattering, bunt, smut, and root rot. North Dakota reported information on test weight ratings, protein ratings, and an end-use quality rating. Only agronomic and yield information was reported for Canadian varieties (test weight and kernel weight were reported only in recent years).

Variety maturity in North Dakota was reported as early, medium early, etc. and was transformed into an ordinal scale from 1 to 5 with 1 representing early and 5 very late. Maturity for varieties in Saskatchewan and Manitoba were published on days to maturity. This days to maturity measure was utilized for these two provinces. Stem rust, leaf rust, shattering, lodging, bunt, smut, and root rot were similarly transformed from subjective rankings to an ordinal scale with 1=excellent, 2=fair, and 3=poor. Test weight ratings were similarly transformed from subjective ratings of high, average, and low to an ordinal scale with 1=high, 2=medium, and 3=low. Quality ratings were the same as in previous sections with highest quality rated as 4 and lowest as 1, although no varieties were classified with a quality rating of 1, so the relevant range was from 4 to 2.

A variable representing the release agency was included for North Dakota. Agencies were classified as either 0 for private releases or 1 for public releases. This variable should represent the increased seed cost of private releases.

Other variables potentially impacting the price of wheat produced included deficiency payments and protein premiums. Incorporation of protein premiums was tried in North Dakota, but dropped due to multicollinearity with deficiency payments. Deficiency payments were incorporated by creating a new variable that represented the interaction between average deficiency payments as a percent of wheat prices and yields. Protein premiums and an interaction term between protein premiums and yields were tried in the Canadian provinces, but rejected due to insignificance. This suggest that Canadian growers have not been responsive in variety choice to protein premiums.

In contrast to Barkley and Porter, varietal adoption was incorporated in the context of the life cycle of varieties rather than past behavior. Varieties are developed, released, and adopted by farmers for a given period before they fall out of favor and are replaced by newer improved varieties. Varieties can fall out of favor due to a number of factors, including loss of disease resistance as varieties get older and pathogens evolve, release of a newer variety with improved characteristics, or poor agronomic performance (lodging, shattering, poor thresh ability, etc). This pattern of varietal adoption including variety life cycles was incorporated by calculating years since release for varieties. Parameters for squared and cubic terms of years since release were included to allow for all aspects of the distribution, reflecting varietal life cycles (growth, maturity, and decline).

Two types of models of varietal adoption were developed. First, a linear model of varietal adoption was estimated. This model has limits because it allows relationships to be fit that may lie outside the range of possible shares of planted acres. Second, the data were fitted to a double truncated model (limits imposed on minimum and maximum market shares achievable). Both types of models were estimated on a state/provincial level due to varying data availability. Models were estimated for North Dakota using data from 1978 to 1995; Manitoba, 1985-1992; Alberta, 1976-1992; and Saskatchewan, 1984-1992.

Data for shares of planted acres for dominant varieties indicate differences across regions (Figures 27-30). North Dakota and Manitoba have more varieties that have attained significant portions of planted acres from 1974 to 1995, yet few varieties dominate planted acres over an extended period. In contrast, production of hard red spring wheat in Saskatchewan and Alberta was dominated over an extended period by the variety Neepawa and to some extent by Katepwa.

Average characteristics for North Dakota and the Canadian provinces were calculated (Table 4). The average North Dakota variety from 1978 to 1995 had 5.36 percent share of planted acres compared to 8.29 percent, 7.93 percent, and 11.35 percent in Alberta, Saskatchewan, and Manitoba, respectively. Average years since release for varieties also indicated that varieties in North Dakota were younger (5.35 years) than varieties in the Canadian provinces (9.69, 11.54, and 12.89 for Manitoba, Saskatchewan, and Alberta) which were nearly twice as old as those in North Dakota. North Dakota varieties in the sample were 70 percent public varieties and had average end-use quality characteristics that ranked poor to average.

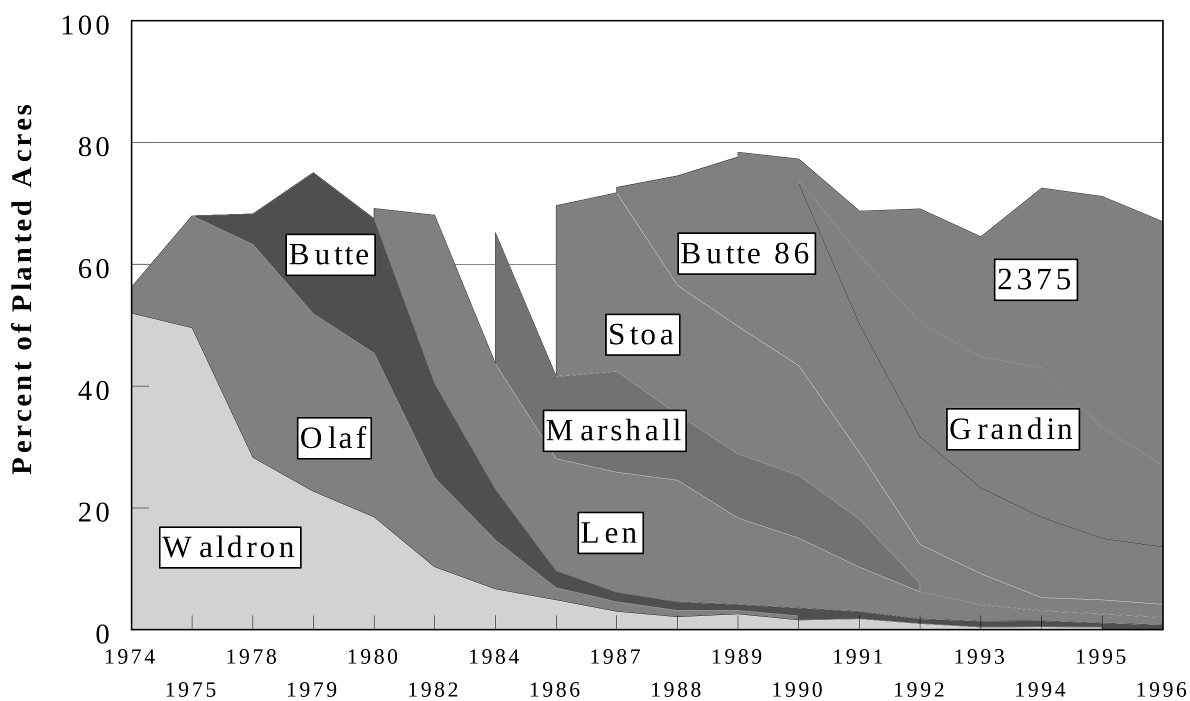

Figure 27. Percent of Planted Acres for Selected Hard Red Spring Wheat Varieties, North Dakota, 1974-1996.

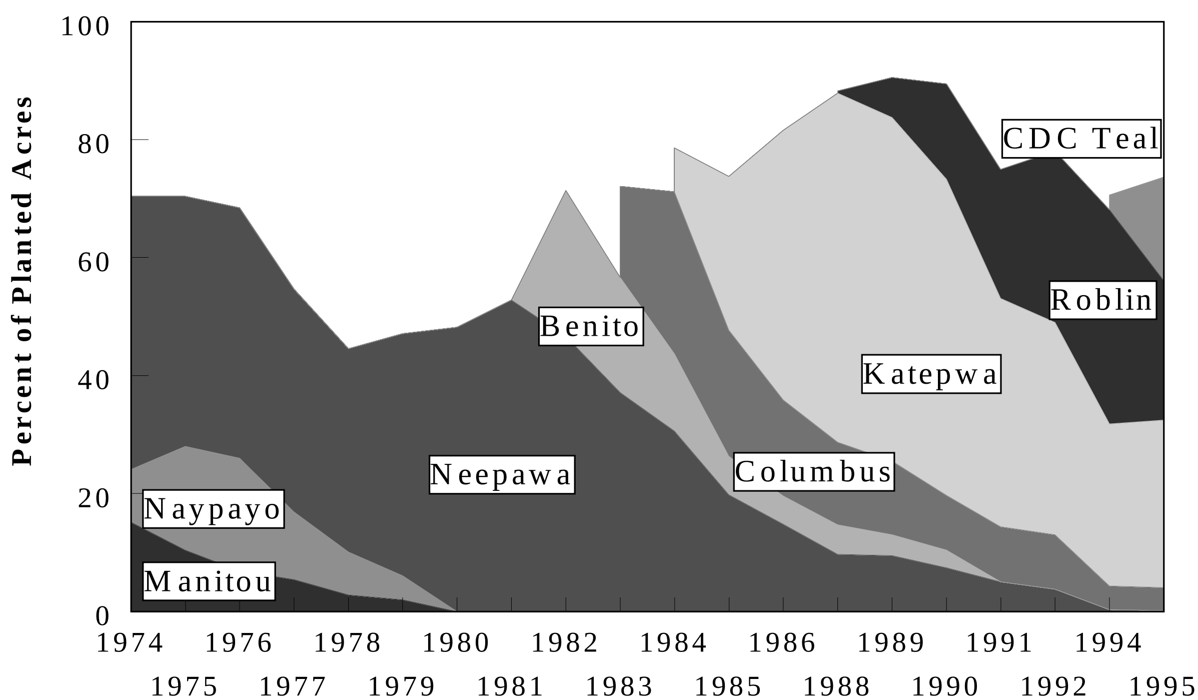

Figure 28. Percent of Planted Acres for Selected Canadian Western Red Spring Varieties, Manitoba, 1974-1995.

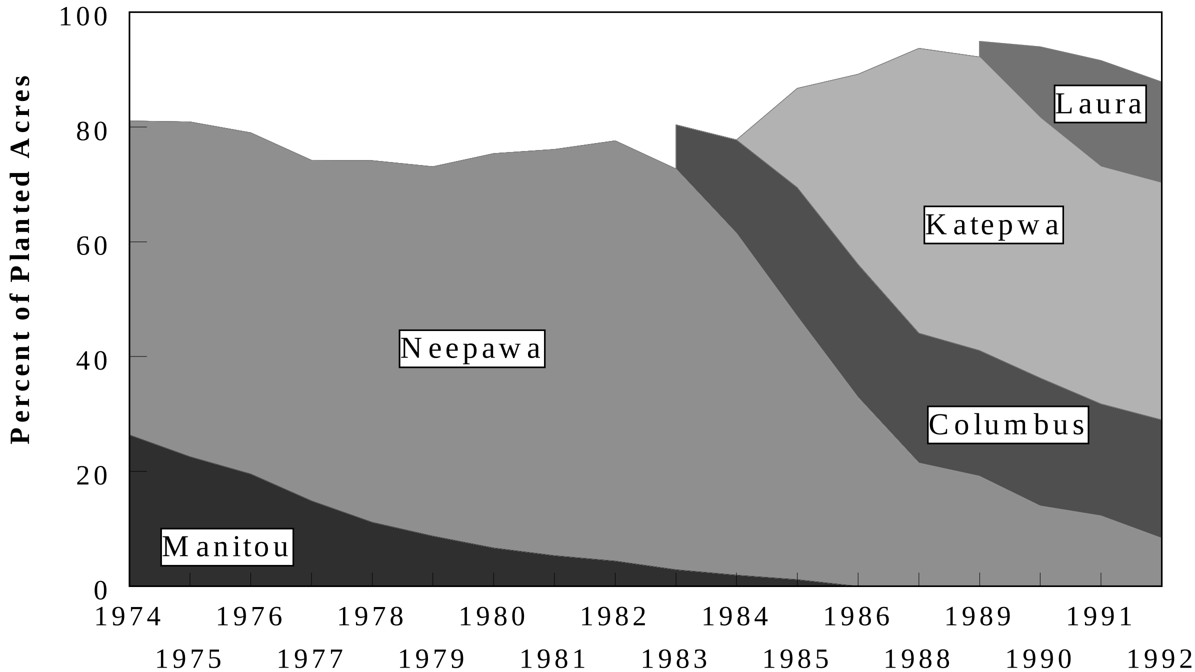

Figure 29. Percent of Planted Acres For Selected Canadian Western Red Spring Wheat Varieties, Saskatchewan, 1974-1992.

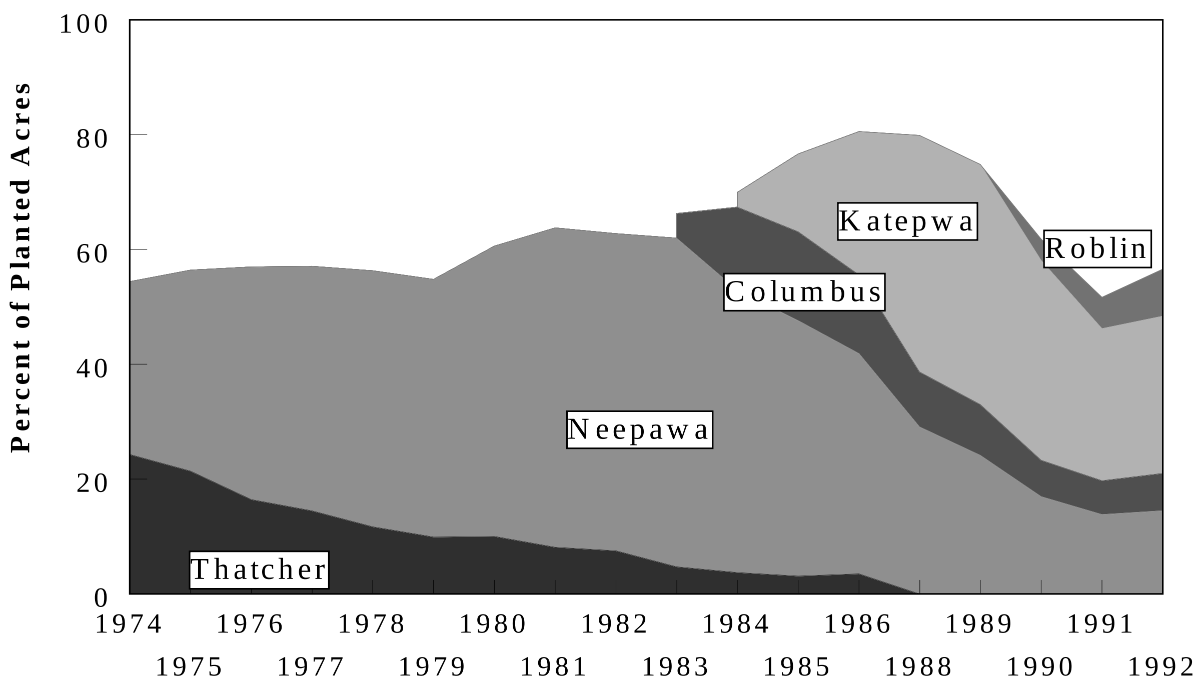

Figure 30. Percent of Planted Acres For Selected Canadian Western Red Spring Wheat Varieties, Alberta, 1974-1992.

Table 4. Average Characteristics for Varieties, by State/Province.

	North Dakota	Manitoba	Saskatchewan	Alberta
Share of Planted Acres	5.36	11.35	7.93	8.29
Relative Yield	1.007	1.034	1.024	0.967
Years Since Release	5.35	9.69	11.54	12.89
Stem Rust	1.04	1.00	0.95	
Leaf Rust	1.42	1.32	1.59	
Maturity	2.46	98.51*	99.59*	0.39
Straw Strength	2.22			
Quality Rating	2.75			
Test Weight Rating	1.46			
Agency	0.70			
Lodging		0.63	1.23	1.21
Shattering			1.18	1.23
Smut		1.62	1.70	1.53
Bunt		1.95	1.96	1.87
Root Rot			2.11	2.15

* Represents days to maturity, whereas Alberta and North Dakota have maturity ranks on ordinal scales of -2 to -3 for Alberta and 1-5 for North Dakota.

Linear Models

Linear models of variety adoption were estimated for each of the states/provinces for the years data were available. Models were tested as panel data to determine if there were group (crop reporting district) and/or year effects. In all cases, group and year effects were rejected. Thus, these models were unable to ascertain regional differences in market shares or trends in market shares. This may be due to the generic quality of market shares when they are not tied directly to a variety.

Results for North Dakota, Alberta, and Manitoba (the states/provinces with most data available) indicate that OLS models explain 23 to 33 percent of the variability in market shares for varieties. Signs for estimated parameter coefficients were appropriate for all three of these state/province models as well. In North Dakota, increased scores for leaf and stem rust (implying more susceptibility to disease infestation) indicated reduced market shares (Table 5). Similarly, increased susceptibility to lodging, shattering, smut, and root rot in Alberta indicated lower market shares for varieties. Parameters for lodging, bunt, and smut were also negative and significant in Manitoba. Coefficients for maturity were significant for North Dakota, Alberta, and Saskatchewan. The signs for coefficients were as expected for North Dakota and Alberta where earlier maturing varieties (lower score for maturity) had increased market shares. Meanwhile, the model for Saskatchewan was able to explain more of the variability (.67 R-square), but had contrary signs on coefficients for both maturity and leaf rust.

Table 5. Estimated Parameter Coefficients for Linear Estimation Models of Varietal Selection

Variable	North Dakota	Alberta	Saskatchewan	Manitoba
Constant	-20.15*	-48.65*	-411.04*	-3.76
Relative Yield	14.08*	0.73*	.008	.34*
Release	3.81*	2.40*		6.14*
Release2	-0.42*	-0.11*	0.24*	-0.67*
Release3	0.01*	0.01*	-0.01*	0.02*
Stem Rust	-1.79*		-19.52*	
Leaf Rust	-0.90*		9.92*	
Maturity	-1.10*	-5.20*	4.64*	
Quality Rating	2.93*			
Test Weight Rating	-1.74*			
Agency	3.91*			
Deficiency Payment * Yield	0.68*			
Lodging		-2.40*	-17.44*	-7.01*
Shattering		-1.62*	-7.63*	
Bunt			-6.80*	-6.92*
Smut		-3.80*		-8.41*
Root Rot		-2.70*		
R-square	.23	.33	.67	.32

Coefficients for years since release for a variety for North Dakota, Alberta, and Manitoba indicated increasing initial effects as varieties are adopted, a slowdown and decline as peak adoption is attained, and a decline and re-emergence stage. Estimated coefficients for the years since release variables indicate that Saskatchewan and Alberta reach maximum area shares for varieties well after North Dakota and Manitoba. In fact, maximum penetration for a variety (within the life of a variety) was 5-7 years for North Dakota and Manitoba, compared to 15 years for Saskatchewan and Alberta (Figure 31). This is born out by shares of planted acres for major varieties grown in the states/provinces (Figures 27-30).

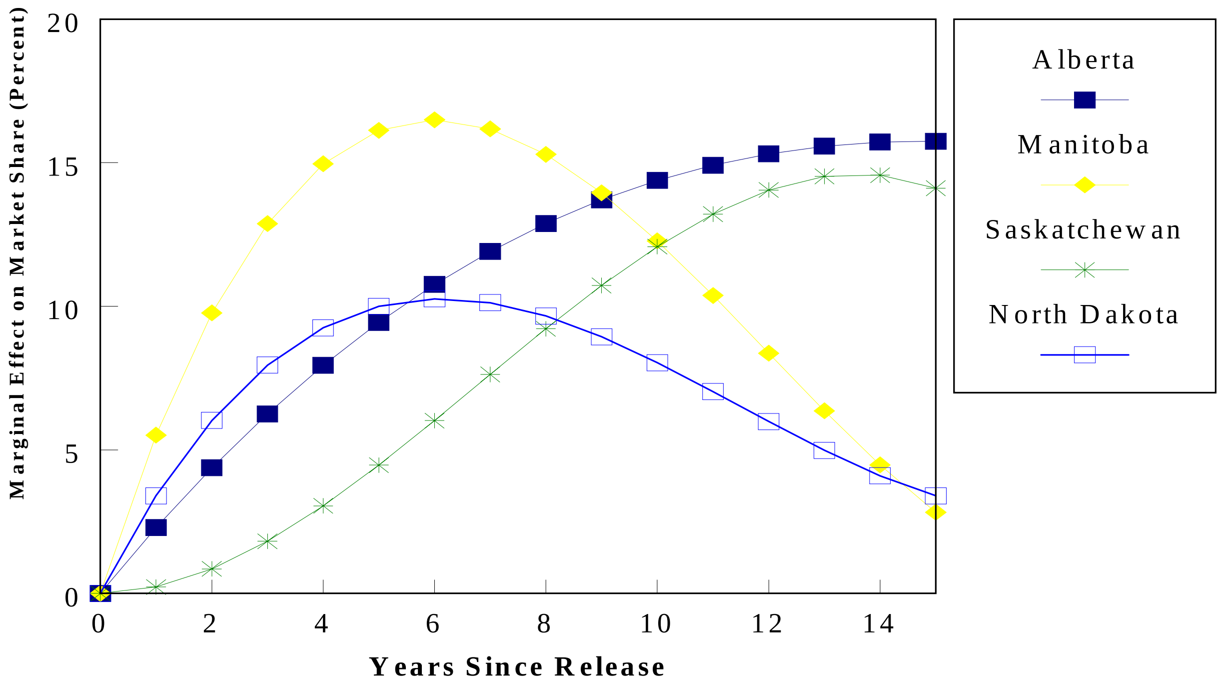

Figure 31. Relationship Between Variety Share of Planted Acres and Years Since Release, by State/Province, Linear Model.

Estimates for coefficients for relative yields were significant only in North Dakota, Alberta, and Manitoba. Signs of the parameters were appropriate because as relative yields increased, area shares increased. The effects of relative yields on market shares was more dramatic in North Dakota.

Quality parameters for North Dakota indicated that as the overall quality rating increased, (higher quality) area shares increased. This suggests that for two varieties, all other factors equal, one with an end-use quality rating of 4, the other with an end-use quality rating of 3, the variety with the higher end-use quality rating would be adopted on 3 percent more wheat acres than the lower end-use quality variety. Similarly, as the test weight rating increased, (lower test weight) market shares declined. This also suggests that improvements in test weights increase the amount that a variety is planted. Therefore, in both of these instances, improvements in wheat quality appear to increase adoption rates. Data on quality parameters were not available for

Canadian varieties and not included in Canadian models.

Effects of the agency's releasing varieties were significant for North Dakota and indicate, everything else being equal, a 4 percent increase in area shares for publicly released varieties over privately released varieties. Another economic variable that was significant was the interaction of deficiency payments as a percent of average farm price with relative yields. This parameter indicates that as deficiency payments become a higher proportion of farm income, farmers increase market shares for higher yielding varieties. For example, if deficiency payments are $1/bu and the average farm price is $3.50/bu and either deficiency payments increase to $1.10/bu or average farm prices decrease to $3.18/bu (10 percent changes), a variety with average yields (100 percent relative yield) would be planted on 0.68 percent more wheat acres. Therefore, a 10 percent change in the importance of protein premiums for wheat income results in less than a 1 percent change in wheat acres planted to that variety. Protein premiums and interactions of protein premiums were examined; however, they were not significant.

Double Truncated Models

The relevant range for area shares lies between 0 and 100 percent. A double truncated model of varietal shares was developed to incorporate these limitations of the dependent variables. Models were developed again on a state/province level and tested for group (crop district) and year effects. In Alberta, group effects were significant while year effects in Alberta and group and year effects in the other state/province models were rejected. Because of the estimation procedure, parameter estimates do not reflect marginal changes in area shares. Instead, marginal effects were calculated for all variables. Results from the four models indicated a correlation between predicted and actual area share values that ranged from .42 for North Dakota to .76 in Saskatchewan. Correlations for Alberta and Manitoba were .61 and .63, respectively.

Results for North Dakota were similar to results from the linear model except the parameter for relative yields was not significant and opposite in sign from what would be expected (Table 6). Parameters for the remaining variables were significant and of the appropriate sign. Increases in susceptibility to leaf rust or stem rust, movement toward a later maturing variety, and lower test weight ratings (lower test weights) all decreased area shares. An increase in quality rating, choice of varieties released by public agencies, or higher values for the term representing the interaction between deficiency payments as a percent of total farm prices and yields all increased area shares. Results for variables associated with years since release of the variety also have the same signs as in the linear models (Figure 32).

Table 6. Estimated Parameter Coefficients for Double Truncated Models of Varietal Selection.

Variable	North Dakota	Alberta	Saskatchewan	Manitoba
Constant		-0.57*		
Relative Yield	-0.018	0.009*	0.010*	0.0032*
Release	0.048*	0.030*		0.0816*
Release2	-0.005*	-0.001*	0.003*	-0.0089*
Release3	0.0001*	0.00001*	-0.0001*	0.0003*
Stem Rust	-0.056*		-0.117*	-1.0291*
Leaf Rust	-0.028*		0.093*	
Maturity	-0.022*	-0.072*	-0.006*	-0.0102*
Quality Rating	0.023*			
Test Weight Rating	-0.041*			
Agency	0.060*			
Deficiency Payment * Yield	0.012*			
Lodging		-0.065*	-0.139*	-0.0980*
Shattering		-0.016	-0.057*	
Bunt			-0.115*	-0.0721*
Smut		-0.058*		-0.1062*
Root Rot		-0.048*		
Correlation Predicted vs Actual	.42	.61	.76	.63

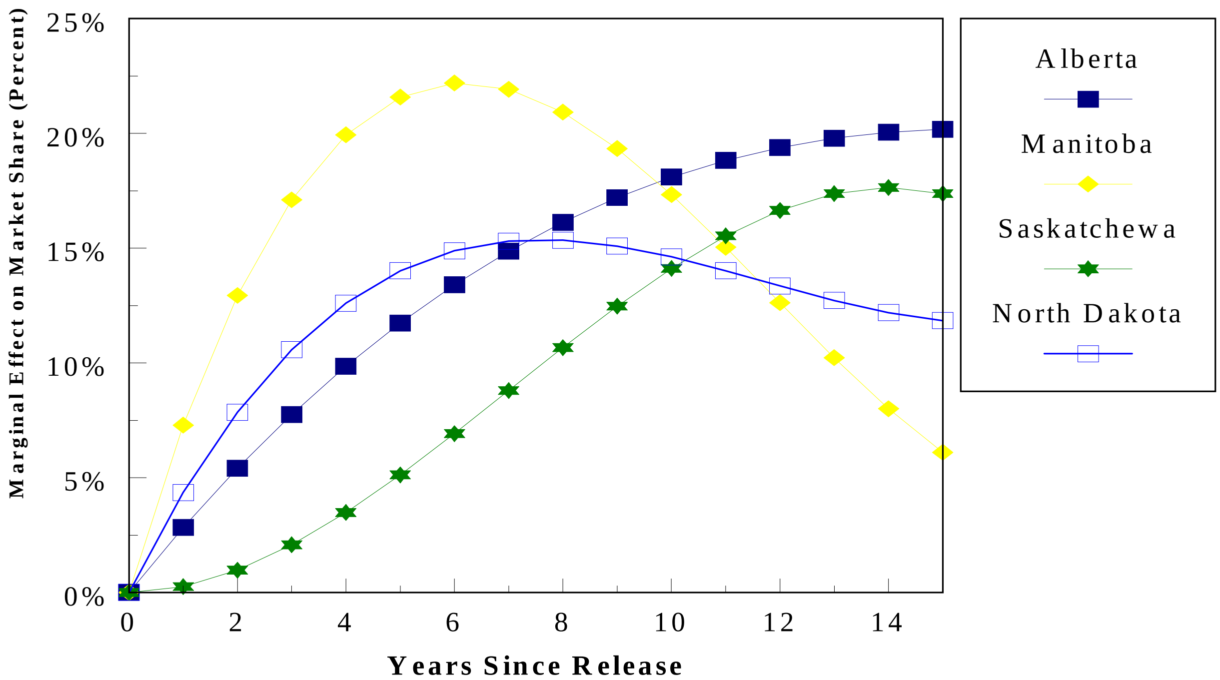

Figure 32. Relationship Between Variety Share of Planted Acres and Years Since Release, by State/Province, Double Truncated Model.

Marginal effects for these parameters were derived on a percentage basis for ease of comparison (Table 7). A one unit increase in stem rust susceptibility for North Dakota would reduce variety area shares by 3.65 percent. Overall, in North Dakota, the size of marginal effects coefficients suggests that agency (public or private), test weight rating, stem rust, and where a variety lies on the varietal life cycle are the largest shifters of area shares. The insignificance of the relative yield parameters suggest that the effects of this variable may be captured by other parameters, at least for North Dakota.

Marginal effects for North Dakota are similar to estimates for the linear models for many parameters. For example, the marginal coefficient for an agency's releasing a variety in North Dakota indicates that publicly released varieties have 3.91 percent more area share than privately released varieties. This is equivalent to the parameter estimate for the agency in the linear model for North Dakota. However, several changes in parameters from the linear model to the double truncated model for North Dakota were apparent. Parameter estimates for relative yield moved from significant to insignificant and changed sign. The marginal effects of stem rust, leaf rust, and test weight rating on area share in the double truncated model are about double those in the linear model. Therefore, a variety with a higher test weight rating (lower test weight) would be planted on 2.67 percent less wheat acres. Marginal effects for the quality rating in the double truncated model were about half as large as those in the linear model. Thus, for two varieties, all other factors the same, the variety with the higher end-use quality rating should be planted on 1.50 percent more wheat acres. Both quality parameters (end-use quality rating and test weight) indicate that improvements in quality increase the adoption of varieties.

Table 7. Marginal Effects for the Double Truncated Models of Varietal Selection.

Variable	North Dakota	Alberta	Saskatchewan	Manitoba
		Crop District 1		
Relative Yield	-1.15	0.72	0.64	0.24
Release	3.14	2.35		6.07
Release2	-0.31	-0.10	0.17	-0.67
Release3	0.009	0.001	-0.008	0.02
Stem Rust	-3.65		-7.41	-76.64
Leaf Rust	-1.82		-5.92	
Maturity	-1.44	-5.75	-0.37	0.76
Quality Rating	1.50			
Test Weight Rating	-2.67			
Agency	3.91			
Deficiency Payment * Yield	0.80			
Lodging		-5.17	-8.82	-7.30
Shattering		-1.26	-3.62	
Bunt			-7.32	-5.37
Smut		-4.61		-7.91
Root Rot		-3.77		

Examination of the changes in marginal effects from the linear model to the double truncated model for the Canadian models indicates similar patterns. For example, the parameters for leaf rust and maturity in Saskatchewan switched signs from opposite of what is expected in the linear model to what we would expect in the double truncated model. Marginal effects for relative yields in Saskatchewan increased to near the size of that for Alberta. Many of the marginal effects for agronomic characteristics were lower in the double truncated models that in the linear model.

Comparison of the results for the double truncated models for the state/provinces indicated a few differences. First, effects of relative yields were not significant for North Dakota, but were significant for all three Canadian provinces. Marginal effects of relative yields in the Canadian provinces ranged from a .24 to .73 percent increase in shares of planted acres for a

1 percent change in relative yields. Second, agronomic variables to a large extent had larger marginal effects on shares of planted acres in the Canadian provinces than in North Dakota. This suggests that agronomic characteristics are more predominant determinants of variety choice in Canada than in North Dakota. Third, effects of a price parameter (interaction of deficiency payments and yields) were significant in North Dakota; however, no price parameters were found to be significant in the Canadian provinces. In addition, the model for Alberta was the only one in which group effects were significant, although the effect on marginal values was minor (Table 8).

Table 8. Marginal Effects for Double Truncated Model for Alberta, by Crop District.

Crop District	Yield	Release	Maturity	Lodge	Shatter	Smut	Root Rot
1	0.73	2.35	-5.75	-5.17	-1.27	-4.61	-3.77
2	0.62	1.99	-4.89	-4.40	-1.08	-3.92	-3.21
3	0.59	1.92	-4.70	-4.22	-1.03	-3.76	-3.08
4	0.73	2.38	-5.83	-5.24	-1.28	-4.67	-3.82
5	0.63	2.02	-4.97	-4.47	-1.09	-3.98	-3.26
6	0.59	1.91	-4.68	-4.21	-1.03	-3.75	-3.07
7	0.65	2.10	-5.15	-4.63	-1.13	-4.13	-3.38
10	0.66	2.13	-5.23	-4.70	-1.15	-4.19	-3.43
11	0.64	2.06	-5.06	-4.55	-1.11	-4.05	-3.31
12	0.63	2.05	-5.02	-4.51	-1.10	-4.02	-3.29
13	0.63	2.06	-5.05	-4.54	-1.11	-4.04	-3.31
15	0.64	2.07	-5.08	-4.56	-1.11	-4.07	-3.33

PROPOSED CHANGES IN POLICY

There has been discussion and analysis on potential changes in the Canadian grain marketing system. Proposed changes have focused on a number of areas. One of the areas is the possibility of changes in the varietal registration process (CWB and CGC). Other areas are the sale of identity preserved grains (CWB and CGC), treatment of unlicenced varieties, the structure of the market system as a whole in Canada, and incentives. Similar discussions have occurred in the United States system. The following sections review proposed changes in policy first for the Canadian system and then for the United States system.

Proposed Changes in the Canadian System

Many changes in the Canadian system have been proposed. This section focuses on three main areas of changes (varietal regulation/identification, identity preserved sales, and treatment of unlicenced varieties). In addition to these areas, there has been an extensive proliferation of incentives introduced into the Canadian grading system (See Page 8).

Varietal Regulation/Identification

Proposed changes in the varietal registration process have focused on the requirement of kernel visual distinguish ability (KVD). The current system relies on varieties within classes having visual distinguish ability so that different classes of wheat can be identified quickly throughout the marketing system. The CWB and CGC indicate that this restriction is limiting improvement in varietal development primarily for classes other than CWRS and CWAD. Four proposed changes in the Canadian Quality Assurance System in 1996 were examined: Change in current quality system; 2) modification of quality parameters for registration within the current system; retaining KVD for all classes of registered wheat; 3) retaining KVD for CWRS and CWAD and discontinuing KVD for all other classes of registered wheat; and 4) discontinuing KVD requirements for all registered classes of wheat.

The CWB and CGC indicate that retaining the current system has limited varietal improvements. However, totally eliminating of KVD would reduce varietal life (a prime characteristic they indicate has been desired by customers), increase kernel size and shape variations (which they indicate will increase clean-outs and reduce milling performance), and increase the potential for misrepresentation of varieties. The second proposed option identified lower protein limits for CWRS and CWRW as a potential change in quality parameters. This option could have significant effects on production. They indicate that the current trade-off of protein for yield is 1 percent protein for 10 percent yield increase. This compares to 13 percent to 21 percent for the results presented in this paper. The CWB and CGC indicate that this would not be appropriate for CWAD where demand for high protein wheat is increasing.

Identity Preserved Sales

A second area of proposed change has focused on identity preserved sales. Canada has already initiated identity preserved sales of wheat. Aaness and Manitoba Pool Elevators indicated that a large independent bakery in the United Kingdom contracted with the Manitoba Pool Elevators for the production of three specific varieties in 1995/96. Wheat that made desired specifications was shipped identity preserved.

Treatment of Unlicenced Varieties

Changes in the marketing system for Canadian grains were examined extensively in 1996. Unlicenced varieties (like Grandin) that have high yield potential and the visual characteristics, but not the quality characteristics for a wheat class, have posed a problem. The Western Grain Marketing Panel recommended the Canadian grain marketing system should be altered so that "unlicenced varieties would be outside the jurisdiction of the Canadian Wheat Board (CWB) and handled through an IP system supervised by the CGC with CWB participation optional" (page 100). Further, United States agencies have started to look at licensing United States varieties in Canada. This allows these agencies another avenue to recapture investments in research.

United States Proposed Changes

The United States marketing system has also been questioned. The United States Office of Technology Assessment (OTA) examined quality issues for United States grain exports. They identified a range of potential changes for three main areas (variety controls, market interventions, and grain standards). Another area (incentives) has been expanded by buyers.
Variety Controls

The OTA study indicated that three main factors have contributed to potential changes in variety controls: 1) grain standards do not measure important intrinsic characteristics, 2) intrinsic quality differs significantly across some varieties, and 3) varieties are not visually distinguishable. These factors increase uncertainty about quality. The OTA identified three proposed policies for varietal controls in the United States system: 1) no change in the present system, 2) variety identification and categorization, and 3) variety licensing.

Movement toward variety identification has occurred on a limited basis. A few identity preserved sales have occurred for specific wheat varieties in the United States Generally, these identity preserved sales are to specific markets for specific uses. Brester et al. indicated that premiums are being paid for the variety Karl in some locations in the United States Further, they examined the American White Wheat Producers Association which is involved in marketing identity preserved hard white wheat. Another example of identity preserved sales in the United States is the production of a hard white wheat variety in Idaho that is being marketed through a co-op (Pro-Mar) (Agweek, November 4, 1996, p. 13).

Grain Standards

The OTA study indicated three potential changes to grading standards. These changes are largely procedural and include mandatory USGSA inspection, single agency to approve testing, and mandatory USGSA inspection in conjunction with NIST equipment approval. Actual changes to grain standards in the United States have occurred. These changes have focused on tightening grain quality. Changes include the lowering of foreign material allowed in the top three grades of wheat. Dockage is now reported in .1 percent rather than .5 percent.

Incentives

Proposed changes have been made for incentives. Many of the changes focus on increasing or expanding the current incentives. For example, Japan has introduced limits on the amount of dockage allowed in shipments and has been steadily decreasing the maximum allowed. For 1997, the maximum allowed will be dropped from .7 percent to .5 percent. This has induced some exporters to introduce premiums for low dockage wheat (Niedens). Other countries have introduced premiums/discounts for other factors and/or are requiring additional non-standard measures in contracts (falling numbers, pesticide residues, and other end-use quality parameters).

CONCLUSIONS AND IMPLICATIONS

The demand for quality wheat had been increasing which has focused attention on the supply and consistency of high quality wheats. The supply of higher quality wheat in Canada and the United States is affected by the types of varieties grown, their inherent quality, the extent that they are adopted, the degree that intervarietal differences are blended withing the marketing system, and agronomic practices and environment. There are differences in processes between Canada and the United States that affect the types of varieties grown and the extent they are adopted. In this study, the extent that varieties are adopted was compared and contrasted among North Dakota, Saskatchewan, Alberta, and Manitoba utilizing a number of measures. Second, protein/yield trade-offs were examined. Third, varietal selection models were developed to identify factors important for determining adoption rates.

There are differences in the varietal release process between the United States and Canada. The process is less regulated in the United States than in Canada where it is written in law. Varieties in Canada can be released with a national, regional, or provincial registration. In the U.S. policies for release are recommendations and vary between the release agencies (private, public) and varieties can be developed and released for specific areas including areas within a state. In Canada, KVD is required for all varieties released within a class. In the U.S., no mention is made of KVD.

Grade standards and incentives differ between the U.S. and Canada. In Canada, varieties are included in grade definitions. Only licensed varieties in Canada can be sold for the top grades of milling wheats. This relegates unlicenced varieties to CWAD5 or feed for all other wheat classes. In the U.S. no mention of varieties are in grade specifications. In the U.S., incentives are measured in relation to a base grade, while in Canada incentives are for grade segregations. Incentives for grade separations (price spreads) between grades 1 and 2 are larger in the U.S. than in Canada. In the U.S. protein is a non-grade factor and incentives for protein are paid throughout the marketing system. In Canada, protein segregations within a grade have been specified and premiums are paid to farmers, although the realization of the full incentive payment can be delayed until the final payment is made.

Processes in Canada are designed to control varietal release and the class/grade in which a variety can be marketed to maintain quality and extend the period when varieties are grown. This has resulted in lower numbers of wheat varieties grown in the Canadian provinces than in North Dakota. This phenomenon is more prevalent for durum wheats than for spring wheats. However, the trend in numbers of spring wheat varieties are toward equal numbers. In the middle 1990s, Manitoba has increased the number of varieties grown to levels equal to or greater than those in North Dakota.

The distribution of shares of planted acres for varieties was examined by comparing shares of planted acres for the dominant variety, shares of planted acres for the top 4 varieties and Herfindahl index scores. Shares of planted acres for the dominant variety in the Canadian provinces were larger than for North Dakota for most years from 1974 to 1996. This is more prevalent for durum wheats than for hard red spring wheats. Shares of planted acres for the dominant variety in some of the Canadian provinces exceeded 70 percent of hard red wheat acres while shares for the dominant variety in North Dakota were seldom higher than 30 percent. This trend is moderating as Canada is moving toward reduced shares for the dominant variety while shares for North Dakota have increased to levels higher than Manitoba for 1995.

Four-variety shares of planted acres and Herfindahl index scores were also higher for the Canadian provinces for most of the 1980s and 1990s. Both of these ratings indicated domination of planted acres by a few varieties with large shares of planted acres in Canada. Further, both indexes indicate that the range of difference between the United States and Canada is more prevalent for durum wheats and that of hard red wheats appear to be becoming more similar (North Dakota has been increasing concentration in fewer varieties while Canadian provinces were reducing concentration over more varieties). Results for all of these measures indicate that during the 1980s and early 1990s, production of hard red wheat and durum in Canada was more concentrated in fewer varieties. This concentration in fewer varieties planted suggests that end-use variability should be lower in Canada than in North Dakota. However, the extent and degree of any changes also depends on other factors (end-use characteristics of individual varieties involved, quality variability between varieties, effects of environment on specific varieties, etc). One possible explanation for the increase in concentration for North Dakota is that few varieties released have disease resistance/tolerance for wheat scab/Vomitoxin which was a significant problem in North Dakota in 1993-1995. Therefore, planted varieties with resistance/tolerance are adopted on more acres.

Trade-offs of protein and yield were compared across Alberta, Saskatchewan, Manitoba, North and South Dakota, Minnesota, and Montana. Results indicated that the Canadian provinces, South Dakota, and Montana have a comparative advantage over North Dakota and Minnesota in increasing protein in hard red wheats. In terms of yield forgone, producers in these areas should be able to increase protein with less yield loss than in North Dakota and Minnesota. This is strictly a comparative advantage in terms of yield forgone to increase protein; it doesn’t say anything about the level of protein (Eg. N.D. greater than S.D.).

Two different types of varietal selection models were developed. Both models indicate that many agronomic factors are important for varietal selection in North Dakota, Saskatchewan, Manitoba, and Alberta. Agronomic factors appeared to have larger impacts on shares of planted acres in Canada than in North Dakota. Relative yields were significant for all regions and models except for the double truncated model for North Dakota. Parameters were included that represent the life cycle of varieties. These parameters were significant in all models and suggest a shorter life cycle for varieties grown in Manitoba and North Dakota (5-7 years to maximum adoption) than for Alberta and Saskatchewan (15 years or more to maximum adoption). This suggests that Alberta and Saskatchewan should have lower variability in end-use quality due to the long period that single varieties are planted. This is primarily evident due to the long adoption periods for the varieties Neepawa and Katepwa in these provinces.

Adoption of varieties by end-use quality was examined for North Dakota. Differences in the variety adoption indicate that crop reporting districts in the northwest portion of North Dakota planted a higher proportion of wheat acres in varieties with good end-use quality. Farmers in the eastern crop reporting districts planted higher proportions of wheat acres in varieties with average to poor end-use quality. The trend in the eastern portions of the state was toward production of wheat varieties with average end-use quality.

Overall, comparisons of variety adoption among North Dakota, Saskatchewan, Alberta, and Manitoba indicated a number of important observations. First, the number of HRS and durum wheat varieties grown in North Dakota is greater than in the Canadian Provinces. Second, in the Canadian provinces, varieties grown have been concentrated in fewer varieties with larger shares of planted acres than in North Dakota. Third, the life cycle for varieties in Alberta and Saskatchewan are longer than for North Dakota and Manitoba. All of these factors suggest that the variability of end-use quality characteristics of HRS wheat and durum grown in Canada should be lower than for production in North Dakota. The extent and degree of lower variability would also depend on other factors (end-use characteristics of individual varieties involved, the degree of intervarietal differences and the extent that they are blended throughout the marketing system, effects of environment on specific varieties, etc). If no intervarietal differences exist, then these conclusions do not hold. Fourth, the trend primarily in hard red spring wheat is toward more uniformity in the number of varieties grown and the distribution of varieties planted. Farmers in North Dakota have been reducing the numbers of varieties grown and have increased reliance on fewer varieties with larger shares of planted acres; while the Canadian provinces are increasing the numbers of varieties grown and are spreading planted acres over more varieties with smaller shares of planted acres. Fifth, South Dakota, Alberta, Montana, and Saskatchewan have a comparative advantage over North Dakota and Minnesota in the production of higher protein wheats. This is strictly a comparative advantage in terms of yield forgone to increase protein and doesn't say anything about the level of protein.

Proposed changes in policies affecting the quality of grains have been advanced. It is interesting to note that many of the changes proposed would move each of the country's market systems and variety controls in the direction of the other's established marketing systems and varietal controls.

REFERENCES

Agweek Staff and Wire Reports. 1996. "New Wheat Type Competes With Australia." *Agweek*. Published by the Grand Forks Herald, Grand Forks, North Dakota, November 4, p. 13.

Barkley, Andrew P., and Lori L. Porter. 1996. "The Determinants of Wheat Variety Selection in Kansas, 1974-1993." *American Journal of Agricultural Economics*. Vol. 78, February, pp. 202-211.

Brester, Gary W., Arlo Biere, and Justin Armbrister. 1996. "Industry Note: Marketing Identity Preserved Grain Products: The Case of American White Wheat Association." *Agribusiness*. John Wiley and Sons, Inc. New York. Vol. 12 (3), pp. 301-308.

Canadian Grain Commission. (Various Years). Quality of Western Canadian Wheat. Grain Research Laboratory. Winnipeg, Manitoba.

Canada-United States Joint Commission on Grains. 1995. *Canada-United States Joint Commission on Grains Final Report*. Washington, DC. October. Vol. 1, pp. 219.

Canadian Wheat Board. 1996. *Grain Matters*. Canadian Wheat Board, Winnipeg, Manitoba. September-October, p. 6.

Canadian Wheat Board and Canada Grains Council. 1996. The Future Quality System for Canadian Wheat. Discussion Paper by the Canadian Wheat Board and Canada Grains Council. Winnipeg, Manitoba. June 5, pp. 15.

Dahl, Bruce L., and William W. Wilson. 1996. *Grades/Classes of Hard Wheats Exported From North America: Analysis of Demand and Trends*. Department of Agricultural Economics, North Dakota State University, Fargo. Agricultural Economics Report No. 348. June, pp. 96.

Dexter, Dr. James E. 1993. "Quality Requirements of Western Canadian Bread Wheats," in *Grains & Oilseeds: Handling, Marketing Processing, Volume II*. Canadian International Grains Institute, Winnipeg, Manitoba. pp. 701.

Helm, James L. (Various Years). *North Dakota Hard Red Spring Wheat, Hard Red Winter Wheat Variety Performance Descriptions*. North Dakota State University Extension Service, Fargo. Circular 574.

Ito, S., W. R. Grant, and M.E. Rister. 1992. *Impacts of Technology Adoption on the United States Rice Economy*. Department of Agricultural Economics, Texas A&M University, College Station. Paper 92-6.

Johnson, D. Demcey, William W. Wilson, and Matthew Diersen. 1995. *Quality Uncertainty and Grain Merchandising Risk: Vomitoxin in Spring Wheat.* Department of Agricultural Economics, Fargo. Agricultural Economics Report No. 333. August, pp. 37.

Lin, J. Y. 1991. "Education and Innovation Adoption in Agriculture: Evidence from Hybrid Rice in China." *American Journal of Agricultural Economics*. Vol. 73, August, pp 713-723.

Manitoba Agriculture. (Various Issues). Seed Manitoba: Variety Recommendations and Growers Directory. The Manitoba Cooperator in cooperation with the Manitoba Seed Growers Association and Manitoba Agriculture, Winnipeg.

Manitoba Crop Insurance Corporation. 1996. Management Plus Program (MPP) Varietal Performance and Acreage, 1994-1995. Manitoba Crop Insurance Corporation, Winnipeg. Internet pages.

Manitoba Pool Elevators. 1996. *1996 Annual Report*. Manitoba Pool Elevators, Winnipeg.

Menke, Jayson. 1996. "Exploring the Options: Future of Wheat Dependent on Development and Funding of New Varieties." *Agweek*. Grand Forks Herald, Grand Forks, ND. November 18, pp. 25.

Mercier, Stephanie. 1993. *The Role of Quality in Wheat Import Decision Making.* U.S. Department of Agriculture Economic Research Service. Washington, DC. pp. 66.

Minnesota Association of Wheat Growers and Minnesota Wheat Research & Promotion Council. *Identifying and Defining Key Quality Criteria for Spring Wheat Flour in the Domestic Market*. A report submitted by Ag-Nomics Research. Red Lake Falls, MN. September 30, 1994.

Moore, W.R., T.C. Olson, R. Nelson, A. Hanson, and D. Hansen. (Various Years). Quality of the Regional (Montana, North and South Dakota, Minnesota) Hard Red Spring Wheat (DNS) Crop. North Dakota Agricultural Experiment Station, Department of Cereal Chemistry and Technology, Fargo.

Niedens, Lyle. 1996. "Japan tightens wheat specs: New dockage rules take effect in January." *Agweek*. Grand Forks Herald, Grand Forks, ND. November 18, pp. 19.

North Dakota Agricultural Statistics Service. (Various Issues). *North Dakota Agricultural Statistics*. North Dakota Agricultural Statistics Service. Fargo.

Pitt, M. M., and G. Sumodiningrat. 1988. *The Determinants of Rice Variety Choice in Indonesia*. University of Minnesota, St. Paul. Economic Development Center Bulletin 88-3. September.

Saskatchewan Wheat Pool. (Various Years). *Prairie Grain Variety Survey.* Published cooperatively by Alberta Pool, Saskatchewan Wheat Pool, and Manitoba Pool Elevators. Saskatoon, Saskatchewan.

Saskatchewan Agriculture. (Various Years). *Cereal Crops: Wheat-Main Characteristics of Varieties*. Saskatchewan Agriculture, Saskatoon.

U.S. Congress. Office of Technology Assessment. 1989. *Grain Quality in International Trade: A Comparison of Major U.S. Competitors*. F-402, Office of Technology Assessment, Washington, DC.

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

Wilson, W. W. 1995. *Decentralization of Grain Trading: Trends, Implications, and Challenges.* Australian Wheat Board Address, Perth.

Western Grain Marketing Panel. 1996. *Grain Marketing*. Western Grain Marketing Panel, Winnipeg, Manitoba. July 1.